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С А Д Р Ж А Ј

С О Д Е Р Ж А Н И Е

C O N T E N T S

CONTRACTIVE CONDITIONS IN *b*-METRIC SPACES

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Abstract:

The purpose of this paper is to consider various contractive conditions in b-metric spaces which have been recently published. Our results improve and complement many recent results from this field. Using the recently obtained result by R. Miculescu and A. Mihail (Miculescu & Mihail, 2017, pp.1-11) the authors of this article show that the proofs of the majority of known results in the context of b-metric spaces can be shortened.

Keywords: metric space, common fixed point, altering distance function, point of coincidence, weak compatibility.

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Introduction

It is well known that the Banach Contraction Principle (Banach, 1922, pp.133-181) states that, if a self-mapping T of a complete metric space (M,d) is a contraction mapping, then T has a unique fixed point (say u) and for each $v \in M$ the corresponding Picard sequence $\{T^n(v)\}$ converges to this fixed point u. In general, this principle has been generalized in two directions. On the one hand, the usual contractive condition is replaced by a weakly contractive condition. On the other hand, the action spaces are replaced by metric spaces endowed with an ordered or partially ordered structure or with some kind of generalized metric space (like cone metric space, G-metric space, partial metric space, fuzzy metric space, etc.).

In 1989 I. A. Bakhtin (Bakhtin, 1989, pp.26-37) and in 1993 S. Czerwik (Czerwik, 1993, pp.5-11) introduced a new distance on a non-empty set which is called a *b*-metric. A *b*-metric space is an attempt to generalize the metric space by replacing only the triangle inequality introducing one real constant. Their definition of this new kind of generalized metric space is the following.

Definition 1 (Bakhtin, 1989, pp.26-37), (Czerwik, 1993, pp.5-11) Let M be a (non-empty) set and $K \geq 1$ a given real number. A function $d_1 : M \times M \to [0,\infty)$ is called a *b*-metric on M if, for all $p,q,r \in M$, the following conditions hold:

(b1) $d_1(p,q) = 0$ if and only if $p = q$;

(b2) $d_1(p,q) = d_1(q,p)$;

(b3) $d_1(p,r) \leq K\left(d_1(p,q) + d_1(q,r)\right)$.

In this case, (M,d_1,K) is called a *b*-metric space. If (M, $\preccurlyeq$) is still a partially ordered set, then $(M,\preccurlyeq,d_1,K)$ is called an ordered *b*-metric space.

Otherwise, for all other definitions of the notions in *b*-metric spaces such as *b*-convergence, *b*-Cauchy sequence, *b*-completeness, see (Abbas et al, 2016, pp.1413-1429), (Ansari et al, 2017, pp.315-329), (Bakhtin, 1989, pp.26-37), (Huang et al, 2015), (Jovanović, 2016), (Radenović et al, 2017a, 2017b), (Roshan et al, 2013), (Zhang et al, 2017, pp.1334-1344) and the reference therein.

Definition 2 (Khan et al, 1984, pp.1-9) A function $\varphi : [0,\infty) \to [0,\infty)$ is called an altering distance function if the following properties hold:

(1) φ is continuous and nondecreasing;

(2) $\varphi(t)=0$ if and only if $t=0$.

First, a very known (important) result from a *b*-metric space is the following:

Theorem 1 (Czerwik, 1993, pp.5-11, Theorem 1) Let (M,d_1,K) be a b-complete *b*-metric space and let $T:M\to M$ satisfy

$$d_1(T(p),T(q))\le\varphi(d_1(p,q)),\ p,q\in M, \tag{1}$$

where $\varphi:[0,\infty)\to[0,\infty)$ is an increasing function such that $\lim_{n\to\infty}\varphi^n(t)=0$ for each fixed $t>0$. Then T has an exactly one fixed point *v* and

$$\lim_{n\to\infty}d_1(T^n(p),v)=0 \tag{2}$$

for each $p\in M$.

Lemma 1 (Miculescu & Mihail, 2017, Lemma 2.2.) Let $\{t_n\}$ be a sequence in a *b*-metric space (M,d_1,K) such that

$$d_1(t_n,t_{n+1})\le\mu\cdot d_1(t_{n-1},t_n) \tag{3}$$

for some $\mu\in[0,1)$, and each $n=1,2,\ldots$. Then $\{t_n\}$ is a *b*-Cauchy sequence in (M,d_1,K).

Remark 1 In several published papers based on the *b*-metric concept, the authors assume that $\mu\in[0,\frac{1}{K})$ instead of $\mu\in[0,1)$, which is obviously weaker. Then under this weaker condition they show that the Picard sequence $\{t_n=T(t_{n-1})\}_{n=1,2,\ldots}$, $t_0\in M$ is a b-Cauchy. For the proof, the authors used the following clear inequality:

$$d_1(t_m,t_n)\le Kd_1(t_m,t_{m+1})+K^2d_1(t_{m+1},t_{m+2})+\ldots+K^{n-m-1}d_1(t_{n-2},t_{n-1})+K^{n-m}d_1(t_{n-1},t_n), \tag{4}$$

where $n,m\in N$ and $n>m$.

However, putting $\varphi(r)=\mu\cdot r,\ r\in[0,\infty),\ \mu\in(0,1)$ in (1), the proof of Theorem 1 from (Czervik, 1993, pp.5-11) follows that Picard sequence $\{t_n=T(t_{n-1})\}_{n=1,2,\ldots}$, $t_0\in M$ is a b-Cauchy.

Now, we can show that Lemma 2.2. from (Miculescu & Mihail, 2017) is an immediate consequence of the one part of Theorem 1 from (Czerwik, 1993, pp.5-11).

First of all, we give the next result:

Lemma 2 If $\{t_n\}_{n\in N}$ is an arbitrary sequence in the nonempy set M, then there exists at least one mapping $T: M \to M$ such that it is Picard sequence of T with t_1 as the beginning point.

Proof. We define $T: M \to M$ as $T(t_k) = t_{k+1}$ for $k = 1,2,3,...$ as well as $T(t) = v_0$ in case $t \in M \setminus \{t_1, t_2, ..., t_n, ...\}$ and $v_0 \notin \{t_1, t_2, ..., t_n, ...\}$. The last one is possible if $\{t_1, t_2, ..., t_n, ...\} \subseteq M$ and $\{t_1, t_2, ..., t_n, ...\} \neq M$.

Proposition 1 Lemma 2.2. from (Miculescu & Mihail, 2017) is an immediate consequence of (Czerwik, 1993, pp.5-11, Theorem 1).

Proof. Indeed, the $\{t_n\}$ is a Picard sequence of the mapping defined in Lemma 2. It is obvious that the mapping T satisfies the condition (1) where $\varphi(r) = \mu \cdot r, \quad r \in [0, \infty), \quad \mu \in (0,1)$. Further (3) becomes $d_1(T(t_{n-1}), T(t_n)) \leq \mu d(t_{n-1}, t_n), n = 2,3,4,..$ i.e. the sequence $\{t_n\}$ is a *b*-Cauchy according to the proof of (Czerwik, 1993, pp.5-11, Theorem 1).

Now, by (Czerwik, 1993, pp.5-11, Theorem 1) that is, by (Miculescu, Mihail, *2017*, Lemma 2.2.), the majority of already known results can be improved. Also, by using the same argument some known results can be made significantly shorter and nicer.

The first such result is the following:

Proposition 2 Let T be a self-map on a b-complete *b*-metric space (M, d_1, K) satisfying

$$d_1(T(p), T^2(p)) \leq \mu d_1(p, T(p)) \text{ for some } \mu \in (0,1), \tag{5}$$

either (**i**) for all $p \in M$, or (**ii**) for all $p \in M, p \neq T(p)$, and suppose that T has a fixed point. Then T has a property P.

Otherwise, if T is a map which has a fixed point v, then v is a also a fixed point of T^n for every natural number n. However, the converse is false. For, consider $M = [0,1]$, T is defined by $T(p) = 1 - p$. Then T has a unique fixed point at $\frac{1}{2}$, but $T^n = I$ for each $n > 1$, which has every point of $[0,1]$ as a fixed point. On the other hand, if $M = [0, \pi]$, $T(p) = \cos p$, then T is nonexpansive and every iterate of T has the same fixed point as T. Involutions are also examples where $F(T) \neq F(T^n)$. See, e.g. (Jeong & Rhoades, 2005, pp.71-105) and the references therein.

We shall say that a map T has a property P if $F(T) = F(T^n)$ for every $n \in N$.

Proof (of Proposition 2). The statement for $n=1$ is trivial. Therefore, we shall assume that $n>1$ is a given (fixed natural number). It is clear that $F(T)\subseteq F(T^n)$. Let $v\in F(T^n)$.

Case 1. Suppose that T satisfies (i). Then, using (5),

$$\begin{aligned} d_1(v,T(v)) &= d_1(T^n(v),T^{n+1}(v)) \\ &= d_1(T(T^{n-1}(v)),T^2(T^{n-1}(v))) \le \mu d_1(T^{n-1}(v),T(T^{n-1}(v))) \\ &= \mu d_1(T(T^{n-2}(v)),T^2(T^{n-2}(v))) \\ &\le \mu^2 d_1(T^{n-2}(v),T(T^{n-2}(v))) \le \ldots \le \mu^n d_1(v,T(v)), \end{aligned}$$

which implies that $v=T(v)$.

Case 2. Let now T satisfy (ii).

If $v=T(v)$, then there is nothing to prove. Suppose, if possible, that $v\neq T(v)$. Then a repetition of the argument for Case 1 again leads to $d_1(v,T(v))\le \mu^n d_1(v,T(v))$, which implies that $v=T(v)$ and $F(T^n)=F(T)$.

Remark 2 Proposition 1.8. obviously generalize the corresponding result, Theorem 1.1. from (Jeong & Rhoades, 2005, pp.71-105), for standard metric spaces.

Corollary 1 Let T be a selfmap of a b-complete *b*-metric space (M,d_1,K) satisfying

$$d_1(T(p),T(q))\le \mu d_1(p,q) \text{ for all } p,q\in M \text{ and for some } \mu\in(0,1). \quad (6)$$

Then T has a property P.

Proof. Indeed, condition (6) implies (5). Also, by (Czerwik, 1993, pp.5-11, Theorem 1) $F(T)\neq\varnothing$. Then the result follows according to Proposition 2.

The next is also generalization of one result from a metric to a *b*-metric space.

Proposition 3 Let T be a selfmap of a b-complete *b*-metric space (M,d_1) satisfying

$$d_1(T(p),T^2(p))\le \mu d_1(p,T(p)) \text{ for all } p\in M \text{ and some } \mu\in(0,1). \quad (7)$$

Then $F(T)\neq\varnothing$, if T is a $b-$continuous.

Proof. Let $p_0\in M$ be an arbitrary point and let $\{p_n\}$ be a corresponding Picard sequence. For each $n\in\{0\}\cup N$ we have

$$d_1(p_{n+1},p_{n+2}) = d_1(T(p_n),T^2(p_n)) \le \mu d_1(p_n,T(p_n)) = \mu d_1(p_n,p_{n+1}). \quad (8)$$

Further, according to (Miculescu & Mihail, 2017, Lemma 2.2.) (see also (6)) follows that $\{p_n\}$ is a b-Cauchy sequence. Since (M,d_1) is a *b*-complete *b*-metric space there is $v \in M$ such that $p_n \to v$ as $n \to \infty$. The continuity of T implies that $T(v) = v$, i.e., $F(T) \neq \varnothing$.

Jungck's result in the concept of *b*-metric spaces:

Theorem 2 Let (M,d_1,K) be a *b*-metric space and $T,S : M \to M$, $T(M) \subseteq S(M)$ be self mappings such that for all $p,q \in M$.

$$d_1(T(p),T(q)) \leq \mu d_1(S(p),S(q)), \text{ where } \mu \in (0,1). \quad (9)$$

Also, assume that, at least one of the following conditions hold:

(i) $(T(M),d_1)$ or $(S(M),d_1)$ is *b*-complete;

(ii) (M,d_1,K) is *b*-complete, S is *b*-continuous and T and S are commuting.

Then T and S have a unique point of coincidence. Moreover, if T and S are weakly compatible (for case (i)) then they have a unique common fixed point in M.

Proof. First, we notice that if a point of coincidence of T and S exists, then it is unique. Indeed, if w_1 and w_2 are two distinct points of coincidence of T and S, then there exist two points $u_1,u_2 \in M, u_1 \neq u_2$, such that $T(u_1) = S(u_1) = w_1 \neq w_2 = S(u_2) = T(u_2)$. Now, by (9) we have $d_1(w_1,w_2) = d(T(v_1),T(v_2)) \leq \mu d_1(S(v_1),S(v_2)) = \mu d_1(w_1,w_2) < d_1(w_1,w_2)$, which is a contradiction.

Further, the condition $T(M) \subseteq S(M)$ implies that there exists Jungck's sequence $j_n = T(v_n) = S(v_{n+1})$, where $\{v_n\}$ is a sequence in $M, v_0 \in M$ is an arbitrary point. We shall prove that the sequence $\{j_n\}$ is a *b*-Cauchy. Indeed, for each $n \in \{0\} \cup N$ we have that

$$d_1(j_{n+1}, j_{n+2}) = d_1(T(v_{n+1}),T(v_{n+2})) \leq \mu d_1(S(v_{n+1}),S(v_{n+2})) = \mu d_1(j_n, j_{n+1}),$$

i.e., for all $n \in \{0\} \cup N$ the sequence $\{j_n\}$ satisfies condition (3). This means that it is *b*-Cauchy.

Now, let (i) holds. Therefore, since $(S(M),d_1)$ is a *b*-complete *b*-metric space, it follows that there exists $v \in M$ such that $T(v_n) = S(v_{n+1}) = j_n \to Sv$ as $n \to \infty$. We will prove that $T(v) = S(v)$. In order to prove this equality, we have

$\frac{1}{K} d_1(T(v), S(v)) \le d_1(T(v), T(v_n)) + d_1(T(v_n), S(v)) \le \mu d_1(S(v), S(v_n)) + d_1(j_n, S(v))$
$= \mu d_1(S(v), j_{n-1}) + d_1(j_n, S(v)) \to \mu \cdot 0 + 0 = 0.$

Hence, $T(v) = S(v) = w$ is a point of coincidence (unique) of the pair (T, S).

If $(T(M), d_1)$ is a *b*-complete the proof is very similar.

If (ii) holds, then since (M, d_1) is *b*-complete, there exists $v \in M$ such that $T(v_n) = S(v_{n+1}) = j_n \to v$, as $n \to \infty$. Since both self-mappings T and S are *b*-continuous, we have when $n \to \infty$:

$$S(T(v_n)) \to S(v) \text{ and } T(S(v_n)) \to T(v) \text{ when } n \to \infty.$$

Since T and S are commuting, we again obtain that $T(v) = S(v) = w$ is a point of coincidence (unique) of the pair (T, S).

For both cases (i) and (ii), according to the known Jungck's result, it follows that w is a unique common fixed point of T and S.

The next is a common fixed point theorem of the Zamfirescu type in $b-$metric spaces.

Theorem 3 (Jovanović, 2016), (Khan et al, 1984, pp.1-9), (Rhoades, 1977, pp.257-290, Theorem 4.3.) Let (M, d_1, K) be a *b*-complete *b*-metric space and let $T : M \to M$ be a mapping and let there exist nonnegative numbers a, b, c such that for all $p, q \in M$ at least one of the following conditions:

$1^0\ d_1(T(p), T(q)) \le a d_1(p, q)$;

$2^0\ d_1(T(p), T(q)) \le b[d_1(p, T(p)) + d_1(q, T(q))]$;

$3^0\ d_1(T(p), T(q)) \le c[d_1(p, T(q)) + d_1(q, T(p))]$

holds.

If $a < \frac{1}{K}, b < \frac{1}{2K^2}, c < \frac{1}{2K^2}$ then T has a unique fixed point.

Remark 3 By using (Miculescu & Mihail, 2017, Lemma 2.2) the conditions for a, b, c can be relaxing, that is., we get $a < 1, b < \frac{1}{2}$ i $c < \frac{1}{2K}$ (for details see Theorem 2.2. below).

Main results

In this section, we shall consider several important as well as significant contractive conditions announced in the existing literature. Readers can compare all these conditions to the corresponding ones in the context of standard metric spaces, for more details see (Rhoades, 1977, pp.257-290).

Let Ψ_1 be the family of all nondecreasing functions $\psi_1 : [0,\infty) \to [0,\infty)$ such that $\lim_{n\to\infty} \psi_1^n(t) = 0$, for all $t > 0$.

It is well known that if $\psi_1 \in \Psi_1$ then $\psi_1(t) < t$ if $t > 0$ as well as $\psi_1(0) = 0$.

Our first result is the improvement of the proof in (Abbas et al, 2016, pp.1413-1429, Theorem 2.2.)

Theorem 4 Let $(M, \preccurlyeq, d_1, K > 1)$ be a partially ordered b-complete b-metric space and let T: M → M be an increasing mapping with respect to $\preccurlyeq$ such that there exists an element $p_0 \in M$ with $p_0 \preccurlyeq T(v_0)$. Assume that

$$K \cdot \frac{1 + K \cdot d_1(p,q)}{1 + \frac{1}{2} d_1(p, T(p))} \cdot d(T(p), T(q)) \le \psi_1(M_1(p,q)) + L_1 \cdot N_1(p,q) \tag{10}$$

for all comparable elements $p, q \in M$, where $L_1 \ge 0, \psi_1 \in \Psi_1$,

$$M_1(p,q) = \max\left\{ d_1(p,q), \frac{d_1(p,T(p)) d_1(q,T(q))}{1 + d_1(T(p), T(q))} \right\} \tag{11}$$

and

$$N_1(p,q) = \min\{d_1(p,T(p)), d_1(p,T(q)), d_1(q,T(p)), d_1(q,T(q))\}. \tag{12}$$

If T is continuous, then T has a fixed point.

Proof. If $p_0 \neq T(p_0)$ then $p_0 \prec T(p_0)$. Further, for the Picard sequence we can assume that $d_1(p_n, p_{n+1}) > 0$ for all $n \in \{0\} \cup N$. Now, we will prove that

$$d_1(p_n, p_{n+1}) \le \frac{1}{K} d_1(p_{n-1}, p_n), \text{for all } n \in N. \tag{13}$$

Indeed, since

$$\frac{1+Kd_1(p_{n-1},p_n)}{1+\frac{1}{2}d_1(p_{n-1},T(p_{n-1}))}=\frac{1+Kd_1(p_{n-1},p_n)}{1+\frac{1}{2}d_1(p_{n-1},p_n)}>\frac{1+d_1(p_{n-1},p_n)}{1+\frac{1}{2}d_1(p_{n-1},p_n)}>1,$$

then by using (10) with $p=p_{n-1}, q=p_n,$ we obtain

$$Kd_1(p_{n+1},p_n)=Kd_1(T(p_n),T(p_{n-1}))\le\psi_1(d_1(p_n,p_{n-1}))+L_1\cdot N_1(p_n,p_{n-1}).$$

Because $M_1(p_n,p_{n-1})=d_1(p_{n-1},p_n),\psi_1(d_1(p_n,p_{n-1}))<d_1(p_n,p_{n-1})$ and $N_1(p_n,p_{n-1})=0$ we obtain that (13) holds.

This means that the sequence $\{p_n\}$ is a *b*-Cauchy, according to Lemma 2.2. from (Miculescu & Mihail, 2017) which then converges to some $u\in M$. The continuity of T implies that u is a fixed point of T.

Remark 4 *All that shows that our approach gives a much shorter and nicer proof than the ones in (Ansari et al, 2017, pp.315-329). Also, by the same method, the proofs of all results in (Ansari et al, 2017, pp.315-329) can be improved.*

In fact, the main (important) question is the following: Does some given contractive condition in the framework of any class of generalized metric spaces imply (give) that the corresponding Picard sequence is a Cauchy (in this class)? The previously contractive condition is such. We proved that for it holds $d_1(p_n,p_{n+1})\le\mu d_1(p_{n-1},p_n)$ for all $n\in N$ and some $\mu\in(0,1)$. Since $K>1$ and $\mu=\frac{1}{K}$ then the result follows by (Miculescu & Mihail, 2017, Lemma 2.2.).

In the framework of $b-$metric spaces, the following two results are specific.

Theorem 5 *Let (M,d_1,K) be a b-complete b-metric space and let $T:M\to M$ be a b-continuous mapping. Also let*

$$d_1(Tp,Tq)\le ad_1(p,Tp)+bd_1(q,Tq),\text{ for all } p,q\in M,a,b\ge 0,a+b<1$$

that is

$$d_1(Tp,Tq)\le ad_1(p,Tq)+bd_1(Tp,q),\text{for all } p,q\in M,a,b\ge 0,a+b<\frac{1}{K}$$

In each of the given cases, T has a unique fixed point (say v) and for any $u\in M$ the sequence $\{T^n(u)\}\to v$ as $n\to\infty$.

Proof. In the first (Kannan) case, we obtain that $d_1(p_{n+1}, p_n) \leq \frac{a}{1-b} \cdot d_1(p_n, p_{n-1})$, while in the second one (Chatterjea), we have $d_1(p_{n+1}, p_n) \leq \frac{(a+b)K}{2-(a+b)K} \cdot d_1(p_n, p_{n-1})$. According to (Miculescu, & Mihail, 2017, Lemma 2.2.) it follows that in both cases that the Picard sequence $\{T^n p_0\}_{n\in\{0\}\cup N}, p_0 \in M$ is a *b*-Cauchy. Since T is *b*-continuous, the result follows.

Conclusion

Based on the previous discussion, we can conclude that the proofs of the majority results in the existing literature for the concept of b-metric spaces can be significantly shortened by using (Miculescu & Mihail, 2017, Lemma 2.2.).

All these results are in the following papers (Aghajani et al. 2014, pp. 941-960), (Allahyar et al, 2014), (Chandok et al, 2017a), (Chandok et al, 2017b, pp.331-345), (Demma & Vetro, 2015), (Ding et al, 2016, pp. 151-164), (Dung & Hang, 2016, pp. 267-284), (Harandi, 2014, pp. 351-358), (Kaushik et al, 2017), (Khamsi & Husain, 2010, pp. 3123-3129), (Kir & Kiziltunc, 2013, pp. 13-16), (Kumam et al, 2015), (Latif et al, 20915, pp. 363-377), (Liu & Gu, 2016, pp. 5909-5930), (Ozturk & Ansari, 2017, pp. 45-52), (Parvaneh et al, 2013), (Petrusel et al, 2017, pp. 199-215), (Piri & Kumam, 2016), (Roshan et al, 2014a, pp. 725-737), (Roshan, et al, 2015), (Roshan et al, 2014b, pp. 613-624), (Sarwar et al, 2017, pp. 3719-3731), (Sarwar & Rahman, 2015, pp. 70-78), (Sintunavarat, 2016, pp. 397-416), (Zabihi & Razani, 2014).

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УСЛОВИЯ СЖАТИЯ В *b*-МЕТРИЧЕСКИХ ПРОСТРАНСТВАХ

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ОБЛАСТЬ: математика (математическая тематическая классификация: первичная 47H10, вторичная 54H25)
ВИД СТАТЬИ: оригинальная научная статья
ЯЗЫК СТАТЬИ, английский

Резюме:

В данной работе представлен анализ различных условий сжатия в b-метрических пространствах, которые недавно были опубликованы. На основании исследований настоящих результатов мы дополнили и откорректировали многие аспекты результатов в данной области. Так, например, исследовав недавние результаты, полученные Р. Микулеску и А. Михаилом (Miculescu & Mihail, 2017, pp.1-11), авторы настоящей статьи доказали, что многие известные результаты в контексте b-метрических пространств могут быть значительно сокращены.

Ключевые слова: метрическое пространство, общая фиксированная точка, функция изменения расстояния, точка совпадения, низкая совместимость.

КОНТРАКТИВНИ УСЛОВИ У *b*-МЕТРИЧКИМ ПРОСТОРИМА

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ЈЕЗИК ЧЛАНКА: енглески

Сажетак:

Циљ овог рада јесте да размотри разне контрактивне услове у b-метричким просторима који су недавно објављени. Наши резултати поправљају и допуњују многе недавне резултате из

овог контекста. Користећи недавно добијени резултат Р. Микулескуа и А. Михаила, (Miculescu & Mihail, 2017, pp.1-11) аутори овог чланка показују да докази многих познатих резултата у контексту b-метричких простора могу бити доста скраћени.

Кључне речи: метрички простор, заједничка фиксна тачка, функција промене раздаљине, тачка коинциденције, слаба компатибилност.

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CONTROLING AN ISOLATED OVERSATURATED INTERSECTION IN REAL TIME. FUZZY LOGIC APPROACH.

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Abstract:

In this paper we consider a problem of controling an oversaturated intersection in real time. We developed a mathematical model for solving the problem, based on fuzzy logic. The model can be applied to intersections characterized by oversaturated traffic flows. We compared this fuzzy logic approach to the "fixed time" controling of the oversaturated intersection. By "fixed time" we understood controlling based on the hystorical data about traffic flows. In the case of the oversaturated intersection considered in this paper, a classical approach of controlling in real time ("actuated time control") gives the same solutions as "fixed time" control. The criterion function for comparing solutions represents the control delay of all vehicles that pass through the intersection within a certain period of analysis. We tested these approaches on a "T" intersection, where the suggested model based on fuzzy logic generated solutions with less control delay in comparison to the "fixed time" model.

Key words: isolated signalized intersections, oversaturated traffic flows, fuzzy logic, real time control, vehicle control delay.

Introduction

One of the biggest problems faced by the authorities in large cities around the world is the problem of traffic congestion. City authorities allocate significant resources to solve this problem which affects various aspects of life of residents. The negative consequences of traffic congestion are reflected primarily in increased time losses of traffic participants. In addition, the consequences can be economic (higher fuel consumption), ecological (additional air pollution) and many others. Since it is not always possible to build new roads, in order to solve the problem described, traffic engineers apply various control and management measures and strategies to avoid or at least to mitigate traffic congestion. Congestion pricing, park and ride and car sharing are just some of them. The control of the operation of traffic signals has proven to be efficient and at the same time an economically cost effective measure.

In this paper, we consider the problem of managing isolated signalized oversaturated intersections. A mathematical model for controlling an oversaturated intersection, based on the fuzzy logic system ”Sugeno” type is developed. The criterion function represents the control delay of vehicles in a certain period of analysis. The proposed model has been compared with ”fixed time” control with respect to the values of the criterion function. A simulation approach was used as a comparison method.

Data on traffic flows were obtained from the detector. We considered the case when the intersection is oversaturated in all flows (”full oversaturated intersection”). Such a case is possible in the central zones of large cities, especially in peak periods of traffic load.

Real time management is characterized by dividing time into small intervals, 2 to 5 seconds, after which a decision is made whether to extend the existing phase or to interrupt it. This type of traffic control is characteristic of the following works (Miller, 1963, pp.200-220), (Bang, 1976, pp.288-292), (Vincent & Young, 1986, pp.385-387), (Lin et al, 1987, pp.89-98). There are also approaches where the decision time is longer and their characteristic is a prediction of signal plans for future traffic flows (Gartner, 1983, pp.75-81).

Since Pappis and Mamdani published a paper in 1977 in which they proposed controlling the intersection which consists of two one-way streets based on the fuzzy logic approach (Pappis & Mamdani, 1977, pp.707-717), the interest of traffic engineers for the application of this mode of operation has been growing. An analysis of the use of several types of fuzzy logic management systems for the controling of an isolated inter-

section was presented in the paper (Jacques et al, 2002, p.81). In this paper, the directions for future development of fuzzy logical systems are given in order to improve the work of the isolated intersection.

In the paper (Murat & Gedizlioglu, 2005, pp.19-36), the implementation of fuzzy logic was demonstrated in order to optimize the schedule of flows in phases. Murat in his work (Murat, 2006, pp.316-334) showed that the problem of controling a signalized intersection can be successfully solved by a hybrid algorithm of neural networks and fuzzy logic. A hybrid model of genetic algorithms and fuzzy logic for the control of flows at an isolated intersection can be found in the paper (Yang et al, 2006, pp.3391-3395). In the paper (Nair & Cai, 2007, pp.1229-1233), a unique fuzzy logic model is developed for controling traffic flows in specific situations at the intersection, such as traffic accidents, works in the intersection zone, etc.

The fuzzy logic system "Mamdani" type for controlling an isolated oversaturated intersection has been developed and shown in the paper (Zhang et al, 2008, pp.179-184). They considered the problem when there are two oversaturated approaches, in a mutual conflict. Other currents are unsaturated. In this case, there is a possibility of application of classical control in real time with the detectors ("actuated time control"). The authors compared their approach with the indicated classic approach, where fuzzy logic was better in all criteria. To compare the results, they used the simulation model proposed in the paper (Li & Prevedouros, 2004, pp.594-601), who developed the TACOST algorithm ("Traffic Adaptive Control for Oversaturated Intersections") by solving the same problem.

The application of simulation and a fuzzy logic system, implemented in MATLAB environment, to the problem of controlling isolated signalized intersections can be found in the work (Soh et al, 2010, pp.924-933). The possibility of using a detector with a camera in the traffic flow control at the intersection in real time is shown in the paper (Diaz-Cabrera et al, 2015, pp.3911-3923). The authors used fuzzy clustering to process the image they get from the camera in the best possible way.

This work is organized in the following way: after the introductory review and a brief review of some of important papers in this field, the second chapter is devoted to setting the problems and goals of this paper. The third chapter provides a methodology for solving a problem based on the fuzzy logical system. In the fourth chapter, the proposed approach was tested on an "T" intersection. A simulation was used to compare the results obtained by the classic approach and the methodology proposed in this paper. Chapter 5 is dedicated to concluding observations and directions for future research.

Setting up problems and goals

This paper examines an intersection that has oversaturated traffic flows at all phases. This intersection is called completely oversaturated and it is different from the ones considered in the paper (Zhang et al, 2008, pp.179-184), where an intersection with two oversaturated flows in mutual conflict is considered.

In the aforementioned work, the authors compared fuzzy logical control with classical detector control. When the intersection is overloaded in practically all streams, "fixed time" management is recommended as it provides the same signaling plans as classical detector control (Roess et al, 2011).

Fuzzy logical systems are managed using linguistic variables that are characterized by unclear boundaries. For example, is it possible to accurately estimate the travel time between two nodes on the transport network or whether it is possible to say precisely for a branch of the network whether it is congested or not, or whether it can be precisely stated what is the degree of that congestion. The answer to these questions is definitely negative. According to the classical theory of sets, the branch of the transport network may either belong to or not belong to a group of congested ones. In other words, the elements of a set can absolutely belong to that set, or absolutely do not belong to it.

Inspired by this kind of thinking, Zadeh in his famous work from 1965 proposed a modified theory of sets (fuzzy sets) in which the membership of a set can be expressed by some percentages, and not only or absolutely belongs (1) or absolutely does not belong (0), see (Zadeh, 1965, pp.338-353). Accordingly, according to this modified theory, sets of branches of the network can with 70% belong to a set of congested branches, and with 30% collection where there is no congestion.

Fuzzy logic is suitable for controlling an oversaturated isolated intersection because it is able to imitate the "ideal" policeman at the intersection. Such a policeman does not count the vehicles, but he/she intuitively knows (feels) when enough cars have been released from one approach while vehicles are piled from the other approach.

The aim of this research is to show that the fuzzy logic approach can be competitive with respect to the classic approach, in conditions of total oversaturation. What is more, using the unevenness of vehicle's approach during the phase which we analyze, the fuzzy logical system tries to find better signaling plans than a fixed time control strategy. The measure of the quality of the received signaling plans (cycle values and green times per phase) is control delay of the vehicle.

Methodology

The fuzzy logic controller that we developed and present in this paper controls the queues of vehicles based on two input and one output fuzzy set. The first input fuzzy set is the number of vehicles in a queue that is served during the green phase (Vap). The second input fuzzy logic set represents the number of vehicles in a queue waiting for the green time of the next phase (Vq). Fuzzy logical sets are shown in Figure 1. The input fuzzy sets consist of three membership functions represented by Gaussian curves: the small, middle and large order of the vehicle. The limit values for the number of vehicles in a row shown in Figure 1 can be changed depending on the specific intersection.

The developed fuzzy logic system is of a "Sugeno" type and determines at each 2 s whether the existing phase is extended, or is interrupted (EXT). The output size consists of two numbers: 1 if the phase is extended by another 2 s, and 0 if the phase is interrupted.

Each phase has its minimum green time (gmin) and its maximum green time (gmax). The minimum green time is determined based on the distance of the detector from the stop line. More details on determining the minimum green phase time can be found in the book (Roess et al, 2011). The maximum green time is determined by optimization in the case of "fixed time" control. More details about optimization in "fixed time" control can be found in the paper (Jovanović & Teodorović, 2017, pp.556-576).

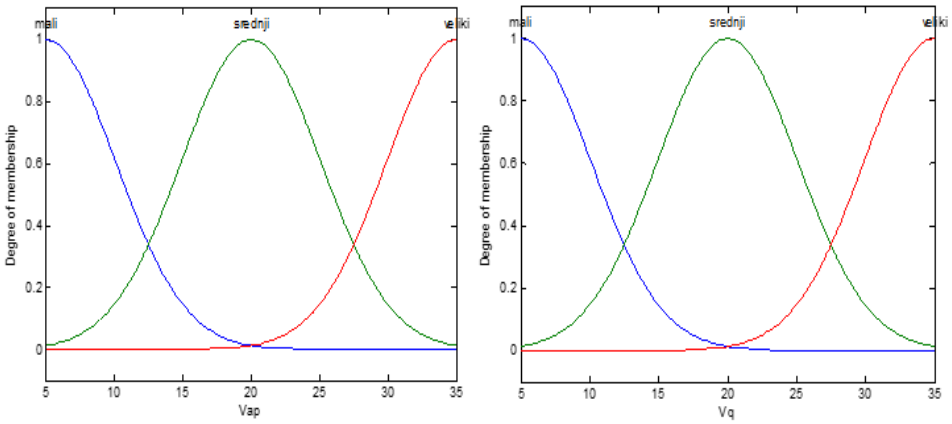

Figure 1 – Input variables into the fuzzy logical system
Рис. 1 – Входные переменные в системе Фаззи-логики
Слика 1 – Улазне величине у фази логички систем

The EXT value has a range of 0 to 1. If the EXT value is greater than or equal to 0.5, the phase is extended; if less than 0.5 the current phase is

interrupted. Therefore, each phase can be interrupted either by the decision of the fuzzy logical system or if it has reached its maximum green time. The algorithm for deciding on an extension or phase break is given in Figure 2.

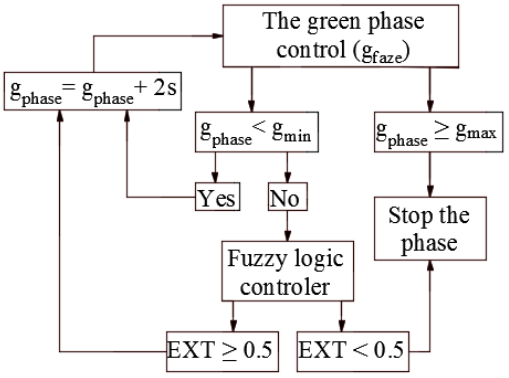

Figure 2 –The algorithm for the control of the green phase time
Рис. 2 – Алгоритмы для управления продолжительностью зеленой фазы
Слика 2 – Алгоритам за управљање зеленим временом фазе

The developed model does not anticipate the skipping of the phases, nor the choice between the several phases to which the green time will be assigned. Considering the subject of the study of this work (the intersection oversaturated in all phases), such changes in the algorithm would not lead to significant improvements in the value of control delay.

The fuzzy logic system is formed based on the ”If-Then" rules. The "If" part of the rule is a premise, while the "Then" part represents a consequence. In this case, the "Then" part of the rule is a binary decision about whether to extend the phase for another two seconds or to interrupt it. The basis of the rule of the phase of the logical system is formed and shown in Table 1.

Table 1 – Fuzzy rules base
Таблица 1 – База фаззи правил
Табела 1 – База фази правила

Serial number	if $\mathbf{V_{ap}}$ (voz) is	and $\mathbf{V_q}$ (voz) is	then **EXT** is	Weight factor
1.	small	small	1	0.8
2.	small	medium	0	0.8
3.	small	big	0	1
4.	medium	small	1	1
5.	medium	medium	1	0.6
6.	medium	big	0	0.8
7.	big	small	1	1
8.	big	medium	1	0.8
9.	big	big	0	0.6

The exit from the logical system stage is the value of EXT, which is between 0 and 1. Based on the value of the EXT size, a decision is made on the extension or interruption of the green phase time (the algorithm in Figure 2). EXT is obtained by defuzzification, which is the last step of the proposed methodology. Defuzzification and the fuzzy logical system are implemented in the program package "MATLAB" 2010, and in its "Toolbox" called "FIS Editor". The "3D" dependence of the input and output variables is shown in Figure 3.

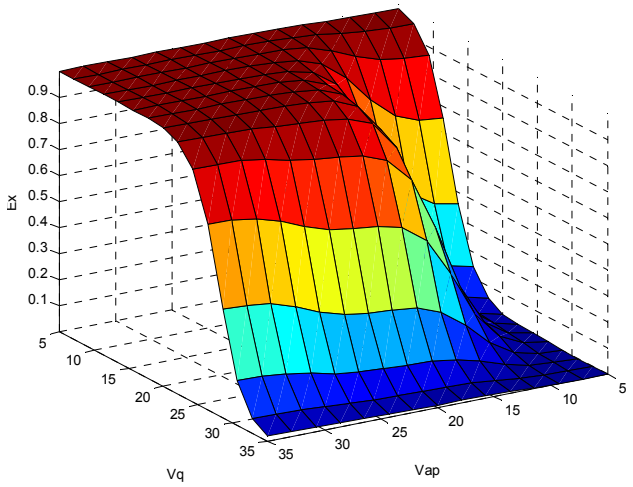

Figure 3 – "3D" dependence of the fuzzy logical system variables
Рис. 3 – "3D" зависимость переменных в системе фаззи-логики
Слика 3 – „3D" зависност променљивих величина фази логичког система

Test example

As a test example, we take a hypothetical "T" intersection with a traffic flow in each approach having its own phase. The intersection is in full mode, with one traffic lane at each approach. Detectors are located at a sufficient distance from the stop line so they can count all vehicles that make up the queue on the access roads.

At every 2 s, the detector sends the binary information to the stage to a fuzzy logical controller in the form of 0 (no new vehicle) or 1 (precisely 1 vehicle appeared). Also, 2 seconds is provided for serving a vehicle (when it leaves the stop line). By this setting, at every 2 seconds the queue of vehicles is updated at each of the intersection approaches, whether the queue has the green time or is waiting for service.

Figure 4 shows the test intersections with the layout of flows in all approaches during the phases. The figure shows a lane traffic flows (veh / h). All red time between all phases is 2 s, within which the detector sends the information whether a new vehicle has joined the queue or not.

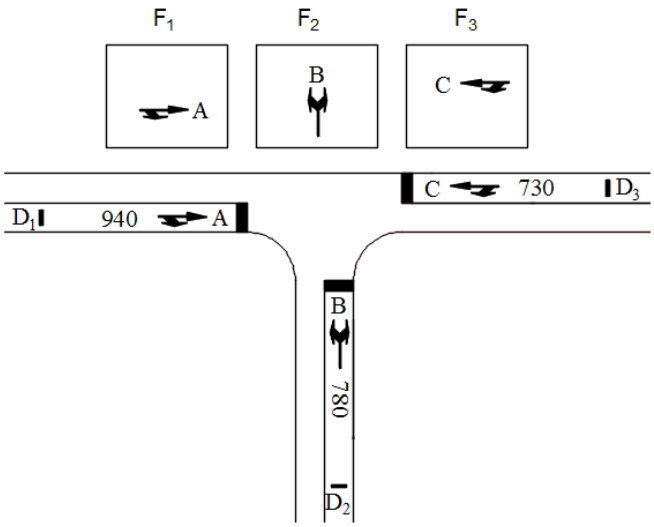

Figure 4 – Test intersection
Рис. 4 – Тест перекресток
Слика 4 – Тест раскрсница

Based on the optimization, a solution with the minimum value of control delays is obtained. This solution implies "fixed time" control. At the same time, the green timing of the phases obtained in this way represents the maximum green time in "real time" control. The solution gives a cycle value of 120 s and a green time value of 40 s, 38 s and 36 s, respectively, in phases. The minimum green time for all phases was adopted at 10 s.

The fuzzy logic controller uses imbalances in the coming of a vehicle during the cycle. The schedule of vehicles approaching in 10 minutes time is given in the Appendix. Vehicle arrival is generated in a random way (Appendix). The solutions offered by the model developed in this paper are presented in the form: C; g1phase, g2phase, g3phase. The following solutions were obtained: 1) 72; 18, 38, 10. 2) 100; 36, 28, 30. 3) 68; 14, 38, 10. 4) 46; 10, 20, 10. 5) 120; 40, 38, 36. 6) 112; 40, 30, 36. In the last, seventh cycle, phase 3 was not tested because the analysis period, which was 10 minutes, expired. The time for phase 1 and 2 was obtained from 40 s and 10 s, respectively, while the interrupted phase 3 was 28 s. In this case, it can be concluded that the incomplete cycle was 82 s, with the cycle lost time of 4 s.

Simulation

In order to test the performance of the generated solutions, a simulation model has been developed to calculate the control delay of the vehicle. The basic geometric model on which the calculation of control delay of vehicles is based, given by (Akçelik, 1980) and the model assumes that the arrival of the vehicle during the cycle is constant. Within the framework of the developed simulation, in this paper, vehicle flows vary from phase to phase, which reflects the real situation at the intersection more closely.

In this case, vehicles are served within three phases, with the initial queues of unserved vehicles from the previous cycle. The total control delays during the k-cycle are obtained by calculating the surface of the highlighted parts in Figure 5. The total control delays per cycle are divided by vehicle flows (A, B and C of Figure 4). In the further test, the equations will be given only for the flow of the vehicle A, while the control delay for flows B and C are calculated analogously to that.

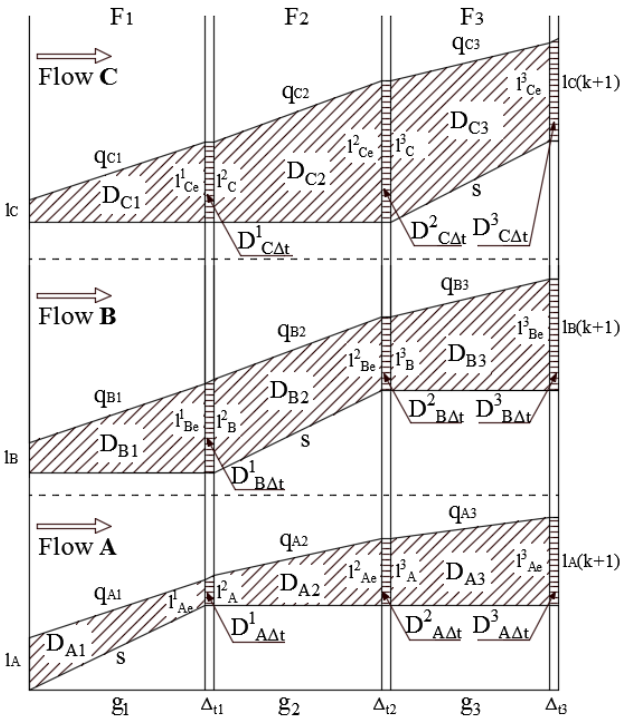

Figure 5 – The calculation of the control delays during the kth cycle
Рис. 5 – Расчет потерь времени в течение „к“ цикла
Слика 5 – Прорачун временских губитака током к-тог циклуса

The control delays for phases 1, 2, and 3, during the k cycle, are denoted by $D_{A1}(k)$, $D_{A2}(k)$ and $D_{A3}(k)$, respectively. They are counted as follows:

$$D_{A1}(k) = \frac{1}{2} \cdot \left(l_A(k) + l_{Ae}^1(k) \right) \cdot g_1(k)$$

$$D_{A2}(k) = \frac{1}{2} \cdot \left(l_A^2(k) + l_{Ae}^2(k) \right) \cdot g_2(k)$$

$$D_{A3}(k) = \frac{1}{2} \cdot \left(l_A^3(k) + l_{Ae}^3(k) \right) \cdot g_3(k)$$

where we denoted: $l_A(k)$ – number of vehicles in the flow *A* at the beginning of the kth cycle, $g_1(k)$; $g_2(k)$; $g_3(k)$ – green time for phases 1, 2 and 3 in the kth cycle. The number of vehicles in the flow *A* at the end of phases 1, 2 and 3 in the kth cycle: $l^1_{Ae}(k)$; $l^2_{Ae}(k)$ i $l^3_{Ae}(k)$ is calculated in the following way:

$$l_{Ae}^1(k) = l_A(k) + q_{A1} \cdot g_1(k) - g_1(k) \cdot s$$

$$l_{Ae}^2(k) = l_A^2(k) + q_{A2} \cdot g_2(k)$$

$$l_{Ae}^3(k) = l_A^3(k) + q_{A3} \cdot g_3(k)$$

In the proposed simulation, we consider the case when s is constant and equal to ½ for each vehicle approach. Calibration of the model is possible also for different values of s in different approaches.

After completing one phase, the model does not switch to the next one immediately, but there is also the protection time Δt. Within this time, the detector can register a new vehicle. Accordingly, the following binary variable is introduced:

$$\delta_F = \begin{cases} 1 \text{ if at the end of the phase F detector} \\ \text{register the vehicle in the time } \Delta t, \\ 0 \text{ othervise.} \end{cases}$$

The numbers of the vehicles in the approach *A* at the beginning of the phases 2 and 3 in the kth cycle $l^2_A(k)$ and $l^3_A(k)$, and the number of unserved vehicles during the kth cycle (represent the initial queue at the beginning of the *k+1*-st cycle): $l_A(k+1)$ are calculated in the following manner:

$$l_A^2(k) = l_{Ae}^1(k) + \delta_F$$

$$l_A^3(k) = l_{Ae}^2(k) + \delta_F$$

$$l_A(k+1) = l_{Ae}^3(k) + \delta_F$$

The control delays for the approach *A* during the protected time *Δt*: $D^1_{A\Delta t}(k)$; $D^2_{A\Delta t}(k)$ i $D^3_{A\Delta t}(k)$, for phases 1, 2 and 3, respectively, are obtained from the next calculations:

$$D_{A\Delta t}^1(k) = \frac{1}{2} \cdot \left(l_{Ae}^1(k) + l_A^2(k)\right) \cdot \Delta t_1$$

$$D_{A\Delta t}^2(k) = \frac{1}{2} \cdot \left(l_{Ae}^2(k) + l_A^3(k)\right) \cdot \Delta t_2$$

$$D_{A\Delta t}^3(k) = \frac{1}{2} \cdot \left(l_{Ae}^3(k) + l_A(k+1)\right) \cdot \Delta t_3$$

In this case, the time Δt is 2s for all phases. This value is constant throughout the entire simulation. In other words, the Δt times are the same during all k cycles.

Denote by $D_A(k)$ control delays for approach *A* during the *k*th cycle. Then, we finally obtain:

$$D_A(k) = D_{A1}(k) + D_{A2}(k) + D_{A3}(k) + D^1_{A\Delta t}(k) + D^2_{A\Delta t}(k) + D^3_{A\Delta t}(k).$$

Results

For the data presented at the beginning of the fourth chapter, control delays of vehicles are generated in the case of fixed-time control (FTC) and also for the fuzzy logical time controller (FLTC). The values for 10 minutes of simulation are shown in Figure 6.

After 10 minutes of simulation, the control delays of vehicles in the case of FTC control were 66 853 s, while in the case of FLTC control they were 58 468 s. Fuzzy logic gave better results for 8 385 s, or 12.54%.

If with CVD (s) we denote the control delays generated during the simulation, and with Q_1, Q_2 and Q_3, the total number of vehicles per phase (data given in Figure 4), the average control delays of the vehicle (ACVD (s / veh)), during the simulation, are obtained as follows:

$$ACVD = \frac{6 \cdot CVD}{Q_1 + Q_2 + Q_3}$$

Accordingly, the average control delays of the vehicles in the case of FTC control were 164 s / veh, while in the case of FLTC they were 143 s / veh. Fuzzy logic gave better results for 21 s / veh.

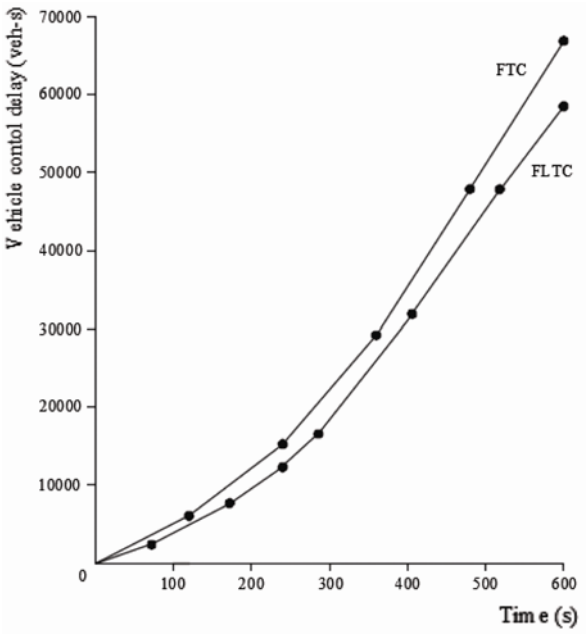

Figure 6 – The simulation results
Рис. 6 – Результаты моделирования
Слика 6 – Резултати симулације

Conclusion

In this paper, the fuzzy logical model of the Sugeno type for controlling an isolated oversaturated intersection in real time has been developed. The intersection is oversaturated, so there are unserved queues of vehicles at the end of the cycle in all approaches (fully oversaturated intersection).

For an intersection characterized by such oversaturation, it is recommended that it should be controlled using a fixed-time strategy and fixed green-time in all phases. If it were controlled by the classic detector strategy, the same values of cycles and green times would be obtained, as well as in the case of fixed-time control.

Using the unevenness of the vehicle arrivals, the fuzzy logical controller developed in this paper succeeds in generating different cycle and green time values in phases. Control delays, tested on a numerical

example, are less than 12.54% for the fuzzy logic control compared to fixed time control. Control delays are calculated during a ten-minute simulation, which is specially developed for the purpose of this paper.

The directions of future research could go towards the application of the proposed model to the coordinated work of traffic signals, both for linear and zonal coordination. Also, consideration could be given to improving the results by optimizing the membership functions of the fuzzy logical system or the fuzzy rules.

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Appendix: The vehicles’ approaches

faza	s / inicijalni	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60
F1	12	0	1	1	1	1	1	0	0	1	1	1	1	0	1	1	1	0	0	0	1	1	0	0	0	0	1	1	0	1	1
F2	7	1	0	1	1	1	0	1	0	1	0	1	1	1	1	1	0	1	0	0	1	1	1	0	1	1	1	0	0	1	0
F3	5	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	1
		62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110	112	114	116	118	120
		1	0	0	1	0	1	0	0	1	0	0	0	0	1	1	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0
		1	1	1	1	1	1	1	0	1	1	0	0	0	0	0	0	1	0	1	1	0	1	1	1	1	0	1	1	0	0
		1	1	1	0	1	0	1	0	0	1	0	1	1	1	0	1	0	0	1	0	0	0	0	0	0	0	1	1	1	1
		122	124	126	128	130	132	134	136	138	140	142	144	146	148	150	152	154	156	158	160	162	164	166	168	170	172	174	176	178	180
		1	1	0	0	0	1	1	0	0	0	1	0	1	1	0	0	0	0	1	1	1	0	1	0	1	0	0	1	1	1
		1	0	1	1	0	0	0	0	1	1	1	1	0	1	0	1	1	1	0	0	1	0	0	1	0	0	1	0	1	1
		0	1	1	0	1	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
		182	184	186	188	190	192	194	196	198	200	202	204	206	208	210	212	214	216	218	220	222	224	226	228	230	232	234	236	238	240
		1	1	0	0	0	1	0	1	0	0	1	0	0	1	1	1	0	1	0	0	0	0	1	0	1	1	0	1	0	0
		0	0	1	0	0	1	0	1	0	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	0	1
		0	1	0	0	1	1	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	1	0
		242	244	246	248	250	252	254	256	258	260	262	264	266	268	270	272	274	276	278	280	282	284	286	288	290	292	294	296	298	300
		1	1	1	0	0	1	0	0	1	1	0	0	1	0	1	0	1	1	0	0	1	0	1	1	1	0	0	1	1	1
		1	0	1	0	1	1	1	1	0	1	1	1	1	1	0	0	1	1	1	0	1	0	1	1	1	0	0	1	1	0
		1	1	0	1	0	0	1	1	1	0	0	1	0	0	1	1	0	1	0	0	1	1	1	1	1	0	0	1	0	1
		302	304	306	308	310	312	314	316	318	320	322	324	326	328	330	332	334	336	338	340	342	344	346	348	350	352	354	356	358	360
		0	1	1	1	1	1	0	1	1	1	0	1	0	1	0	1	1	0	0	1	1	0	1	1	0	1	0	1	1	0
		1	0	1	1	1	0	1	1	1	0	0	0	0	1	0	1	0	1	0	1	1	0	1	1	1	1	1	1	1	1
		0	1	0	0	0	0	1	1	1	1	0	1	0	1	1	0	0	1	0	0	0	1	0	1	1	1	1	1	0	0	1
		362	364	366	368	370	372	374	376	378	380	382	384	386	388	390	392	394	396	398	400	402	404	406	408	410	412	414	416	418	420
		1	0	1	1	0	1	0	1	0	0	1	1	1	1	0	0	0	1	1	0	1	1	0	1	0	1	0	0	1	1
		0	1	0	0	0	1	0	1	1	0	0	1	1	0	0	1	1	0	1	1	0	1	1	0	0	0	0	0	0	0
		0	1	1	1	1	1	0	1	0	0	0	0	1	1	1	0	0	1	1	1	1	0	0	1	0	1	1	0	0	0
		422	424	426	428	430	432	434	436	438	440	442	444	446	448	450	452	454	456	458	460	462	464	466	468	470	472	474	476	478	480
		0	0	1	0	0	0	1	1	1	0	0	0	1	1	0	1	1	0	1	1	1	1	1	0	0	1	0	0	1	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		1	0	0	0	1	1	1	1	1	0	1	0	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0
		482	484	486	488	490	492	494	496	498	500	502	504	506	508	510	512	514	516	518	520	522	524	526	528	530	532	534	536	538	540
		0	0	0	1	1	1	0	0	0	0	1	0	0	1	0	0	0	0	1	1	1	0	0	1	1	0	0	0	1	0
		0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	1	1	0	0	0	0	0	1	0	0	0	1	1	1	0	1	1	0	0	1	1	1	1	0	0	1	0
		542	544	546	548	550	552	554	556	558	560	562	564	566	568	570	572	574	576	578	580	582	584	586	588	590	592	594	596	598	600
		1	1	0	1	0	1	1	1	1	1	1	1	1	0	1	1	1	1	0	0	1	1	1	0	1	1	0	1	0	1
		0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	1	0	1	0	0	0	0	0	0	1	0	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0

УПРАВЛЕНИЕ ИЗОЛИРОВАННЫМ ЗАГРУЖЕННЫМ ПЕРЕКРЕСТКОМ В РЕАЛЬНОМ ВРЕМЕНИ. МЕТОД ФАЗЗИ-ЛОГИКА.

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ОБЛАСТЬ: математика, информатика, дорожное движение
ВИД СТАТЬИ: оригинальная научная статья
ЯЗЫК СТАТЬИ: английский

Резюме:

В данной работе рассматривается проблема управления светофором на изолированном перекрестке в реальном времени. В статье представлена разработанная на основании фаззи-логики математическая модель, которую можно использовать в подобных ситуациях. Данная модель специально разработана для регулирования перекрестка с загруженным транспортным потоком. Разработанный метод сравнивается с управлением загруженным перекрестком методом «фиксированного времени». Метод «фиксированного времени» подразумевает управление на основании базы данных о транспортном потоке. В случаях загруженности перекрестка, о которых идет речь в данной статье, применяется метод «реального времени», который по результатам не уступает методу «фиксированного времени» управления. Функция сравнительных критериев представляет суммарную потерю времени всех транспортных средств, проезжающих перекресток в течение проведения анализа. Методы были испытаны на перекрестке «Т», результаты тестирования показали, что модель, основанная на фаззи-логике дала решения с меньшими значениями критериев функций в анализируемом промежутке времени, по сравнению с прочими методами.

Ключевые слова: изолированный перекресток со светофором, загруженный транспортный поток, фаззи-логика, управление в реальном времени, потери времени транспортных средств.

УПРАВЉАЊЕ ИЗОЛОВАНОМ ПРЕЗАСИЋЕНОМ РАСКРСНИЦОМ У РЕАЛНОМ ВРЕМЕНУ (ПРИСТУП ФАЗИ ЛОГИКОМ)

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ВРСТА ЧЛАНКА: оригинални научни чланак
ЈЕЗИК ЧЛАНКА: енглески

Сажетак:

У раду је разматран проблем управљања изолованом семафорисаном раскрсницом у реалном времену. Развијен је математички модел за решавање предметног проблема који је базиран на фази логици. Модел се односи само на раскрсницу коју карактеришу презасићени саобраћајни токови. Приступ решавању предметног проблема поређен је са „fihed time" управљањем презасићеном раскрсницом. "Fihed time" подразумева управљање на основу података о саобраћајним токовима. У случају презасићене раскрснице класничан приступ управљања у реалном времену („actuated time control") даје иста решења као и „фихед тиме" управљање. Критеријумска функција за поређење решења представља укупне временске губитке свих возила која прођу раскрсницом у одређеном периоду анализе. Приступи су тестирани на „T" раскрсници, где је модел заснован на фази логици генерисао решења са мањом вредношћу критеријумске функције у односу на остале приступе, у одређеном периоду анализе.

Кључне речи: изолована сигналисана раскрсница, презасићени саобраћајни токови, фази логика, управљање у реалном времену, временски губици возила.

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CONTRIBUTION TO RESEARCH OF THERMAL LOADS IN COMMERCIAL VEHICLES POWERTRAIN MOUNTS

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Abstract:

Due to the effects of excitations of road micro-roughness and the powertrain as well as due to the conditions of movement (acceleration, braking, curvilinear movement), the weights of commercial vehicles perform complex spatial oscillations. The negative impact of these movements or dynamic loads caused by them and transmitted to the supporting system of the vehicle can be reduced by a proper selection of the position and characteristics of the powertrain mounts. Elastic and damping forces in mounts perform mechanical work that turns into heat energy. Theoretical, experimental and combined methods can be used for the analysis of thermal loads of mounts. In this paper, research was carried out with theoretical methods using a mechanical model of the powertrain. Vibrations were observed on a freight vehicle powertrain of FAP 1314 middle-class vehicles. Bearing in mind the presence of classical (rubbermetal) and hydraulic mounts in modern commercial vehicles, the authors analysed the thermal loads of the mentioned vehicle type using a mathematical model.

Key words: excitation, commercial vehicles, mounts, modeling, powertrain, heat.

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Introduction

The powertrain vibrations are transmitted over the mounts to the vehicle frame, while noise is transferred to the vehicle frame (structural) through the environment (air) as well. In order to reduce this effect to a satisfactory measure, the powertrain is elastically bound to the vehicle carrier system. At the same time, this system absorbs vibration excitations which are transferred to the powertrain from the road surface through the vehicle suspension system. Due to the kinetic energy of the powertrain resulting from vibrations, mechanical work is converted to heat in the mounts (Mitschke & Wallentowitz, 2004).

In practice, the characteristics of the powertrain system are chosen from the conditions of minimizing noise and vibration. The task can be solved using analytical (theoretical) methods, using mathematical models, or experimentally. The progress of computer technology has contributed to greater application of mathematical models, while experimental methods, due to high costs, are rarely used. In doing so, the thermal loads which powertrain mounts are exposed to are usually ignored, which, in cases of poorly solved heat removal, can cause distortion of mount characteristics. Therefore, it is considered appropriate to analyze their thermal loads.

Research has shown that mechanical work due to powertrain vibrations turns into heat energy that is transmitted, in a wider sense, to the environment (Bojić, 2011), (Ilić et al, 1996), (Moran, 2010), (Fermi, 2011), (Demić & Diligenski, 2016), (Mitschke & Wallentowitz, 2004):

$$A = Q_t + Q_f + Q_o\,, \tag{1}$$

where A is a mechanical operation (equivalent to the amount of heat), J; Q_t part of the heat surrendering to the mount body, J; Q_f part of the heat surrendering to the fluid (for hydraulic mounts), J; and Q_o part of the heat surrendering to the environment, J.

The work of elastic and damping forces in mounts is important for the analysis of heat loads, and it can be measured and experimentally measured (Mitschke & Wallentowitz, 2004) with more difficulty. Due to the distribution of heat inside the mount, as well as around it, the problem becomes significantly more complex.

It is noted that most of the heat is transferred by convection (the phenomenon that occurs when the fluid convection material exchanges heat within itself). A slightly smaller part of the heat is transferred by conduction (molecules of solids that vibrate at a higher temperature vibrate more rapidly over the equilibrium position and in collision with molecules having a lower temperature cause an energy impulse that accelerates the vibrations of these molecules and increases the temperature) and radiation

(occurs between any two objects at different temperatures, whether vacuum is between them or not) (Bojić, 2011), (Mitschke & Wallentowitz, 2004).

Converting mechanical work into heat largely depends on the construction of mounts. Therefore, during the design of the powertrain system, consideration should be given to creating the conditions for the good transfer of heat to the environment. It should be noted that the aim of this paper is not to investigate the transfer of heat to the environment from powertrain mounts, but to determine the amount of heat generated by vibrations in mounts.

As it is known, classic mounts consist of rubber-metal elements, with a dampening of the hysteresis of the tire, while hydraulic mounts have additional damping due to oil which they contain. Bearing in mind the presence of classical (rubber-metal) and hydraulic mounts in modern freight vehicles, the authors analysed the thermal loads of a FAP 1314 vehicle.

Motor vehicles represent complex oscillation systems with a large number of masses of interconnected elasto-damping elements, of most often non-linear characteristics. When traveling on uneven roads, the exitations from road roughness are transferred through the wheels and the elastic suspension system to the frame and further on to the powertrain (through the powertrain suspension system). In addition, the drive unit additionally oscillates the movable mass of the vehicle. The negative impact of vibrations on the characteristics of motor vehicles can be reduced by a correct selection of the position and characteristics of the elastodamping elements. This can be done using theoretical-experimental, theoretical or experimental methods (Frolov & Furman, 1990).

In the literature (Demić, 1990), (Demić, 1997a), (Demić, 1997b), (Demić, 2002), (Demić, 2013), (Simić, 1988), (Simić & Demić, 1992), (Bendat, 1998), (Igami et al, 2008), (Genta, 2003), (Shanguan et al, 2016) there are a number of mathematical-experimental methods for modeling the behavior of the powertrain. In this paper, a freight vehicle from the FAP 1314 production program, (whose scheme of the suspension of the powertrain is shown in Figure 1) was observed and the modeling process was applied based on the principles of classical mechanics (Atkins, 2010), (Pars, 1981).

The aim of the research is to begin theoretical analyzes of the problem of thermal loads of powertrain mounts, and the verification of the obtained results will be performed at a later stage in experimental research. It is expected that the results obtained will be used in designing new vehicles from the FAP production program.

Model of a powertrain

Depending on the task being worked out, various mechanical models of powertrains and vehicles can be found. From (Demić, 1990), (Demić,

1997), (Rotenberg, 1972), (Genta, 2003), (Gillespie, 1992), (Milliken & Milliken, 1995), (Simić & Demić, 1992), (Kennings et al, 2014), (Shanguanet al, 2016), it is known that during the analysis of the problem of transferring dynamic loads from the powertrain to the frame (chassis) of the vehicle, the oscillations of the cabin and the carriage compartment can be ignored. More precisely, the analysis includes only the oscillatory movements of the powertrain of the vehicle and the corresponding exitations from the vehicle frame.

The structure of the vehicle model and the powertrain should therefore be chosen to enable the analysis of the desired parameters. This indicates the need to use as simple mathematical models as possible, because due to the absence of precise inertial and geometric parameters of the powertrain and the vehicle itself, as well as the characteristics of the mounts, more complex models can lead to major errors (Demić, 1990), (Frolov & Furman, 1990).

The powertrain, as a rigid body in space, has six degrees of freedom (three translations and three rotations), so, to describe its movement, it is necessary to use six independent generalized coordinates (Demić, 1990), (Frolov & Furman, 1990), (Genta, 2003), (Pars, 1981), (Gillespie, 1992), (Milliken & Milliken, 1995). Here are adopted geometric gravity axes for observing the movement of the powertrains, starting at an equilibrium position, which will be discussed later. It is worth mentioning that the use of the geometric gravity axis leads to the need of using centrifugal moments of inertia, but, for the sake of the ease of analysis, the assumption that they are also the principal axes of inertia is introduced. The powertrain performs spatial vibrations under the action of excitations it receives from the frame (originating from the road roughness, vibrations of the frame as an elastic system, inertial forces of braking, inertial force of acceleration, centrifugal forces in curvilinear movement and Coriolis forces due to the complex movement of the vehicle), as well as from the inertial forces and torque of the engine and the rotating masses.

Six generalized coordinates should be introduced to describe the spatial movement of the powertrain: three translations and three rotations (Demić, 1990), (Frolov & Furman, 1990), (Genta, 2003), (Pars, 1981), (Gillespie, 1992), (Milliken & Milliken, 1995). Two coordinate systems will be adopted (Demić, 1990), Figure 2:

- immobile (OXYZ), with the origin at the center of gravity of the powertrain (defined in relation to its equilibrium position). The axes of this system coincide with the geometric axes of the powertrain symmetry (it is at the same time the global coordinate system),
- movable ($C\xi\eta\zeta$), which is firmly attached to the powertrain and rotates with it. The transformation of the coordinate system from ($C\xi\eta\zeta$) to (OXYZ) and vice versa can be made using three independent angles (Euler angles - which lead to coupled differential equations), or angles of rolling, galloping and winding that lead to a

scattered system of differential equations. Since the model used had only one angle– the rotation around the X axis for the angle φ, it was not necessary to use three angles.

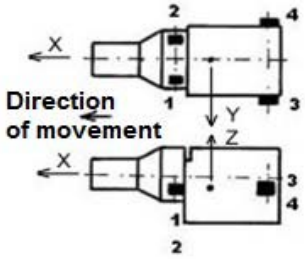


Figure 1 – Scheme of the powertrain mounts of a freight motor vehicle
Рис. 1 – Схема опоры силового привода грузового автомобиля
Слика 1 – Шема ослањања погонске групе посматраног теретног моторног возила

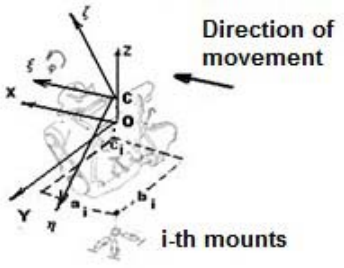
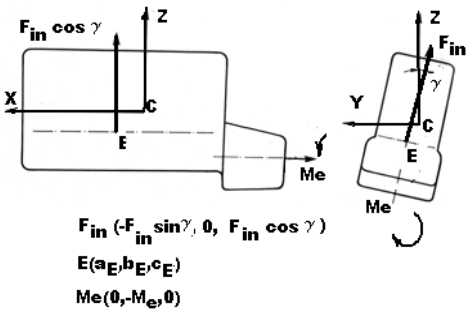


Figure 2 – Introduced coordinate systems to describe the movement of the powertrain
Рис. 2 – Внедрены системы координат для описания движения силового привода
Слика – 2 Уведени координатни системи за описивање кретања погонске групе

Since the aim of the research is to determine the thermal loads of the powertrain mounts, it was considered necessary to analyze only the bouncing and rolling of the powertrain, and in this case the translatory movement of the powertrain gravity center in space is defined by the coordinate Z and the rotation of the powertrain (as a rigid body) around the axis ξ is defined by the rolling angle φ (these generalized coordinates create the conditions to include the vertical exitation from the vehicle frame and the resulting inertial force, as well as the engine torque into the analysis, while respecting the recommendation to apply as simple mathematical models as possible). The elastic-viscous forces perform mechanical work in the mounts (which is converted into heat energy) due to the relative movement of the powertrain relative to the vehicle frame (deformation of the mounts). The adopted mathematical model enables the analysis of the influence of the powertrain mounts on their thermal loads.



F_{in} – the resulting inertial force of the piston group
M_e – engine torque
E – an attack point of the resulting inertial force and its coordinates in relation to the moving coordinate system
γ – the angle of installation of the powertrain (in this case it is 0°)

Figure 3 – Excitation due to inertia force and engine torque
Рис. 3 – Возбуждение от инерционной силы и крутящего момента двигателя
Слика 3 – Побуде од инерцијалне силе и обртног момента мотора

Bearing in mind the above and using the Newton-Euler principle, differential equations can be written to describe the observed oscillatory movements of the powertrain in the form:

$$M \cdot \ddot{Z}_C = \sum Z_i \ , \tag{2}$$

$$I_u \cdot \ddot{\varphi} = \sum M_F{}^u \ . \tag{3}$$

In the literature (Igami et al, 2008), (Kennings et al, 2014), (Shanguan et al, 2016), (Simić & Demić, 1992) there are a large number of mathematical models of powertrain mounts, more or less complex. Since the goal of this paper was to compare the thermal loads of the mounts, it was considered necessary to simplify the expressions for the approximation of force in the mounts (for the projections in the direction of X, Y and Z axes). As far as reactive forces are concerned, they are opposed to movement.

The forces in elastic mounts are assumed in the form (Demić, 1990):

$$F_{ci} = c_{i1} \cdot \Delta_i + c_{i2} \cdot \Delta^2 + c_{i3} \cdot \Delta^3 , \tag{4}$$

where c_i, c_{i1}, c_{i2}, and c_{i3} are the stiffness coefficients, and Δ is the relative deformation of the mount.

The viscous forces in the mounts are assumed in the form (Demić, 1990):

$$F_{ai} = k_{i1} \cdot \dot{\Delta} + k_{i2} \cdot \dot{\Delta}^{\,2} \cdot sign(\dot{\Delta}) , \tag{5}$$

where k_1, k_2 are the damping coefficients, the relative deformation speed of the mount, and *sign* the corresponding mathematical function.

The deformation and deformation projections of the powertrain mount in the Z direction are defined by the terms (Figure 2):

$$\Delta Z_i = Z - Z_O - b_i(\varphi - \varphi_O), \tag{6}$$

$$\dot{\Delta} Z_i = \dot{Z} - \dot{Z}_O - b_i(\dot{\varphi} - \dot{\varphi}_O). \tag{7}$$

The vibrations of the powertrain also depend on the unbalance of the engine (torque and inertial forces).

In this particular case, a four-stroke four-cylinder regular diesel engine with a crankshaft, whose knees were at the same level (angle 180°), was used. The piston mechanisms present forces (Mihalec et al, 2015), which are driven by a piston (the forces of gases and the inertial forces of the piston group), and on the movable bearing of the crankshaft of the centrifugal and tangential force of the crankshaft. In balancing the inertial forces of the mass of the piston group (ideally, if the force develops into the Fourier series), there remain unbalanced inertial forces of the second and higher orders. It is noted that when there are differences in the masses of piston groups per cylinders, unbalanced first-order forces occur (in this case, the case where the masses have been equal to each other).

Assuming that high-order harmonics can be neglected, the unbalanced inertial force of the observed engine can be expressed in the form (Frolov & Furman, 1990), (Milliken & Milliken, 1995), (Rotenberg, 1972), (Genta, 2003), (Simić, 1988):

$$F_{in} = 4 m_r \cdot \omega^2 \cdot \lambda \cdot \cos 2\omega t, \tag{8}$$

where m_r is the reduced mass of the piston group, r is the radius of the crankshaft knee, ω is the angular speed of the engine crankshaft, λ is the ratio of the radius of the crankshaft and the length of the piston engine, and t is time.

Based on elementary knowledge from the vector theory, statics, and Figures 2 and 3, the moment from the resulting inertial force defined by term (8) (Demić, 1990) is:

$$\vec{M}_{Fin} = \begin{bmatrix} \overrightarrow{u_0} & \overrightarrow{v_0} & \overrightarrow{w_0} \\ a_E & b_E & c_E \\ -F_{in}\sin\gamma & 0 & F_{in}\cos\gamma \end{bmatrix}, \tag{9}$$

where the expressions in (9) are in accordance with Figure 3.

Centrifugal forces are partially counterbalanced by counter-strategies, or by other methods, for which readers are referred to (Mahalec et al, 2015).

The tangential force causes the torque of the engine, which due to *i*ts change has a variable value (unevenness is partially reduced by the flywheel) (Mahalec et al, 2015).

In the absence of precise data, we assume that the torque that affects the powertrain can be described by the term (Demić, 1990):

$$M = -M_e \cdot i_0 \cdot i_m (0{,}95 + 0{,}1 \cdot rnd), \tag{10}$$

where M_e is the engine torque, and i_o is the transmission ratio in the differential, i_m is the transmission ratio in the transmission, and *rnd* random numbers are evenly distributed in the interval [0,1].

The vibrations of the powertrain are also influenced by the vibrations of the vehicle frame, which are incidental (Demić, 1997a), (Demić, 1997b), (Shanguan et al, 2016). Since the complexity of the vehicle spatial model exceeds the scope of this paper, it was considered appropriate not to use frame excitations obtained based on a model but to adopt broadband functions of the exitation in the following form:

$$exitation = max(rnd - 0.5), \tag{11}$$

where max = 0.01 m, is work, and *rnd* has the same meaning as with the torque of the engine.

The projections of the generalized forces include all the components of the force and momentum of the corresponding mounts in the direction of the observed axis (for mounts 1 to 4), the inertial forces and torque moments of the engine, or the unbalanced inertial forces, as well as the force of the active suspension which, due to the assumption that it operates at the powertrain center, has no moment.

Heat loads of the powertrain mounts

Due to the relative movement of the powertrain and the vehicle frame, work is carried out in the mounts, which is equivalent to the amount of heat Q (Bojić, 2011), (Ilić et al, 1996), (Moran, 2010), (Fermi, 2011), (Demić, 2001), (Demić, 2013), (Demić & Diligenski, 2016), (Mitschke & Wallentowitz, 2004). Mechanical work in mounts is defined by the expression (Mitschke & Wallentowitz, 2004):

$$A = \int_0^s F_m \cdot dz_{rel} = \int_0^T F_m \cdot \dot{z}_{rel} \cdot dt\,, \tag{12}$$

where F_m is the elasto-damping force in the mount, z_{rel} , $\dot{z}_{rel}$ is the relative deformation and the deformation rate of the mount (respectively), and t is the time of deformation.

The mean mechanical strength is given by the expression:

$$P = \frac{A}{T} = \frac{k}{T}\int_0^T \dot{z}_{rel} \cdot dt. \tag{13}$$

As the effective value of the relative deformation speed of the mount is:

$$\dot{z}_{relef}^{\ 2} = \frac{1}{T}\int_0^T \dot{z}_{rel} \cdot dt \ . \tag{14}$$

then the mean strength can be written in the form:

$$P = k \cdot \dot{z}_{relef}^{\ 2} \ . \tag{15}$$

It turns into heat, with dominant convection:

$$P = \alpha \cdot S \cdot \Delta\tau \ , \tag{16}$$

where P is the power (heat flux), W; α is the coefficient of heat transfer, W/(m^2·°C); S is the convection surface in m^2; and $\Delta\tau$ is the temperature difference between the mounts and the ambient air in °C.

Since α and S are of unknown values and require very complicated research in order to be defined, they are not discussed in this paper.

Bearing in mind that all four mounts had the same characteristics, we considered appropriate to carry out an analysis of total heat loads.

Numerical simulation and analysis of results

From expressions (2-11), it can be established that the differential equations are non-linear and of second order. Since the Runge-Kutta method requires them to be reduced to differential equations of the first order before solving them, they are transformed into this form. In differential equations 20 parameters were used to describe the characteristics of the mounts, two inertial parameters, three parameters describing translatory motion and three parameters describing angular motion (movement, velocity, acceleration), 12 coordinates of the mounts and three coordinates of the attack point of the resulting inertial force. Differential equations were solved using the software that Demić, M. had developed in Pascal. The integration was performed with a time step of 0.0001 s at 524288 points. This enabled a reliable analysis in the range

0.019-5000 Hz. Obviously, this range is considerably broader than the exitation range of engine motions and the complete powertrain of vehicles. The integration of differential equations was performed for the case of classical and hydraulic mounts.

The parameters of the vehicle and its powertrain are given in Table 1, and the coordinates of the connecting points (mounts) in Table 2 (FAP, 2017).

The mechanical and hydraulic mounts had identical stiffness values in the direction of the X, Y and Z axes, which were determined in FAP (FAP, 2017), and shown in Table 3.

Table 1 – Typical parameters of FAP1314 and its powertrain
Таблица 1 – Типичные параметры ФАП1314 и его силового привода
Табела 1 – Карактеристични параметри возила ФАП1314 и његове погонске групе

Maximum engine power, kW	100
Maximum engine speed, min^{-1}	2600
Maximum engine torque, Nm	428
Speed at maximum torque, min^{-1}	1300
Vehicle mass, kg	12000
Mass of the powertrain, kg	1680
Moments of inertia $I_x/I_y/I_z$, kgm^2	85/35/72
Transmission ratio in the main gearbox, -	3.83
Transmission ratio in direct transmission, -	1

Table 2 – The coordinates of the connection points of mounts
Таблица 2 – Координаты точек соединения опоры
Табела 2 – Координате везних тачака ослонаца

Position of mounts →	*a*, m	*b*, m	*c*, m
Mount 1	0.5	0.4	0.1
Mount2	0.5	-0.4	0.1
Mount3	-0.5	0.4	0.1
Mount4	-0.5	-0.4	0.1

Table 3 – Stiffness of the used conventional and hydraulic mounts
Таблица 3 – Жесткость используемых стандартных и гидравлических опор
Табела 3 – Крутости коришћених класичних и хидрауличких ослонаца

	$c_{i1,}$ N/m	$c_{i2,}$ N/m^2	$c_{i3,}$ N/m^3
X	1200000	250000	60000
Y	1200000	250000	60000
Z	1200000	250000	60000

In the absence of more precise data, the damping characteristics of the mounts are approximately defined based on the stiffness of the mounts and the weight they carry (Genta, 2003), (Simić, 1988), and given in Table 4.

Table 4 – Assumed damping characteristics of the mounts
Таблица 4 – Предполагаемые демпфирующие характеристики опоры
Табела 4 – Претпостављене пригушне карактеристике ослонаца

	k_{i1} (mechanical/hydraulic), Ns/m	k_{i2}(mechanical/hydraulic), Ns^2/m^2
X	620/62000	1/100
Y	620/62000	1/100
Z	620/62000	1/100

For the sake of illustration, the vertical oscillatory exitations of the powertrain derived from the frame exitations are shown in Figure 4. It is obvious that the exitations are time-varying and high thermal loads of the powertrain mounts are to be expected. A similar commentary also applies when it comes to frame rolling exitations that are not shown here.

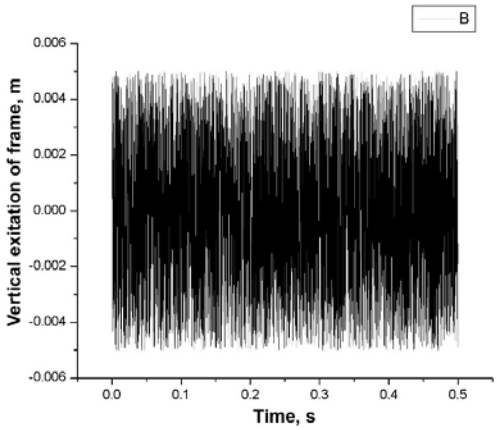


Figure 4 – Illustration of the vertical excitations of the frame
Рис. 4 – Иллюстрация вертикального возбуждения рамы
Слика 4 – Илустрација вертикалних побуда оквира

The total heat loads of the four-point system possessing elastic and damping properties (for all components of force and momentum) are calculated using expressions (2-15), and the results are shown in Figure 5, where the values for the heat amount are given in the logarithmic proportions.

By analyzing the numerical data and Figure 5, it can be found that the mechanical mounts suffer about 49 times less thermal load than the hydraulic ones (for a time period of 52 s, the classical is about 4.85 × 108 J, and the hydraulic one is 2.37 × 1010 J). This is understandable if one takes

into account that the hydraulic mount, in addition to the hysteresis in the tire, also has additional movement of the fluid within the mounts. Figure 5 shows that the amount of heat grows over time, and that, if thermal energy were not conducted from the mounts, they would face distortion of the shape and characteristics.

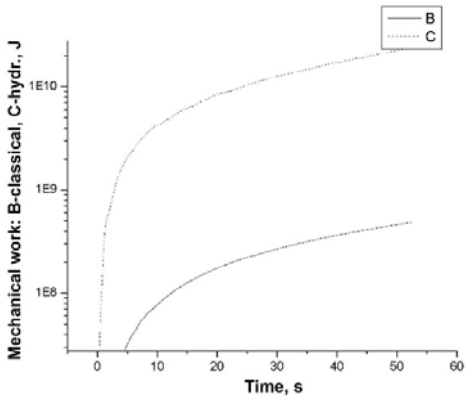


Figure 5 – Heat amount (mechanical energy) depending on the type of mounts
Рис. 5 – Количество тепла (механическойэнергии) в зависимости от типа опоры
Слика 5 – Промена количине топлоте (механичког рада) у ослонцима, зависно од типа ослонаца

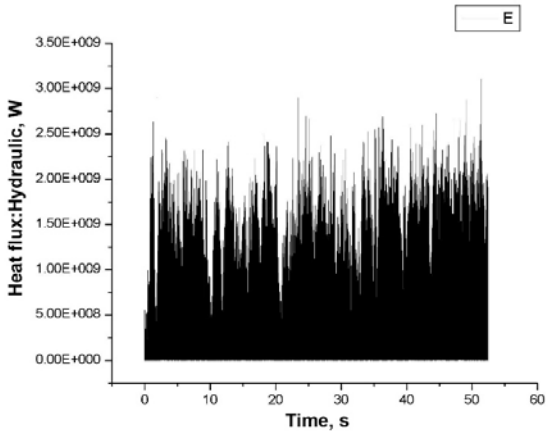


Figure 6 – The heat flux for hydraulic mounts
Рис. 6 – Тепловой поток для гидравлических опор
Слика 6 – Промена топлотног флукса код хидрауличких ослонаца

As noted, the heat flux for both types of mounts is calculated, and the flux for the hydraulic mounts is shown in Figure 6 for illustration. It is

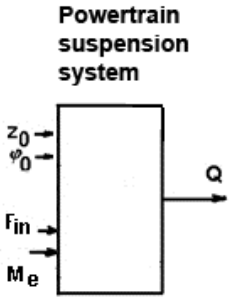
obvious that it changes stochastically with time, so it is useful to calculate the effective values for both types of mounts, given in Table 5.

Table 5 – Statistical data on heat flux
Таблица 5 – Статистические данные о тепловом потоке
Табела 5 - Статистички подаци о топлотном флуксу

Mounts	Effective value of heat flux, W
Classic	$8.261\ 10^{6}$
Hydraulic	$3.639\ 10^{8}$

The analysis of the data in Table 5 indicates that the heat flux is much higher in hydraulic mounts than in the conventional (rubber-metal) mounts of the powertrain. This indicates a higher possibility of disrupting the characteristics of hydraulic mounts than those of conventional ones. That is why they are larger than the classic ones. It points to the fact that such high values are the product of rigorous exitations from the vehicle frame used in the simulation. In practice, they are significantly lower and so are the actual heat loads of the powertrain mounts. However, the research carried out aimed to determine the ratio of the thermal loads of classic and hydraulic mounts, with the help of models, so the results can be adopted as orientational, which is acceptable in the freight vehicle design phase. It should be noted that the amplitudes of vibrations of the powertrains in the case of hydraulic mounts are significantly lower than in the case of conventional mounts (Demić, 1990), (Simić & Demić, 1992), (FAP, 2017).

As the aim of the research was to determine which component of the exitation (including the exitation forces of the inertial force and the torque of the engine) had the greatest impact on the thermal loads of the powertrain mount, it was judged appropriate to clarify this problem further on. It is known that a dynamic system with multiple input quantities and one output quantity can be shown as in Figure 7. If there is a connection between the input quantities, the system must first be decoupled (Bendat & Piersol, 1993), (Bendat & Piersol, 2010). As the oscillatory model of the powertrain had 4 oscillatory exitations (2 shifts and two exitations from resulting inertial forces and the torque of the engine), we will summarize the theory that enables the analysis of the influence of each individual exitation on the thermal load of the powertrain mounts,heat fluxin particular. Figure 8 shows the distribution pattern (Bendat & Piersol, 1993), (Bendat & Piersol, 2010).



Q – amount of heat or heat flux,
z_0 – vertical exitation from the vehicle frame (x1),
φ_0 – exitation from rolling the vehicle frame (x2),
Fin – second-order inertial force (x3),
Me – engine torque (x4)

Figure 7 – Block diagram of the suspension system of the powertrain
Рис. 7 – Блок-схема системы подвески силового агрегата
Слика 7 – Блок-дијаграм система за ослањање погонске групе

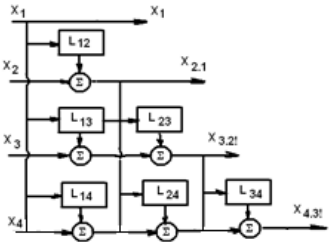


Figure 8 – Decoupling scheme
Рис. 8 – Развязывающая схема
Слика 8 – Шема распрезања

Bearing in mind the theory from (Demić, 1990), (Bendat & Piersol, 1993), (Bendat & Piersol, 2010) and Figure 8, it can be written (all quantities are given in the complex plane-Fourier or Laplace transformation):

$$\begin{aligned} x_{1!} &= x_1, \\ x_{2\cdot1!} &= x_1 - L_{12}\cdot x_1, \\ x_{3\cdot2!} &= x_3 - L_{13}\cdot x_1 - L_{23}\cdot x_{2\cdot1!}, \\ x_{4\cdot3!} &= x_4 - L_{1\cdot4}\cdot x_1 - I_{2\cdot1}.x_{2\cdot4!} - L_{3\cdot4}\cdot x_{3\cdot2!} \end{aligned} \tag{17}$$

where x_1, x_2, x_3, x_4 are the input quantities,
$x_{2\cdot1!}$, $x_{3\cdot2!}$, $x_{4\cdot3!}$-second conditional input with the eliminated influence of the first input; the third conditional input with the elimination effect of the

first and second conditional inputs; the fourth conditional input with the elimination of the influence of the first and the conditional second and the third conditional inputs, respectively.

The transfer functions between the input ports can be displayed as follows:

$$L_{12} = \frac{x_2}{x_1} \quad L_{13} = \frac{x_3}{x_1} \quad L_{14} = \frac{x_4}{x_1},$$
$$L_{23} = \frac{x_{3\cdot 2!}}{x_{2\cdot 1!}} \quad L_{24} = \frac{x_{4\cdot 3!}}{x_{2\cdot 1!}}. \tag{18}$$

where L_{12}, L_{13}, L_{14}, L_{23}, L_{24} are the corresponding transfer functions between the conditional input quantities.

Note that portable functions indicate how much the output quantity is increased or decreased in relation to the input quantity and how big is the phase delay between them.

On the basis of expressions (17) and (18), partial coherence functions can be calculated, and they indicate the coupling between the input and output signals (Demić, 1990), (Bendat, 1998), (Bendat & Piersol, 1993), (Bendat & Piersol, 2010).

$$\gamma_{iQ(i1)!}^{\ 2} = \frac{\left[S_{iQ(i-1)!}\right]^2}{S_{xx(i-1)!}S_{QQ(i-1)!}}, \tag{19}$$

where $S_{iQ(i-1)!}$ is the cross-spectra (the power cross-spectra is a complex quantity that represents the boundary value of the mathematical expectation of the products of the conjugated-complex amplitude of one signal and the complex amplitude of the second signal – it enables the analysis of the spectral content of the interdependencies of the two signals) and $S_{xx(i-1)!}$ and $S_{QQ(i-1)!}$ are the corresponding autospectra (the power autospectrum is a real quantity that makes the limit value of the mathematical expectation of the products of the conjugated-complex and complex amplitude of the observed signal– it enables the analysis of the spectral content of a single signal). The function of ordinary coherence shows whether there is a connection between the input and output quantities of the system, and the partial coherence functions are used to analyze the interconnections of the input and output quantities in the case when there is a connection between the input quantities (Demić, 2001), (Bendat & Piersol, 1993), (Bendat & Piersol, 2010).

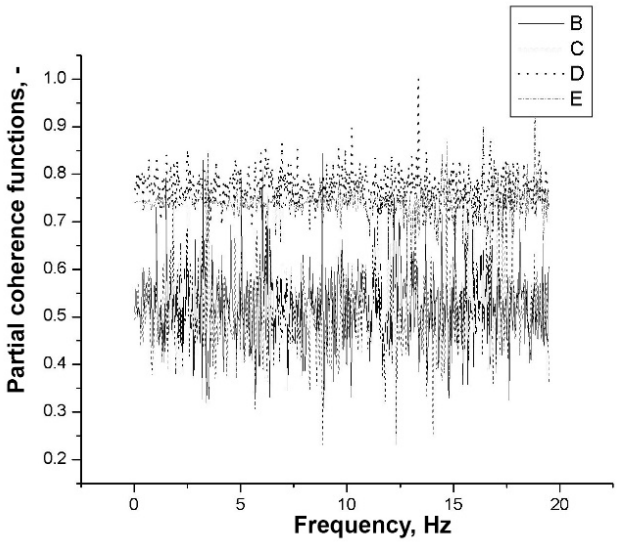


Figure 9 – Partial coherence functions for hydraulic mounts: B-vertical excitation from the frame, C-excitation from the rolling of the frame with excluded influence of the vertical excitation, D-inertial force with excluded influence of the vertical excitation and rolling of the vehicle frame and E-motor torque with excluded influence of vertical excitation and rolling of the vehicle frame and the inertial forces of the engine
Рис. 9 – Частичные функции когерентности гидравлических опор: B-вертикальное возбуждение от рамы, C-возбуждение от качения рамы без возможности влияния вертикального возбуждения, D-инерционная сила без возможности влияния вертикального возбуждения и качения рамы транспортного средства и E- момент двигателя без возможности влияния вертикального возбуждения и качения рамы транспортного средства и сил инерции двигателя
Слика 9 – Парцијалне функције кохеренци за хидрауличке ослонце: B – вертикалне побуде од оквира, C – побуда од ваљања оквира са искљученим утицајем вертикалних побуда, D – инерцијална сила са искљученим утицајем побуда од вертикалних и ваљања оквира возила и E – момент мотора са искљученим утицајем вертикалних побуда и ваљања оквира возила и инерцијалне силе мотора

For a more detailed analysis, the partial coherence functions (expression 19) are calculated using the programs developed by the author in Pascal (Demić, 2001). For the illustration purposes, Figure 9 shows the calculated values for hydraulic mounts. The data analysis for the mechanical hydraulic mounts shown in Figure 9 shows that the coherent partial functions depend on the frequency and type of exitations. It is considered appropriate to carry out a more detailed analysis of the data of the partial coherence functions. In that sense, the minimum and maximum values of the coherent partial functions are calculated and given in Tables 6 and 7.

Table 6 – Minimum and maximum values of the partial coherence functions for mechanical mounts
Таблица 6 –Минимальные и максимальные значения парциальных функций когерентности для механических опор
Табела 6 – Минималне и максималне вредности парцијалних функција кохеренци за механичке ослонце

	min	max
B	0.308	0.843
C	0.230	0.869
D	0.661	1.000
E	0.541	0.956

Table 7 – Minimum and maximum values of the partial coherence functions for hydraulic mounts
Таблица 7 – Минимальные и максимальные значения парциальных функций когерентности для гидравлических опор
Табела 7 – Минималне и максималне вредности парцијалних функција кохеренци за хидрауличке ослонце

	min	max
B	0.252	0.741
C	0.216	0.897
D	0.721	1.000
E	0.600	0.839

The analysis of the data from the given tables shows that the type of mounts has an effect on the partial coherence functions, and that their values are in the interval of 0.216 to 1, indicating that there is a connection between the input quantities (the exitation from the vehicle frame and the resulting inertial force and the engine torque) and heat flux (Bendat & Piersol, 1993), (Bendat & Piersol, 2010). The resulting inertial force and the engine torque have a greater impact on the thermal loads of the powertrain mounts.

The realized research was aimed at determining the relation between the thermal loads of the classical (rubber-metal) mounts and hydraulic mounts, with the help of a model, so that the obtained results can be adopted as a guide, which is necessary during the design phase of the conceptual design of a freight motor vehicle. It should be noted that hydraulic mounts have significantly better powertrain vibration damping parameters than the classical ones (Demić, 1990), (Simić & Demić, 1992).

Conclusion

Based on the research carried out, it can be concluded that with the help of mechanical models, the influence of the characteristics of the powertrain mounts on their thermal loads can be analyzed. The analyzes

have shown that hydraulic mounts are more thermally loaded than the conventional ones. Due to their heat loads and a complex construction, it is understandable why they are more rarely applied in freight motor vehicles. In order to verify the results,experimental research should also be carried out.

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ПРИЛОЖЕНИЕ К ИССЛЕДОВАНИЮ ТЕПЛОВОЙ НАГРУЗКИОПОРЫ СИЛОВОГО ПРИВОДА ГРУЗОВОГО АВТОМОБИЛЯ

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ОБЛАСТЬ: машиностроение, автомобили и двигатели
ВИД СТАТЬИ: оригинальная научная статья
ЯЗЫК СТАТЬИ: английский

Резюме:

Под действием возбуждений, возникающих в результате микрошероховатости дорог, трансмиссии, а также условий движения (ускорение, торможение, криволинейное движение), массы коммерческих транспортных средств совершают сложные колебательные движения. Негативное воздействие этих перемещений, а соответственно и динамических нагрузок на опорную систему транспортного средства, может быть снижено при соответствующем выборе положения и характеристик опоры силового агрегата. Как показывает практика, при согласовании характеристик опоры силового привода чаще всего учитываются такие факторы, как минимальный шум и вибрации транспортного средства, в то время как проблеме тепловых нагрузок, которым они подвергаются при эксплуатации, практически не уделяется никакого внимания. Необходимо учитывать тот факт, что повышенные тепловые нагрузки неизбежно приводят к повреждению опоры и ухудшению ее характеристик. Следует отметить, что силы упруго-демпферных опор выполняют механическую работу, преобразуя механическую энергию в тепловую. Анализ тепловых нагрузок на опоры может быть выполнен с помощью теоретических, экспериментальных и комбинированных методов. В настоящей работе представлены результаты исследования, полученные на основании теоретических методов и упрощенной механической модели трансмиссии. В ходе исследования испытаны вибрации силового привода грузового автомобиля среднего класса производственной линейки ФАП 1314. С учетом того, что современные грузовые автомобили оснащены как стандартными механическими, так и гидравлическими опорами был проведен анализ тепловой нагрузки с помощью математического моделирования, применяемого в обоих случаях. Исследования проведены с целью определения соотношения тепловой нагрузки стандартных механических и гидравлических опор с помощью математических моделей, таким образом, полученные результаты могут считаться ориентировочными, что является важным фактором на этапе проектирования коммерческого автотранспортного средства. Анализ показал, что количество тепла, вырабатываемого при применении гидравлических опор, значительно выше, чем в случае применения стандартных механических опор. Кроме того, расчет парциальных функций когерентности теплового потока показал, что их значения находятся в диапазоне от 0,216 до 1, что указывает на взаимозависимость между входными значениями и тепловым потоком. Кроме того, доказано, что инерционная сила и крутящий момент

оказывают большее влияние на тепловую нагрузку силовых агрегатов, чем вибрационное возбуждение рамы транспортного средства.

Ключевые слова: возбуждение, коммерческий автотранспорт, опоры, моделирование, силовой привод, теплота.

ПРИЛОГ ИСТРАЖИВАЊУ ТОПЛОТНИХ ОПТЕРЕЋЕЊА ОСЛОНАЦА ПОГОНСКЕ ГРУПЕ ТЕРЕТНОГ МОТОРНОГ ВОЗИЛА

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ОБЛАСТ: машинство, моторна возила и мотори
ВРСТАЧЛАНКА: оригинални научни чланак
ЈЕЗИКЧЛАНКА: енглески

Сажетак:

Под дејством побуда од микронеравнина путева, погонске групе, као и од услова кретања (убрзавање, кочење, криволинијско кретање) масе теретних возила врше сложена просторна осцилаторна кретања. Негативан утицај тих кретања, односно динамичких оптерећења које она изазивају и преносе на носећи систем возила, може се смањити правилним избором положаја и карактеристика ослонаца погонске групе.

У пракси се усаглашавање карактеристика ослонаца погонске групе, најчешће, врши из услова минималне буке и вибрација возила, при чему се, углавном, занемарују топлотна оптерећења којима су они изложени у експлоатацији, а зна се да она неминовно доводе до оштећења самих ослонаца и нарушавања њихових карактеристика.

Треба напоменути да еласто-пригушне силе у ослонцима врше механички рад који се претвара у топлотну енергију. Анализа топлотних оптерећења ослонаца може се вршити коришћењем теоретских, експерименталних и комбинованих метода. У овом раду истраживања су вршена применом теоријских метода уз коришћење упрошћеног механичког модела погонске групе. При томе су посматране вибрације погонске групе теретног моторног возила средње класе из производног програма ФАП 1314. Имајући у виду заступљеност класичних (гумено-металних) и хидрауличких ослонаца погонске групе код савремених теретних моторних возила, у раду су извршене анализе топлотних оптерећења поменутог возила, уз коришћење математичког модела.

Реализована истраживања имала су за циљ да се утврди однос топлотних оптерећења класичних и хидрауличких ослонаца, уз помоћ модела, па се добијени резултати могу усвојити као

оријентациони, што је неопходно у фази израде идејног пројекта теретног моторног возила. Анализа је показала да је развијена количина топлоте код хидрауличких ослонаца вишеструко већа него у случају коришћења класичних ослонаца.

Поред тога, израчунате парцијалне функције кохеренци топлотног флукса су показале да су њихове вредности у интервалу 0,216 до 1, што указује на то да постоји веза између улазних величина и топлотног флукса. При томе, већи утицај на топлотна оптерећења ослонаца погонске групе имају инерцијална сила и обртни момент мотора него осцилаторне побуде оквира возила.

Кључне речи: побуда, комерцијална возила, ослонци, моделирање, погонска група, топлота.

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COMBAT STIFFNESS OF THE LAUNCHER PLATFORM

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Summary:

Possible loads on a multiple rocket launcher have been systemized and analyzed. Based on the analysis of loads, a mathematical-mechanical model has been made to describe the stability of a MLR hit by a high explosive-fragmentation projectile (HE-FRAG) in a close range. The results give the dependency of the launcher stability on explosion proximity, its typeand the explosive charge mass. The stability limit is determined by the force that can turn over the laucher and compromise the stability of projectiles inside. To simplify the given model, the kinetic energy is calculated for a projectile fragment that hits the launcher.

Key words: load, explosion effect, surface explosion, above ground explosion, conditions, critical pressure, critical distance, overturn, stability, kinetic energy.

Introduction

In order to meet stringent tactical-technical requirements regarding mobility, efficiency, range, up-to-date targets and stiffness,a multiple launching rocket system construction needs to be specific in comparison to other assets of support (Kari, 2007, p.9). Looking at it generally, a multiple launching rocket system is under the following loads (Milinović, 2002, p.155):

Static loads (mechanical):

– the effects of the vehicle weight and the launcher type.

Thermic loads:

– the effects from the combustion products during the launch on the launcher box;

– the detonation products effects when a projectile explodes in the vicinity of the launcher.

Dynamic loads:

– dynamic loads during above ground and surface explosions in the close proximity;

– dynamic loads from the gases during a rocket launch;

– transport loads;

– wind blasts.

From all these loads, the most critical are the dynamic loads during above ground or surface explosions in the close proximity, so we will only take this group for a further analysis.

Determining the maximum pressure of the blast wave on the launcher

As a model for the blast wave pressure, we have accepted a cylindrical coordinate system with independent variables φ and θ as shown in Figure1.

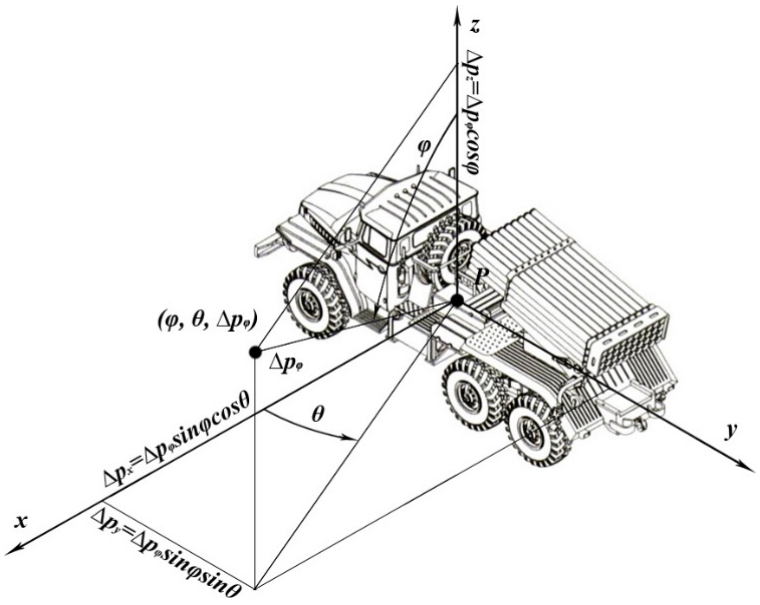

Figure 1 – Physical model for the directional effect of the blast wave on the launcher (Lazarević, 2017, p.11)

Рис. 1 – Физическое воздействие ударной волны на РСЗО (Lazarević, 2017, p.11)

Слика 1 – Физички модел дејства ударног таласа на лансер (Lazarević, 2017, p.11)

Figure 2 represents the basis of the mechanical-mathematical model of the stability of the launcher hit by the blast wave from an explosion. The end result is the maximum pressure of the blast wave during which the stability of the launcher will not be compromised.

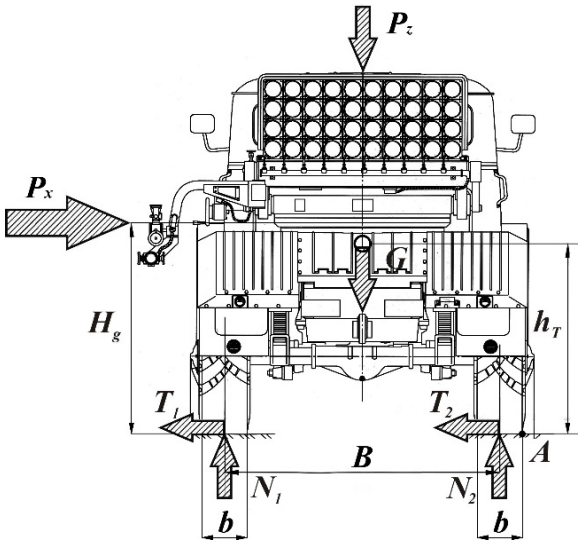

Figure 2 – Balance force of the launcher (Lazarević, 2017, p.20)
Рис. 2 – Равновесие сил РСЗО *(Lazarević, 2017, p.20)*
Слика 2 – Равнотежа сила самоходног лансера (Lazarević, 2017, p.20)

$$\sum F_x = 0;\ \sum F_v = 0;\ \sum M_A = 0$$
$$P - (T_1 + T_2 = 0)$$
$$f(Q + G) = T_1 + T_2 \qquad (1)$$

where:

$P_x = \Delta p \sin\varphi \cos\theta \cdot A_L = c_x \cdot \dfrac{2.5 \cdot \Delta p_\varphi{}^2}{\Delta p_\varphi + 709205} \sin\varphi \cos\theta \cdot A_L$ – the resulting force caused by the explosion from the left side of the vehicle onto the side surface of the launcher A_L;

$P_z = \Delta p_\varphi \cdot A_G$ – the force of overpressure from the blast wave from the upper side of the vehicle on the upper surface of the launcher A_G;

f - adherence coefficient of the self propelled launcher when it is static or when it is on the move.

The average values of the coefficient are given in Table 1.

Based on the balance (equation 1), it follows (Kari & Milinović, 2008, p.36):

$$c_x \cdot \frac{2.5 \cdot \Delta p_\varphi{}^2}{\Delta p_\varphi + 709205} \sin\varphi \cos\theta \cdot A_L = f \cdot \left(\Delta P_\varphi \cdot A_G + G\right) \quad (2)$$

Table 1 – The average values for the adherence cofficient (Simić, 1988, p.104)
Таблица 1 – Средние значения коэффициента сцепления (Simić, 1988, p.104)
Табела 1 – Просечне вредности коефицијента пријањања (Simić, 1988, p.104)

Types and conditions of the road		Adherence coefficient	
		Dry	Wet
Concrete	2 years old 5 years old, dirty	0.74 0.68	0.71 0.64
Asphalt new old, dirty		0.7-0.8 -	0.5-0.6 0.25-0.45
Woodblocks		0.6-0.8	0.3-0.5
Fired bricks sand filling asphalt filling		0.7-0.8 0.82-0.89	0.4-0.5 0.60-0.65
Gravel or macadam		0.6-0.7	0.3-0.5
Slag		0.5-0.6	-
Dirt road		0.50-0.65	0.3-0.4
Lawn25—30%on the wet ground		0.20-0.30	-
Snow	powder packed	0.20-0.40 0.30-0.50	
Ice, flat, glazed (temperature below 0° C)		0.05-0.10	

On the basis of the moment equation (2), we get the condition for the overturning of the launcher onto its side surface during an above ground or surface explosion (Kari & Milinović, 2008, p.37):

$$\left[c_x \cdot \frac{2.5 \cdot \Delta p_\varphi{}^2}{\Delta p_\varphi + 709205} \sin\varphi \cos\theta \cdot A_L\right] \cdot H_G - \left(\Delta P_\varphi \cdot A_G + G\right) \cdot \frac{B+b}{2} = 0 \quad (3)$$

The condition of a critical explosion distance that would impair the stability of the rocket inside the launch tube from the side is:

$$1.2 \cdot \frac{2.5 \cdot \Delta p_{\varphi}{}^{2}}{\Delta p_{\varphi} + 709205} \sin\varphi \cos\theta \cdot A_{L} - 3gT = 0 \qquad (4)$$

The approximate surfaces for the silhouette of the launcher (Figures 3 and 4), are calculatedfor the BM-21 Grad launcher on the basis of the dimensions given in the tactical-technical characteristics (Jovančić, 2014, pp.80-81). Based on them, the surface on which the overpressure of the blast wave acts has been determined.

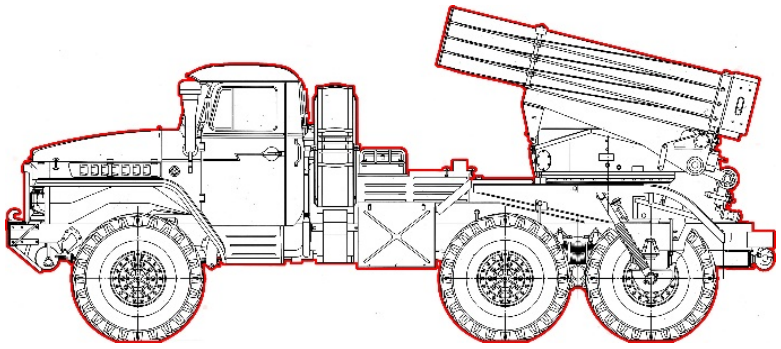

Figure 3 – The left side surface of the rocket launcher (Lazarević, 2017, p.22)
Рис. 3 – РСЗО вид с боку (Lazarević, 2017, p.22)
Слика 3 – Површина бочне стране лансера ракета (Lazarević, 2017, p.22)

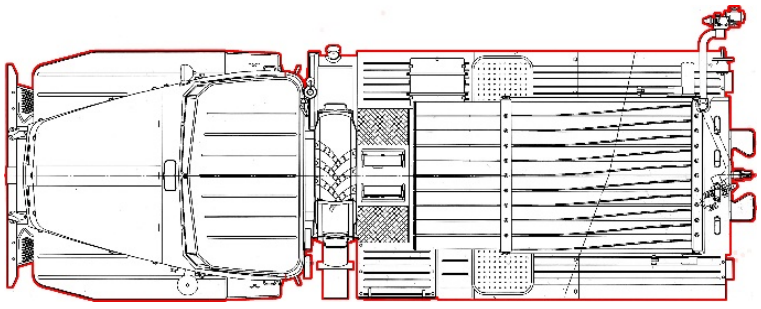

Figure 4 – The surface on the upper side of the rocket launcher (Lazarević, 2017, p.22)
Рис. 4 – РСЗО вид с верху (Lazarević, 2017, p.22)
Слика 4 – Површина горње стране лансера ракета (Lazarević, 2017, p.22)

The obtained input data are shown in Table 2.

Table 2 – Dimensional characteristics of the vehicle (Lazarević, 2017, p.23)
Таблица 2 – Размерные характеристики транспортного средства (Lazarević, 2017, p.23)
Табела 2 – Димензионе карактеристике возила (Lazarević, 2017, p.23)

Weight of vehicle	T	13700 kg
The explosion effect angle	φ	20°÷90°
The explosion effect angle	θ	-180°÷180°
The side surface of the vehicle	A_L	13.6 m^2
The upper surface of the vehicle	A_G	16.8 m^2
The rear surface of the vehicle	A_z	10.1 m^2
The height of the action of the pressure center	H_g	1.58 m
Vehicle center height	h_T	1.2 m
Vehicle width	B	2 m
Tire width	b	0.3 m

Since this is a squared equation, there are two solutions, out of which one is negative, so during our calculations we will only use the positive values of the blast wave pressure acting on the rocket launcher.

Determining the explosion critical distance

Most of the equations for the calculation of the blast wave and the impulse are based on the TNT equation. Thus, for explosives which are not TNT, it is preferable to know their equivalent mass.

The equivalent mass is calculated with the following equation (Mihelič, 2013, p.18):

$$M_{TNTe} = \frac{E_{deksp}}{E_{dTNT}} M_{eksp} \tag{5}$$

where:

M_{TNTe} – equivalent TNT mass [kg];
E_{deksp} – the energy from the explosive detonation [J/kg];
E_{dTNT} – the energy from the TNT detonation [J/kg];
M_{eksp} – explosive mass [kg].

The calculation of the TNT equivalent is commonly based on the energy released during an explosion. The energy can be determined in many ways. Commonly used methods are based on the hydrodynamic or thermodynamic parameters.

In Table 3, the calculated TNT equivalents are shown for secondary explosives. The results are precise enough to be used for the calculation of the critical distance (Mihelič, 2013, pp.18-19).

Table 3 – TNT equivalent for secondary explosives (Mihelič, 2013, p.20)
Таблица 3 – ТНТ эквивалент бризантных снарядов (Mihelič, 2013, p.20)
Табела 3 – TNT еквивалент за бризантне експлозиве (Mihelič, 2013, p.20)

	TNT equivalent		For the range of pressures(MPa)
	Pressure	Impulse	
CompositionB	1.11	0.98	0.035-0.350
Composition C3	1.08	1.01	0.035-0.350
Composition C4	1.37	1.19	0.070-0.700
Octol 72/25	1.06	1.06	-
PETN	1.27	-	0.035-0.700
RDX	1.14	1.09	-
RDX/TNT 60/40	1.14	1.09	0.035-0.350
Tetryl	1.07	-	0.021-0.140
TNT	1.00	1.00	Standard
Tritonal	1.07	0.96	0.035-0.700

In order to make the calculation of equivalent explosive mass in ammunition easier, armies in the world maintain data bases with all necessary data on the amounts of explosives. Such a book is usually called ”the yellow book”.

The necessary data for the explosive mass equivalent to a 155 mm fragmentation shell is shown in Table 4.

Table 4 – Equivalent mass of explosive for the 155 mm HE shell (Lazarević, 2016, p.9)
Таблица 4 – Эквивалентная масса взрывчатых веществ фугасного снаряда, калибра 155 мм (Lazarević, 2016, p.9)
Табела 4 – Еквивалентна маса експлозива за ТФ гранату калибра 155 mm (Lazarević, 2016, p.9)

TNT-RDX	TX	
Mass of explosive charge	M_{eksp}	8.25 kg
TNT Equivalent	E_{deksp}/E_{dTNT}	1.14
Equivalent mass of explosive	M_{TNTe}	9.405 kg

The main characteristics of the blast wave are the overpressure on its front and the time duration of the impulse whose value depends on the type of explosive used, the mass of the explosive and the distance from the explosion. On the basis of the experimental results for spherical blast waves resulting from the detonation of a certain amount of TNT, Sadovsky has suggested an empirical equation for the calculation of the blast wave overpressure in the wave front in the following form (Jeremić, 2002, p.369):

$$\Delta p = k_1 \frac{m_e^{\frac{1}{3}}}{r} + k_2 \frac{m_e^{\frac{2}{3}}}{r} + k_3 \frac{m_e}{r} [bar] \quad (6)$$

where:

m_e – explosive charge mass in kg;

r – distance from the center of the explosion in m;

k_1, k_2, k_3 – empirical coefficients which depend on the explosive chargetype.

For TNT explosive and other types of medium-strength explosives, empirical coefficients for above ground explosions can be taken from Table 5:

Table 5 – Coefficients k_1, k_2, k_3 depending on the type of explosion (Lazarević, 2017, p.13)

Таблица 5 – Коэффициенты k_1, k_2, k_3, в зависимости от типа взрыва *(Lazarević, 2017, p.13)*

Табела 5 – Коефицијенти k_1, k_2, k_3 у зависности од типа експлозије (Lazarević, 2017, p.13)

Type	Above ground explosion	Surface explosion
k_1	0.85	1.1
k_2	3	4.3
k_3	8	14

In the case of a surface explosion, the blast wave in the air spreads in the form of a half sphere (the volume is cut in half), so the overpressure in this case is bigger. That is when double mass (of the explosive charge mass) is usually used in equation (6).

Since during a surface explosion there is also a deformation of the ground, it is necessary to introduce the coefficient η which depends on the type of ground, so the calculation of the explosive mass in equation (6) is equal to (Kari & Milinović, 2008, p.33):

$$m_p = 2\eta m_e \quad (7)$$

By introducing the k_1, k_2, and k_3 coefficients of the equivalent explosive mass, the overturn pressure limit and the pressure which can compromise the stability of the launcher into equation 6, it is possible to determine the critical distance for above ground explosions and surface explosions.

The solution of equation (6) is obtained by transforming it into the following form (http://forum.matemanija.com/viewtopic.php?f=2&t=186, 2017):

$$y^3 + py + cx + d = 0 \quad (8)$$

Where p and q have the following equality:

$$p = -\frac{m^{\frac{2}{3}}\left(k_1^2 + k_2 3\Delta p_\varphi\right)}{3\Delta p_\varphi^2} \tag{9}$$

$$q = -\frac{m\left(27k_3 m\Delta p_\varphi^2 + 9k_1 k_2 \Delta p_\varphi + 2k_1^3\right)}{27\Delta p_\varphi^2} \tag{10}$$

The calculation of the discriminant *D* is done with the following form:

$$D = \frac{q^2}{4} + \frac{p^3}{27} \tag{11}$$

With the help of the Cardan equation, we get the solutions which go by *y*:

$$y_1 = \sqrt[3]{-\frac{q}{2} + \sqrt{D}} + \sqrt[3]{-\frac{q}{2} - \sqrt{D}} \tag{12}$$

So we can get the solution for the third level equation with the following form:

$$r = y - \frac{k_1 m^{\frac{2}{3}}}{3\Delta p_\varphi} \tag{13}$$

Critical distance in the function of mass

Under the assumption of the launcher overturning onto its side with the help of equation 3, we get the maximum pressure of Δp_φ = 314654 Pa. On the basis of that pressure, the diagram which shows the dependence between the critical distance and the explosive charge mass is made. The explosive mass is from 1 to 25 kg. The obtained results are shown in Figure 5.

The influence of fragmentation effects on the launcher

During an explosion of a fragmentation projectile, besides the blast wave effect on the launcher, there is also the fragmentation effect. The fragmentation effect can affect the operation of the launcher system. The fragmentation effect is defined with the kinetic energy of a fragment, because of which a short calculationwill be given further on in the text.

The following fragmentation effect factorsdepend on the HE projectile construction (Stamatović, 1995, p.152):

– the number, individual weight and shape of fragments;
– the look and direction of the fragmentation dispersion form;
– the range and kinetic energy of fragments.

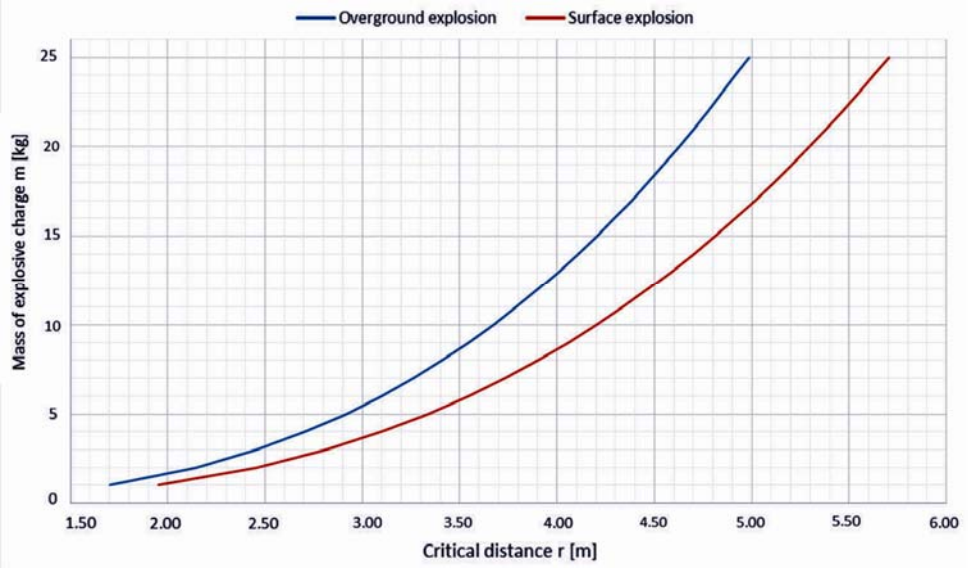

Figure 5 – The correlaction between the critical distance and the explosive chargemass for an above ground and surface explosion (Lazarević, 2017, p.30)
Рис. 5 – Зависимость критического расстояния от массы взрывного заряда, при воздушном и наземном взрыве (Lazarević, 2017, p.30)
Слика 5 – Зависност критичног растојања од масе експлозивног пуњења, при надземној и површинској експлозији (Lazarević, 2017, p.30)

The number, individual mass and shape of fragments

It is usual to evaluate the effect of a projectile on the basis of the following constructional parameters (Stamatović, 1995, p.152):

– relative projectile mass given in the following form $k_p = m/d^3$;
– relative mass of the explosive charge given in the following form $k_e = m_e/d^3$;
– charge coefficient $k = m_e/m \cdot 100$ (%);
– projectile shell thickness δ given in calibers.

If the parameters k_e, k and δ change while caliber stays the same, we will prove that there are optimal values for these parameters with which we get the biggest number of fragments for the given explosive and projectile

mass within the boundaries set beforehand (Table 6) (Stamatović, 1995, p.152).

Table 6 – The fragment mass for the 150 mm HE projectile (Stamatović, 1995, p.156)
Таблица 6 – Масса фрагментов осколочно-фугасного снаряда 155 мм (Stamatović, 1995, p.156)
Табела 6 – Маса парчади тренутнофугасног пројектила 155 mm (Stamatović, 1995, p.156)

Case production	Explosive and mass (kg)	Number of fragments			
		up to 5 g	from 1.5 to 100 g	over 100 g	total
Warm forging	TX/8.25	185	251	14	327
Casting	TX/8.25	1969	1596	1	2263

The look and direction of the fragmentation dispersion form

The usual shape of the inside of a projectile case (Figure 6) produces three beams during an explosion and the case destruction (Stamatović, 1995, pp.159-161):

– the beam formed from the front, oval part (around 10%);
– the side beam of the case cylinder part (around 70%);
– the rear beam formed from the case bottom (20%).

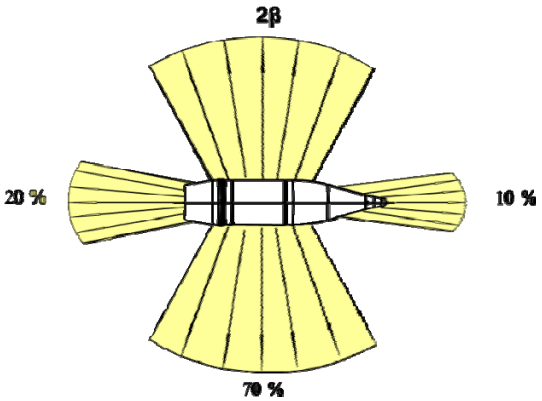

Figure 6 – The directions of fragment dispersion (Stamatović, 1995, p.161)
Рис. 6 – Направления разлета осколков снаряда (Stamatović, 1995, p.161)
Слика 6 – Правци разлетања парчади (Stamatović, 1995, p.161)

We can also adopt that with an explosion in the close proximity of the launcher there are only side beams, i.e. only 70% of the total number of fragments. Also, projectile fragments lighter than 5 grams donot have a significant effect on the launcher, thus they will not be taken into consideration.

The kinetic energy of fragments

The velocity of fragments on the path *x* decrease under the effect of wind resistance, which can be shown with the following equation (Stamatović, 1995, pp.169-172):

$$F_w = \frac{1}{2} C_x S \rho_w V_p^2 \tag{14}$$

where:

C_x – the coefficient of the aerodynamic resistance of the fragment of a mass of m_p;

S – the biggest fragment cross section normal to the direction of movement;

ρ_w – air density;

V_p – fragmentation velocityat the end of the path*x*.

As $m_p V_p dV_p = F_w dx$, it is obtained:

$$dV_p = \frac{1}{2} C_x \frac{S}{m_p} V_p dx \tag{15}$$

By adopting that the aerodynamic resistance coefficientC_x = constfor supersonic speeds (for subsonic and transsonic speeds$C_x$isnot constant) and with the integration of the last equation, we get:

$$V_p = V_{p0} e^{\frac{1}{2} C_x \frac{S}{m_p} \rho_w x} \tag{16}$$

where:

V_{po} – resulting initial velocity of the fragment;

V_p – the velocity of a fragment at the end of the path*x*.

The fragment with the mass m_p possesses kinetic energy, if, when hitting the target, it has the velocity V_{pmin} obtained from the following relation:

$$\frac{m_p V_{p\min}^2}{2} = E \,. \tag{17}$$

The kinetic energy of the fragment with the mass m_p is obtained if we put equation (17) into equation (16):

$$E = \frac{m_p \left(V_{po} e^{\frac{1}{2} C_x \frac{S}{m_p} \rho_w x} \right)^2}{2} \,. \tag{18}$$

Taking into account the initial velocity, the mass, and the total number of fragments from Table 6 as well as the critical distance from equation (13), we get the total kinetic energy of the fragmentation effect on the launcher.

This model is a rough approximation of the real system. For more reliable models, we need to do experimental testing inside a ditch or depression and to determine the initial velocities of fragments using a radar, which is costly.

Overview of the results

The condition for the overturn of the launcher

Under the assumption that the equivalent explosive mass during an above ground detonation is constant, i.e. 9.405 kg (equation 5), the critical distances for overturning are calculated for the independent variables φ and θ, which are between 20 – 90 and -180 to 180, respectively. The obtained results are shown in Figure 7.

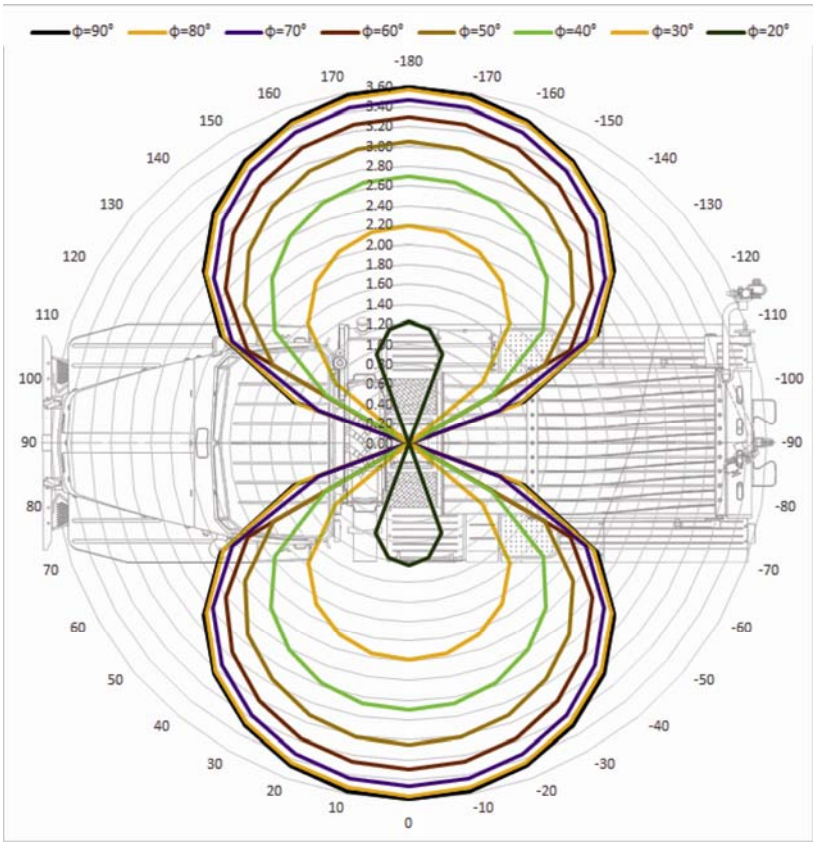

Figure 7 – Critical distance of launcher overturn in the function of φ and θ for an above ground explosion (Lazarević, 2017, p.37)

Рис. 7 – Критическое расстояние опрокидывания РСЗО в функции φ и θ при воздушных взрывах (Lazarević, 2017, p.37)

Слика 7 – Критично растојање превртања лансера у функцији φ и θ при надземној експлозији (Lazarević, 2017, p.37)

Having in mind that the equivalent explosive mass during a surface explosion is two times bigger because of the half spherical spread of the blast wave, multiplied with the coefficient of the ground, we get an explosive mass of 14.108 kg (equation 7). On the basis of the mass and critical distance of overturn (equations 3 and 7), the critical distances of overturn have been calculated for the independent variables φ and θ, which are in the range between 90-20 and -70 to 70, respectively. The obtained results are shown in Figure 8.

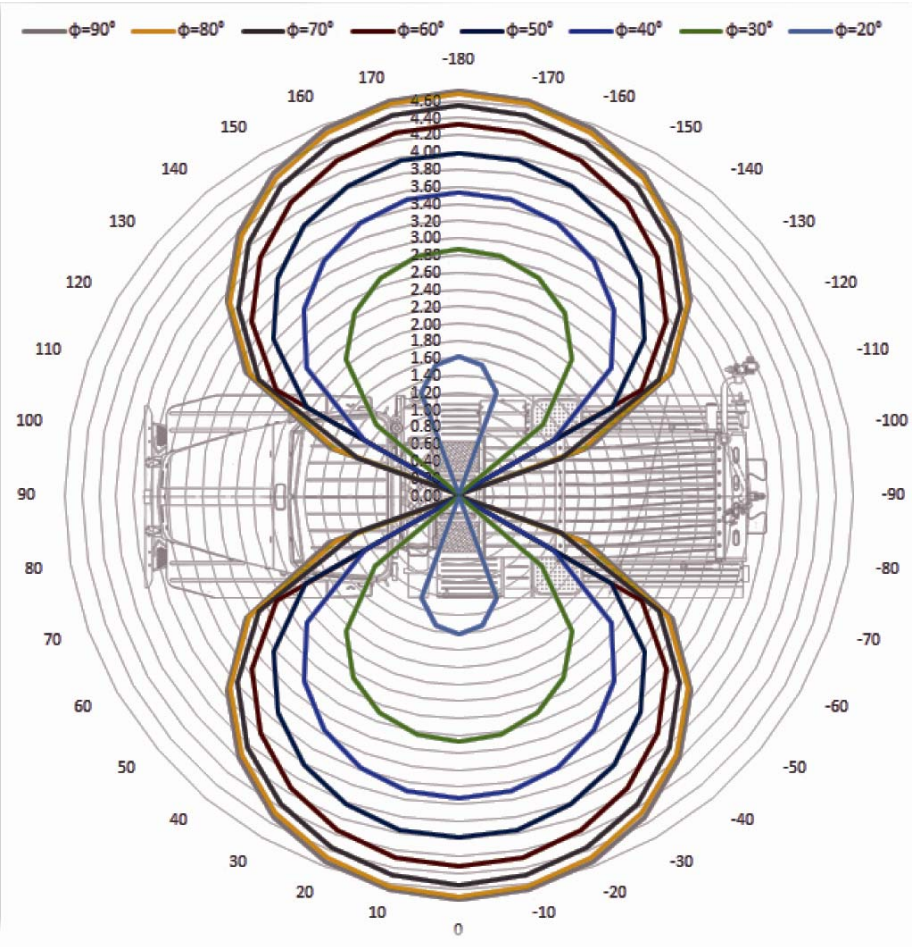

Figure 8 – Critical distance of launcher overturn in the function of φ and θ for a surface explosion (Lazarević, 2017, p.38)
Рис. 8 – Критическое расстояние опрокидывания *РСЗО в функции φ и θ* при наземных взрывах *(Lazarević, 2017, p.38)*
Слика 8 – Критично растојање превртања лансера у функцији φ и θ при површинској експлозији (Lazarević, 2017, p.38)

The condition for compromising the stability of the projectile inside the launcher tube

With a process similar to the one for overturning during an above ground explosion, we calculated the critical distance of compromising the stability of a projectile inside the launcher. With equations (4) and (5), we

get the critical distances for the independent variables φ and θ which vary between 90 to 20 and -80 to 80, respectively. The results are shown in Figure 9.

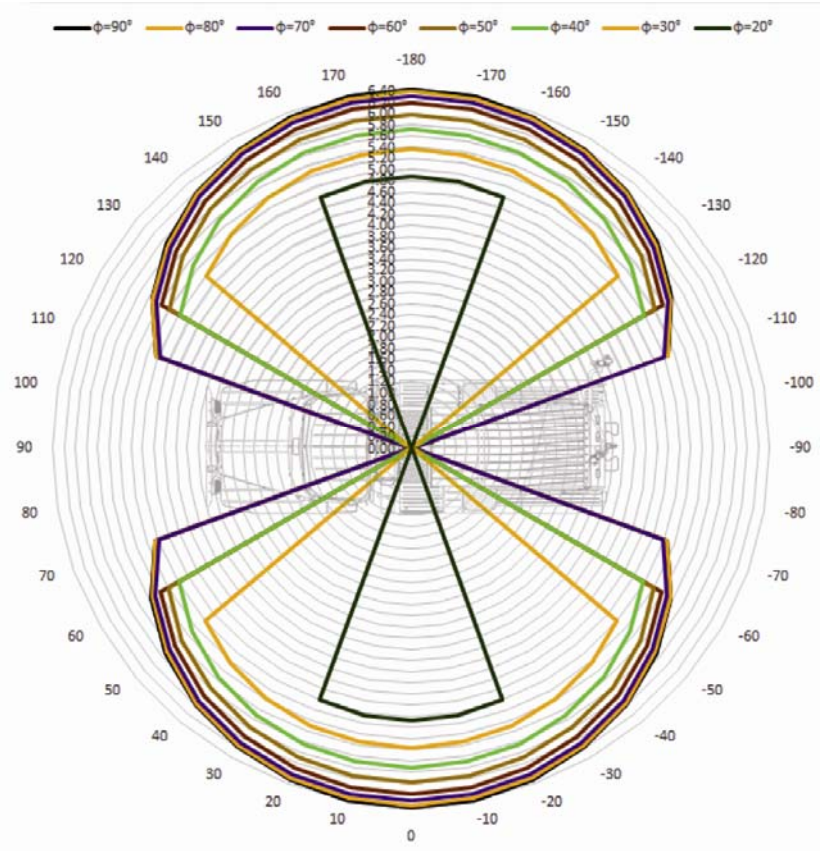

Figure 9 – Critical distance of compromising the projectile stability in the function of φ and θ for an above ground explosion (Lazarević, 2017, p.39)
Рис. 9 – Критическое расстояние нарушения надежного удержания ракеты в функции φ и θ при воздушных взрывах (Lazarević, 2017, p.39)
Слика 9 – Критично растојање нарушавања поузданог држања ракете у функцији φ и θ при надземној експлозији (Lazarević, 2017, p.39)

Having in mind that the equivalent explosive mass during a suface explosion is two times bigger because of the spread of the blast wave multiplied with the ground coefficient, we get an explosive mass of 14.108 kg (equation 7).

For a surface explosion, the critical distances for compromising the projectile stability inside the launcher are calculated. With equations (4) and (7), we get the critical distances for the independent variables φ and θ, which are in the range from 90-20 and -80 to 80, respectively. The obtained results are shown in Figure 10.

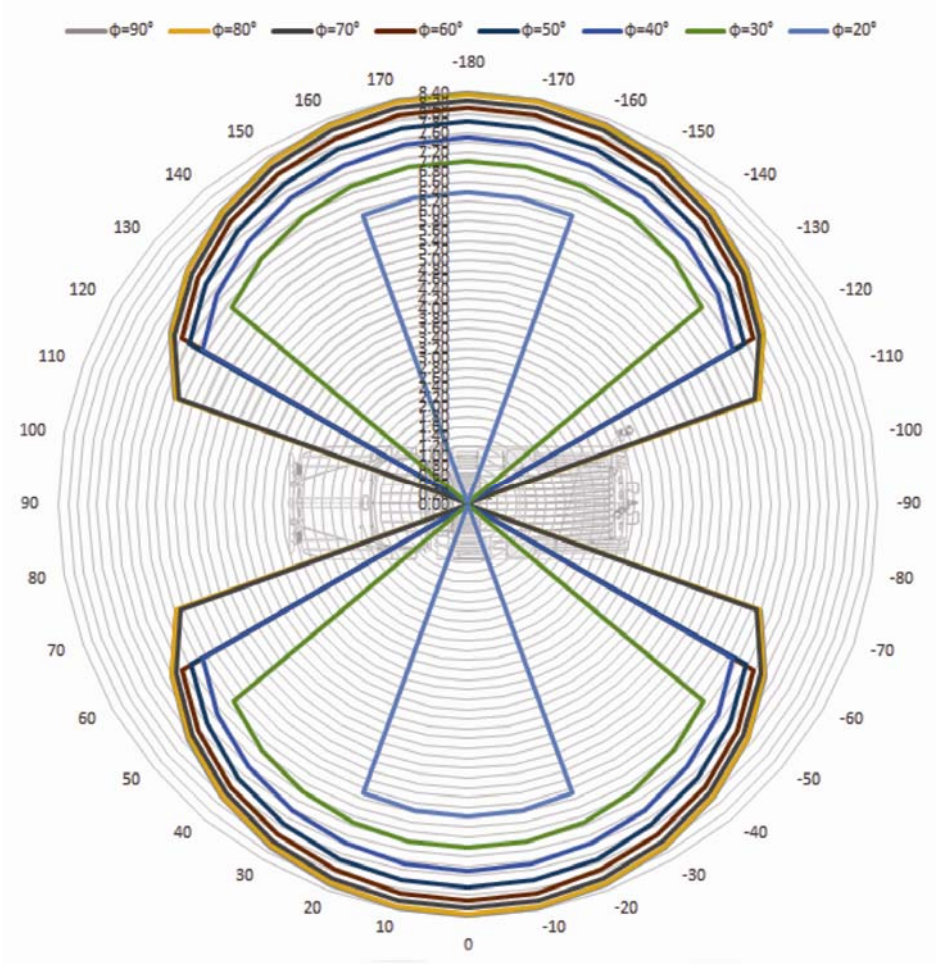

Figure 10 – Critical distance of compromising the projectile stability in the function of φ and θ for a surface explosion (Lazarević, 2017, p.40)
Рис. 10 – Критическое расстояние *нарушения надежного удержания ракеты в функции φ и θ при наземных взрывах (Lazarević, 2017, p.40)*
Слика 10 – Критично растојање нарушавања поузданог држања ракете у функцији φ и θ при површинској експлозији (Lazarević, 2017, p.40)

Conclusion

This mathematical model is a rough approximation of the real situation. To further develop the model, it is required to take into account the launcher suspensionand the launcher oscillations.

The analysis of the results has shown that during an above ground explosion the minimum distance to avoid the overturning of the BM21 Grad launcher iz 3.6 meters and it is 4.71 meters for a surface explosion (Figures 7 and 8).

As an addendum to the paper, the critical distance of the explosion during which the projectile stability would be compromised inside the launcher tube is also calculated. The stability of the projectile inside the launcher tube is defined with a maximum force of 3g.

The analysis of the results has shown that, in an above ground explosion, the minimum distance at which the projectile stability inside the launch tube would not be compromised is 6.42 meters and it is 8.41 meters when an explosion is a surface one (Figures 9 and 10).

A rough approximation of the fragmentation effect of the projectile on the launcher was done.

In order to get reliable data, it is necessary to carry out a series of tests run on a testing field on the given launcher.

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БОЕВАЯ УСТОЙЧИВОСТЬ РСЗО

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ОБЛАСТЬ: машиностроение
ВИД СТАТЬИ: оригинальная научная статья
ЯЗЫК СТАТЬИ: английский

Резюме:

В данной работе приведены систематизация и анализ предельной нагрузки многоствольной ракетной пусковой установки. Исходя из анализа нагрузки, разработана механико-математическая модель устойчивости РСЗО, пораженной ОФ снарядом. На основании полученных результатов выявлена зависимость устойчивости пусковой установки от диапазона взрыва, типа взрыва и массы взрывного заряда. Главным условием боевой устойчивости РСЗО является разработка мер по предотвращению опрокидывания РСЗО и нарушения надежного держания ракеты в пусковой трубе. В целях упрощения данной модели произведен расчет кинетической энергии воздействия осколков на ракетную пусковую установку.

Ключевые слова: нагрузка, действие взрыва, наземные взрывы, воздушные взрывы, условия, критическое давление, критическое расстояние, опрокидывание, устойчивость, кинетическая энергия.

БОРБЕНА ЖИЛАВОСТ ЛАНСИРНОГ СИСТЕМА

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ОБЛАСТ: машинство
ВРСТА ЧЛАНКА: оригинални научни чланак
ЈЕЗИК ЧЛАНКА: енглески

Сажетак:

У оквиру овог рада извршена је систематизација и анализа могућих оптерећења вишецевних лансера ракета. На основу анализе оптерећења израђен је математичко-механички модел стабилности вишецевног лансера ракета погођеног у непосредној близини тренутно-фугасним пројектилом. Добијени резултати указују на зависност стабилности лансера од удаљености експлозије, типа експлозије и масе експлозивног пуњења. Као гранични услов борбене жилавости лансера усвојен је услов почетног превртања лансера и нарушавања поузданог држања ракете у лансирној цеви. Ради упрошћавања приказаног модела извршен је прорачун кинетичке енергије ефикасног парчета које делује на лансер.

Кључне речи: оптерећење, дејство експлозије, површинска експлозија, надземна експлозија, услови, критичан притисак, критично растојање, превртање, стабилност, кинетичка енергија.

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TESTING MECHANICAL STRUCTURAL CHARACTERISTICS OF Al_2O_3 OXIDE CERAMICS RESISTANT TO SLIDING FRICTION

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FIELD: Chemical Technology
ARTICLE TYPE: Original Scientific Paper
ARTICLE LANGUAGE: English

Summary:

Al_2O_3 is hard oxide ceramics, chemically bioinert and with good sliding properties; it has found wide application in the design of engineering components. The aim of the paper was to apply the APS process with the change of plasma currents in order to produce Al_2O_3 layers of such structural and mechanical properties which will find application in the manufacture of biomedical coatings alone or in combination with hydroxyapatite (HA) on the surfaces of alloys used for making implants. The coating was deposited with a plasma current of 700, 800 and 900 A. The mechanical properties of coatings were tested using the Pratt & Whitney standard. The shape of the surface of powder particles and the coating surface were examined by SEM. The metallographic analysis of the inner layers was carried out by light microscopy. The best structural and mechanical properties of the Al_2O_3 coating deposited with 900A were confirmed by testing the sliding properties of the coating deposited and polished to a mirror on the sealing ring paired with the graphite ring on the water brake.

Keywords: sliding, property, oxides, mechanical properties, deposits, coatings, Al_2O_3.

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Introduction

Ceramic coatings are widely used to improve wear resistance of working surfaces of various mechanisms due to their high strength and structural stability (Toma et al, 2001, pp.149-158). Al_2O_3 ceramics is applied to many engineering components where good sliding properties and wear resistance to friction are required. Because being bioinert in living tissues, Al_2O_3 ceramics is applied to the surface modification of biomedical coatings deposited on titanium alloys. Good mechanical characteristics of Al_2O_3 ceramics allow it – since it is inorganic and bioinert - to be combined in different volume ratios with organic bioactive ceramics hydroxyapatite (HA) in the process of producing biomedical coatings. In this way, coating stiffness is reduced, tensile strength and fatigue resistance to friction are increased, which extends the life of the coating (Li et al, 2006, pp.1166-1172), (Liou, 2009). Applying such modified coatings on the surfaces of titanium alloys significantly enhance the biological activity of implants and increase the resistance of titanium alloys to bio corrosion (Gadow et al, 2010, pp.1157-1164). For the manufacture and modification of biomedical coatings, ceramics of Al_2O_3 and ZrO_2 are most frequently used, alone or in combination, as well as hydroxyapatite (HA) (Hsiung et al, 2012, pp.457-463).

In the plasma spray process, due to high speed of plasma particles and uneven distribution of temperature in plasma, plasma current changes significantly affect total or partial melting of Al_2O_3 powder particles, which is reflected in the structure and mechanical properties of the coating (Friis et al, 2001, pp.115-127), (Matejicek & Sampath, 2001, pp.1993-1999). Previous studies have shown that the properties of the coating are directly related to the parameters that influence the degree of melting of particles and the mechanism of deformation of molten drops in collision with the substrate (Li & Ohmori, 2002, pp.365-374), (Mrdak, 2016a, pp.1-25), (Mrdak, 2016b, pp.411-430). The coating quality is primarily defined by its microstructure (type of phases and homogeneity) and its mechanical properties that are critical for reliable behavior of the coating in exploitation (Tucker, 2002, pp.45–53), (Liao et al, 2000, pp.235–242), (Toma et al, 2001, pp.149–158). The share and the phase α-Al_2O_3/γ-Al_2O_3 ratio depends on the amount of heat which drops of molten particles carry with them and which is directly dependent on the size of melting particles, cooling rate and substrate temperature (Kulkarni et al, 2004, pp.124-137), (Yang et al, 2006, pp.1649-1653). The γ-Al_2O_3 phase in the coating is desirable for increasing toughness and cohesive coating / adhesion strength. Resistance to sliding contact fatigue of the

Al_2O_3 coating depends on the phase composition, content and pore size, and presence of unmelted particles and cracks.

The paper presents an analysis of the results of tests of the mechanical properties and the microstructure of Al_2O_3 coatings deposited with 700, 800 and 900A. Because of economic effects, Al_2O_3 coatings were deposited on steel substrates. The aim was to use plasma in the manufacture of coating layers to be applied for the modification of biomedical coatings and the surface modification of alloys used to produce implants. The coating with the best properties is tested on the sealing ring of the water brake paired with the graphite ring. The investigation confirmed that the Al_2O_3 coating, polished to a mirror on the sealing ring, substantially improved the efficiency of the sealing and significantly reduced the sealing ring friction abrasion, thus allowing the use of Al_2O_3 coatings for implant surface modification.

Materials and experimental details

Al_2O_3 oxide powder used for coating deposition is Metco 105NS produced by the technique of melting / grinding molded blocks to a granulation of 15 - 45 μm. (Material Product Data Sheet, 2012). Figure 1 (SEM) shows the surface of Al_2O_3 powder particles used in this work; the particles are of irregular shapes with sharp edges.

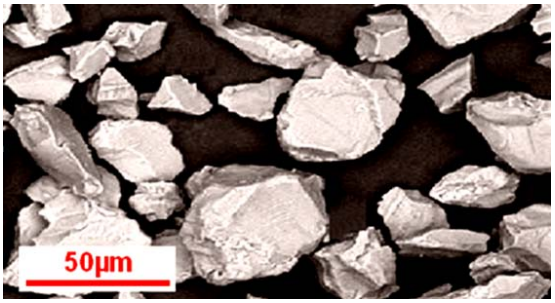

Figure 1 – Surface of Al_2O_3 particles
Рис. 1 – Изображение поверхности частиц Al_2O_3
Слика 1 – Изглед површине Al_2O_3 честица

To test the mechanical properties and the structure of the layers, the powder is deposited on steel samples (X15Cr13 EN10027), the characteristics and dimensions of which are prescribed by the Pratt & Whitney standard (Pratt & Whitney, 2002). To measure the microhardness and adhesion strength, the Pratt & Whitney standard was used, providing the measurement procedure relating to the number of samples and the number of measuring points (Pratt & Whitney, 2002). The paper presents the

minimum and maximum values of microhardness and average adhesion strength. The metallographic analysis of the coatings and the content of pores in the coatings was performed under a light microscope. The paper presents the average values of a share of pores. The analysis of the surface of the powder particles and the surface of the deposited coating is carried out by the SEM method.

The Al_2O_3 powder was deposited at atmospheric pressure with a SG-100 plasma gun and a power supply of 40kW. The Al_2O_3 powder deposition parameters are shown in Table 1. The deposited layers formed a coating thickness from 0.18 to 0.20 mm.

Table 1 – Plasma spray parameters
Таблица 1 – Параметры плазменного напыления
Табела 1 – Плазма спреј параметри

Deposition parameters	Values		
Plasma current, I (A)	700	800	900
Plasma Voltage, U (V)	35	37	42
Primary plasma gas flow rate, Ar (l/min)	50	50	50
Secondary plasma gas flow rate, He (l/min)	32	32	32
Carrier gas flow rate, Ar (l/min)	7	7	7
Powder feed rate, (g/min)	40	40	40
Stand-off distance, (mm)	115	115	115

Results and discussion

Figure 2 illustrates the results of the microhardness of Al_2O_3 coatings deposited with a change in plasma current amperage. The measured values of coating microhardness were directly related to the applied current amperage. The lowest microhardness value of 780 – 1010$HV_{0.3}$ belongs to the coating deposited with 700A, and the maximum value of 990 - 1180$HV_{0.3}$ characterizes the coating deposited with 900A. Nonuniform and different coating microhardness values are the result of uneven distribution of micro pores, different pore content and pore size in the coating layers. The plasma current amperage significantly influenced the melting of powder particles. Lower current intensity was not enough to melt injected particles throughout the complete cross section, which resulted in the deposited particles having a smaller intercon-

tact surface and a higher intercontact content of micro pores. Due to poorer melting of particles and a larger share of pores, the coating had a range of microhardness of 230$HV_{0.3}$. The coating deposited with 900A had a range of microhardness lower than 190$HV_{0.3}$. High amperage affects a greater degree of ionization of the He monoatomic gas, which increases the plasma temperature and heat transfer from plasma to powder particles.

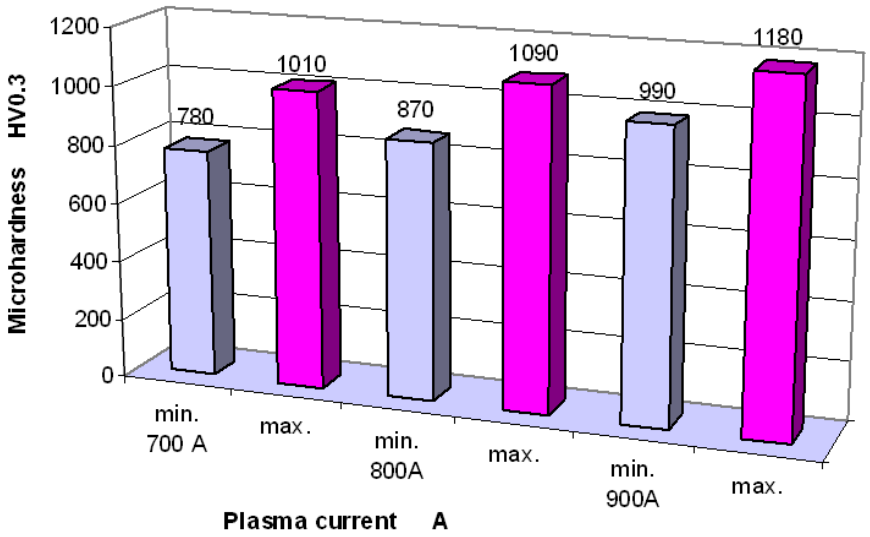

Figure 2 – Results of th e microhardness of Al_2O_3 coatings
Рис. 2 – Результаты микротвердости покрытия Al_2O_3
Слика 2 – Резултати микротврдоће превлака Al_2O_3

Consequently, powder particles melt better and more evenly throughout the cross section. Liquid drops of molten particles are better bonded to one another achieving a greater bonding area and stronger cohesive strength with a smaller proportion of micro pores. Figure 3 shows the results of the adhesion strength of the substrate / Al_2O_3 coating bond depending on the amperage. The Al_2O_3 powder deposited with 700A achieved the lowest value of adhesion strength of 38MPa with the substrate. Due to uneven and incompletely melted powder particles in plasma with 700A, particles carry a small amount of heat. Therefore, incompletely melted particles transfer a smaller amount of heat to the substrate, which is why their bond to the substrate is weak.

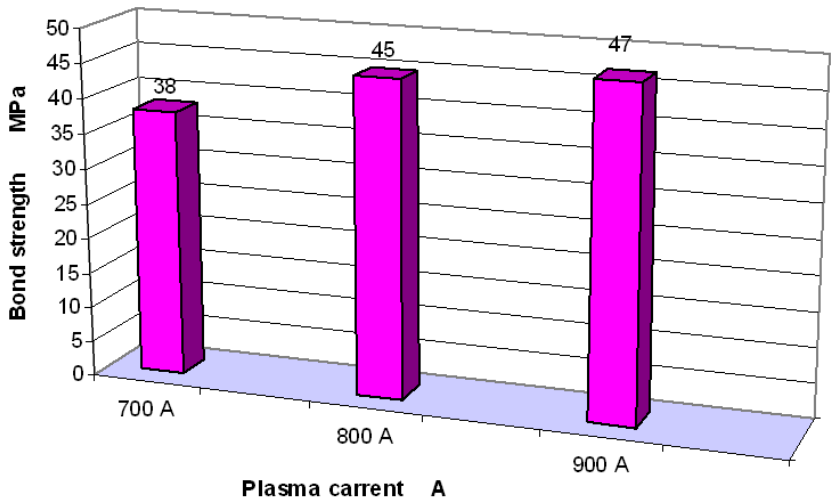

Figure 3 – Results of the bond strength of Al_2O_3 coatings
Рис. 3 – Результаты твердости связи покрытия Al_2O_3
Слика 3 – Резултати чврстоће споја превлака Al_2O_3

Heating the metal substrates from liquid drops of completely melted Al_2O_3 particles deposited with 900A increases the adhesive bond strength to 47 MPa. At the fracture of the samples, it was established that the fracture mechanism was adhesion at the substrate / Al_2O_3 coating interface.

Figure 4 illustrates the cross section of the microstructure of the Al_2O_3 coating deposited with 900A. The substrate / coating bond is very good because contamination from corundum, coarse pores and micro cracks are not visible at the interface. High amperage of plasma current allowed the drops of completely melted particles to overlap completely in collision with the substrate and form thin lamellae and inter lamellar pores of small size and small content in the coating. In the coating, there are micro pores of 5 - 10μm with a mean share of 4.2%. The structure of the coating consists of phases of mixed crystals α-Al_2O_3 + γ-Al_2O_3 (Kulkarni et al, 2004, pp. 124-137), (Yang et al, 2006, pp.1649-1653).

Figures 5 and 6 illustrate the cross sections and the microstructures of the Al_2O_3 coatings deposited with 800A and 700A.

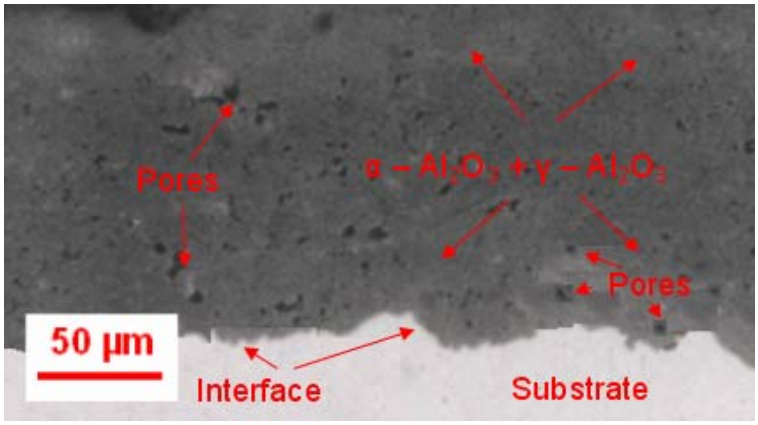

Figure 4 – Cross section and microstructure of the Al_2O_3 (900A) coatings
Рис. 4 – Поперечное сечение и микроструктура Al_2O_3 покрытия (900A)
Слика 4 – Попречни пресек и микроструктура Al_2O_3 превлаке (900 A)

Due to low thermal conductivity of the oxide powder, lower plasma current amperage heats and melts powder particles to a lower extent.

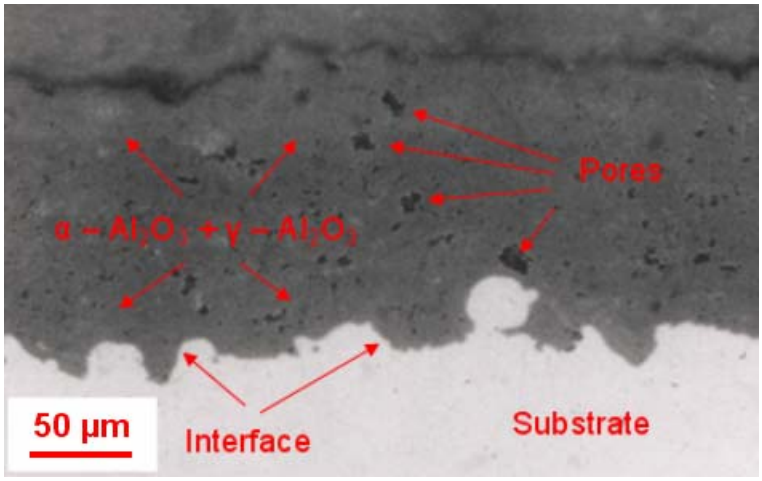

Figure 5 – Cross section and microstructure of the Al_2O_3 (800A) coatings
Рис. 5 – Поперечное сечение и микроструктура Al_2O_3 покрытия (800A)
Слика 5 – Попречни пресек и микроструктура Al_2O_3 превлаке (800 A)

Such semi-melted particles are poorly and improperly deformed in collision with the substrate thus forming pores larger in size and share in the coatings. Coatings with a higher share of pores of irregular shapes and larger pores significantly reduce the cohesive strength of the coating and the coating time and resistance to fatigue friction. Because of their lower density and inhomogeneity, such coatings will wear faster and are unreliable in operation.

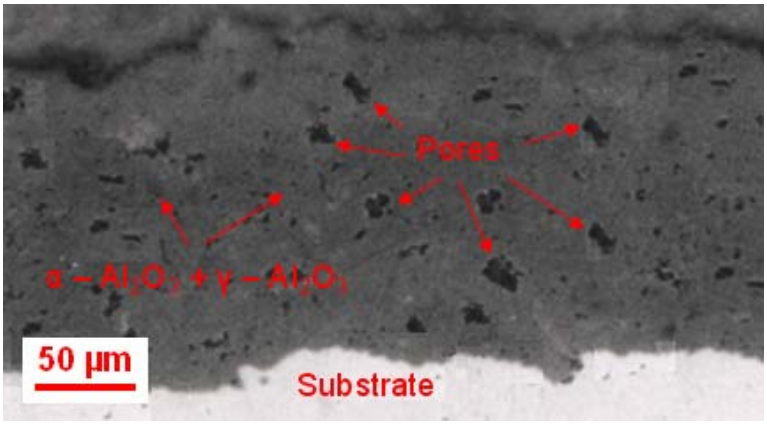

Figure 6 – Cross section and microstructure of the Al_2O_3 (700A) coatings
Рис. 6 – Поперечное сечение и микроструктура Al_2O_3 покрытия (700A)
Слика 6 – Попречни пресек и микроструктура Al_2O_3 превлаке (700 A)

In the structure of the coating deposited with 800A, there are small and rough micro pores of irregular shape marked with red arrows. Micro pores in the coating had a size of 10 - 20µm with a total content of 6.4%. The microstructure of the worst coatings deposited with 700A is illustrated in Figure 6. The highest content of micro pores of 8.6% and formed coarse pores over 20µm resulted in the coating having the lowest microhardness, the highest microhardness range and the lowest adhesion strength.

Figure 7 illustrates the surface morphology of the Al_2O_3 coating deposited with 900A and analyzed by the SEM method. On the surface of the Al_2O_3 coating, overlapped particles can be seen, deformed in a characteristic way in collision with the substrate. Drops of molten Al_2O_3 particles cooled to the substrate temperature and formed a disk-like shape. The morphology of a well-molten particle is marked with a red line in the Figure. Complete overlapping of particles is proof that the Al_2O_3 particles are completely molten in plasma and as such allow deposition of layers of coating with thin disks - lamellae on whose edges (interfaces) fine micro pores and precipitates are present. Micro pores in the Figure are rounded in

yellow, while precipitates are in red and green. Full overlapping of deposited particles, due to a large contact area, indicates a good bond between individual particles in a layer deposited in a single plasma gun shot.

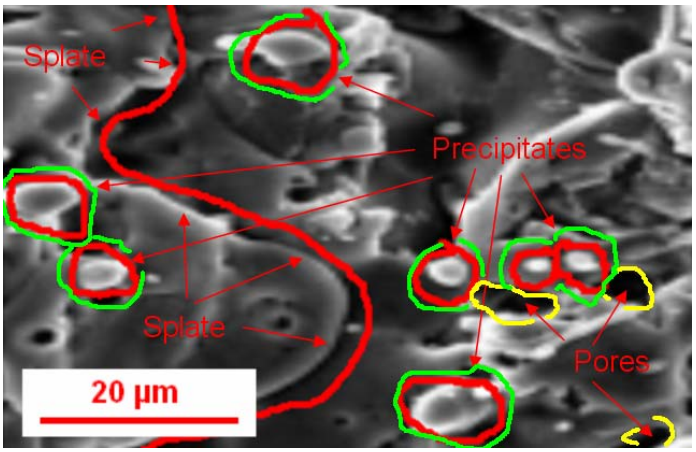

Figure 7 – Morphology surface of the Al_2O_3 coating in the sprayed state, (900A)
Рис. 7 – Морфология поверхности покрытия Al_2O_3, нанесенного напылением, (900A)
Слика 7 – Морфологија површине Al_2O_3 превлаке у напрсканом стању (900 A)

It also indicates good bonding between the layers in the coating as well as good adhesion of ceramic particles with the roughened substrate on whose surface liquid Al_2O_3 ceramic drops stay during cooling to the substrate temperature. Such deposition of fully molten powder particles enables the production of coatings of good adhesion / cohesion strength and provides the coating with good sliding properties and wear resistance to friction.

Conclusion

On the basis of the results of examining the mechanical, structural and sliding properties of the Al_2O_3 coatings deposited with 700A, 800A and 900A, it can be concluded:

The results of coatings microhardness were directly related to the applied current amperage. The current of 900A melted injected Al_2O_3 particles in plasma over the complete cross section, which caused the deposited particles to have a large intercontact surface (good cohesive strength) and maximum microhardness. The transfer of heat from the liquid drops of completely molten Al_2O_3 particles to the metal substrate enabled that the coating has the highest strength of bond adhesion - 47 MPa.

Plasma current of 900A resulted in Al_2O_3 powder particles melting completely and, in collision with the substrate, they completely overlapped and formed a coating of the best microstructure. In this way, thin lamellae and interlamellar pores of small size with a small share in the coating were formed in the layers. Micro pores had a size of 5 - 10μm with a mean share of 4.2% in the coating. The structure of the coating consisted of the phases of mixed crystals of α-Al_2O_3 + γ-Al_2O_3.

The coating deposited with 900A was tested on the sealing ring of the water brake paired with its counter pair made of graphite. Testing the sliding properties showed that the Al_2O_3 coating brushed and polished to a mirror on the sealing ring has good properties of sliding fatigue since the ring sealing efficiency is significantly improved and the ring wear is reduced.

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ИСПЫТАНИЯ МЕХАНИЧЕСКИХ СТРУКТУРНЫХ ХАРАКТЕРИСТИК ОКСИДНОЙ КЕРАМИКИ Al_2O_3 НА ИЗНОСОСТОЙКОСТЬ ПРИ ТРЕНИИ СКОЛЬЖЕНИЯ

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ОБЛАСТЬ: химические технологии
ВИД СТАТЬИ: оригинальная научная статья
ЯЗЫК СТАТЬИ: английский

Резюме:

Al_2O_3 является твердой оксидной керамикой, которая обладает биоинертными свойствами и отличается высокой

стойкостью на скольжение, благодаря чему она широко применяется в проектировании инженерных компонентов. Цель исследования заключалась в приспособлении APS процесса нанесения плазменного напыления, путем изменения плазменного потока, формирующего слои Al_2O_3, обладающие такими структурными и механическими характеристиками, которые могли бы найти применение в производстве биомедицинских покрытий, как в отдельности, так и в комбинации с гидроксиапатитом, в частности для поверхности сплавов, используемых в изготовлении имплантов. Покрытие нанесено плазменной струей 700, 800 и 900А. Механические характерики покрытия испытаны в соответствии со стандартами Pratt & Whitney.

Форма частиц порошка и поверхность покрытия испытаны методом SEM. Металлографический анализ внутренних слоев проведен с помощью световой микроскопии.

Лучшие структурные и механические характеристики Al_2O_3 покрытия выявлены у покрытий, нанесенных при 900А, испытана стойкость на скольжение, путем нанесения на уплотнительное кольцо в паре с графитовым кольцом, защищающее гидравличиский тормоз и путем шлифования покрытия до зеркального блеска.

Ключевые слова: скольжение, свойство, оксиды, механические свойства, нанесение, покрытие, Al_2O_3.

ИСПИТИВАЊЕ МЕХАНИЧКИХ СТРУКТУРНИХ КАРАКТЕРИСТИКА ОКСИДНЕ КЕРАМИКЕ Al_2O_3 ОТПОРНЕ НА КЛИЗАЊЕ ТРЕЊЕМ

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Сажетак:

Al_2O_3 је тврда оксидна керамика, хемијски биоинертна са добрим клизним својствима, која је нашла широку примену у пројектовању инжењерских компоненти. Циљ рада био је да се APS процесом са променом плазма струје произведу слојеви Al_2O_3 структурних и механичких карактеристика који ће наћи примену за производњу биомедицинских превлака засебно или у комбинацији са хидроксиапатитом (ХА) на површинама легура које се користе за израду импланата. Превлака је депонована

Mrdak, M., Testing mechanical structural characteristics of Al_2O_3 oxide ceramics resistant to sliding friction, pp.924-936

са плазма струјом 700, 800 и 900 А. Механичке карактеристике превлаке испитане су применом стандарда Pratt & Whitney. Облик површине честица праха и површина превлаке испитана је методом SEM. Металографска анализа унутрашњих слојева испитана је светлосном микроскопијом. Најбоље структурне и механичке карактеристике Al_2O_3 превлаке депоноване са 900 А потврђене су испитивањем клизних својстава превлаке депоновне и полиране до огледала на заптивном прстену упареном са графитним прстеном на воденој кочници.

Кључне речи: клизање, својство, оксиди, механичка својства, депозити, превлаке, Al_2O_3.

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DECISION-MAKING PROCESS DURING THE FULFILMENT OF MILITARY ASSIGNMENTS

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ARTICLE TYPE: Original Scientific Paper
ARTICLE LANGUAGE: English

Abstract:

The paper deals with the decision-making process in crisis management with focus on the Army of the Czech Republic (soldiers at the University of Defence in Brno). Within the research, 44 soldiers were monitored whilst managing various tactical situations during a three-week complex field training exercise. The soldiers were supposed to carry out the following combat assignments: fire control, battle order and radio operation. Prior the training, the soldiers filled out a questionnaire the questions in which corresponded with the above mentioned practical tasks. Based on the acquired outcomes, it may be stated that the assessment of theoretical solution of selected combat assignments among future squad leaders may be used for the prediction of how successful the management of such assignments may be in practice.

Key words: Army of the Czech Republic, soldier, infantry squad, decision-making process, crisis communication.

Reviewing the Literature

Decision making is a part of everyday life of all people in a society. These days, full of emergency events caused either by people or nature, it is necessary to manage various situations correctly, timely and sufficiently. The decision-making processes play a significant role in security environment when fulfilling the assignments of state. Soldiers face life threatening situations almost every day whilst fulfilling the assignments in the Army of the Czech Republic (ACR), one of state security components. Stress is on the agenda every day. An infantry squad on patrol never knows what will happen. It may be a routine patrol without any unexpected situations, but it may also be a patrol with obstacles to be overcome, including e.g. enemy traps or enemy itself. Therefore, every soldier has to be prepared to face unfavourable emergency events. Faster, more accurate and more powerful information gaining is necessary, capable of being evaluated in the preparation and execution phases of the operation.

If we want to acquire decision making capabilities of higher quality among the ACR personnel, it will be necessary to introduce such activities which may realize such intention. Such activities may be as follows:

1) personnel selection, focused on people with personality prerequisites for a quality decision making or readiness to learn it;
2) education in the area of decision-making processes.

The personnel selection process uses various methods with various criteria validity, such as:

1) biographical data;
2) interview;
3) references;
4) test of expert knowledge;
5) tests of capabilities;
6) tests of personality;
7) simulated situations;
8) assessment centre (combination of the above mentioned methods, especially simulated situations).

Validity of personnel selection represents the relation between the values of an employed method (predictor) and a real criterion (drivers´ accident rate, salesmen´s sales results, superiors´ assessment). Validity is mostly measured as a predictor-criterion correlation coefficient. The most proved tools of personnel selection include simulated situations, often tailored into the form of case studies. The quality preparation of simulated situations ideally proceeds in the following format:

1) data collection in terrain (critical situations);
2) selection of suitable situations for testing (situations distinguishing between right and wrong behaviour, adequately demanding for the candidate and with clear assessment criteria);
3) presentation of situations to a sample group of respondents and collection of responses to individual items;
4) assessment of responses in points by a group of experts;
5) elaboration of a guide for testers.

The case study may be, according to particular conditions, in a written form in which candidates solve a problem or a set of problems, or in a form of a role-play in which candidates are participants in a fictitious situation and their reactions are assessed by an evaluator (or evaluators). (Hroník, 2002), (Hroník, 2007).

A number of research studies deal with the use of simulated situations for the prediction of future performance of policemen and monitor their validity. Love & DeArmond (2007) observed required competences among 54 candidates for the post of a police sergeant and they stated the following ones:

1) providing advice to subordinates;
2) perceptiveness;
3) team leading;
4) problem solving;
5) oral communication;
6) written communication;
7) decisiveness;
8) stress tolerance;
9) planning and organization;
10) independence;
11) work.

The candidates went through a one-day assessment centre, which included the following fictitious situations: daily administration, oral presentation, group discussions, problem solving. (Love & DeArmond, 2007). These were compared with the assessment of real problem solving and the quality of communication. The best problem solving predictors proved to be written communication skills ($r = 0.86$) and decisiveness (0.84), the best communication quality predictors were coping with stress ($r = 0.79$) and perceptiveness ($r = 0.76$).

The assessment centre is considered to be the most common and efficient method of selecting candidates for managerial posts. Israeli police have been using this candidate selection tool for many years. Dayan et al. (2002) assessed the validity of assessment centres as tools for selecting

the candidates for work at police; the participants also went through psychological tests. The participants took part in basic training and were assigned various police posts. The research among 712 participants included psychological tests, simulated situations, and colleagues´ assessment. They were in groups of 13 to 15 people and tasked to manage the situations similar to those from common police practice (e.g. to confiscate debtors´ assets, to evacuate protesters, to search for suspects, to arrest suspects, etc.), design a project (e.g. a campaign to hire new policemen), and prepare a five-minute verbal presentation on a given topic. They were assessed by a psychologist and an experienced police officer on scale from 1 to 7. Their results were compared with the superiors´ assessments after two years of practice, as well as with superiors´ regular assessments and colleagues´ regular assessments. The validity of simulated situations was high especially in relation to the training ($r = 0.34$) and work success rate ($r = 0.43$). Personality inventories had significantly lower validity (although statistically significant).

Research Methodology

During the research, soldiers were monitored when managing various tactical situations during a 3-day complex field training exercise, which took place from 28th February to 2nd March 2017 in the Březina Military Training Area. The aim of the complex field training exercise was to verify outcomes from the learning process in the accredited subject called Field Training II. In the second class, the students are trained to be squad commanders. A student should be capable of independent decision-making as a squad commander not only in tactical situations, but in the whole range of activities related to that post. He/she should be capable of implementing the individual steps of a planning and decision-making process on a squad level, so called Troop Leading Procedure (TLP). He/she should be able to analyse a situation from the platoon commander combat documents, determine options for the solution of a given task, make a decision and elaborate a squad commander battle order. The outcomes from learning on this stage of training also include the issuing of battle order in terrain. There were 44 soldiers, students from the University of Defence, participating in the training exercise.

During the training exercise the soldiers completed long movements in terrain with low food supplies and little time for rest and sleeping. Besides that, the soldiers had to fulfil given assignments while being assessed on the scale from 0 to 10 points.

1) Fire control:

It includes the target (enemy) identification, determination of its distance and direction, and issuing the fire order, or the fire assignment to the squad, or a weapon.

2) Battle order:

It includes the elaboration of the battle order based on the battle order from a superior level (platoon) while applying all steps of the TLP. The assessment was aimed mainly at a correct decision in relation to a tactical situation and the way the battle order was issued (the form of passing one's own decision to subordinates).

3) Radio operation:

It includes putting a RF-13 radiostation into operation, establishing connection and fulfilling pre-set operational assignments.

At the beginning, the soldiers were given a theoretical questionnaire (see Table 1) to be filled in. The questionnaire was designed in such a way that individual questions corresponded to the above mentioned practical assignments. The answers were assessed by the same evaluators on the basis of the same criteria as in practical training. The assessment of each soldier in research was thus based on both practical and theoretical solutions of individual tasks.

Table 1 – Questionnaire
Таблица 1 – Анкета-опросник
Табела 1 – Упитник

Combat assignment	Questions
Fire control	Write the types of fire orders and describe in detail, which information "full fire order" has to include. Write the ways of target designation and describe in detail, which information "direct target designation" has to include.
Battle order	How do you proceed when issuing battle order and what do you have to pay attention to?
Radio operation	How do you put a radio station into operation? What is a shortened form of a report (SALTR) transmitted to superior and subordinate radio stations? What information has to be included in it? What do you have to pay attention to?

The aim of the research was to verify statistically the relation between theoretical readiness and success to manage given tasks in practice. The Wilcoxon signed-rank test was used to test the difference between the outcomes achieved by the monitored group of soldiers in theoretical and practical parts of individual tasks. Then Spearman´s rank correlation coefficient was used to assess the strength of links between the scores in theoretical and practical parts.

Outcomes and Discussion

The outcomes of fulfilling individual combat assignments differed from each other significantly (see Table 2, Figures 1-3). The soldiers´ outcomes in the theoretical questionnaire were better than subsequent practical execution in case of all assignments. This difference was statistically significant only in the case of ”battle order” though. The outcomes in the practical part were much worse than in the theoretical one in this case. The assessment of the practical part was clearly the lowest of all the monitored assignments (average assessment 6.6). It may be assumed on the basis of such outcome that the practical fulfilment of the assignment “battle order” is much more difficult than its theoretical mastering. At the same time, the practical fulfilment of this particular assignment is significantly more difficult than in the case of other assessed assignments. The poor mastering of this assignment can be determined by the following factors:

1) It is a highly complex assignment;
2) The students were asked to fulfil this assignment for the first time;
3) The students do not have experience with acting in a commander role and are not able to interpret their decisions formally.

Issuing the battle order is a highly complex assignment, which requires considerable experience (which the students only start acquiring) and the ability to act publicly in the role of a commander (leader). The algorithm of issuing the battle order to subordinates in terrain was mastered by students very well theoretically. However, practical realization requires further training and repetition.

Table 2 – Average Assessment of Individual Combat Assignments
Таблица 2 – Средняя оценка отдельных боевых задач
Табела 2 – Просечна оцена појединачних борбених задатака

Combat assignment	theory	practice
Fire control	9	8.9
Battle order	8.3	6.6
Radio operation	9.4	9.2

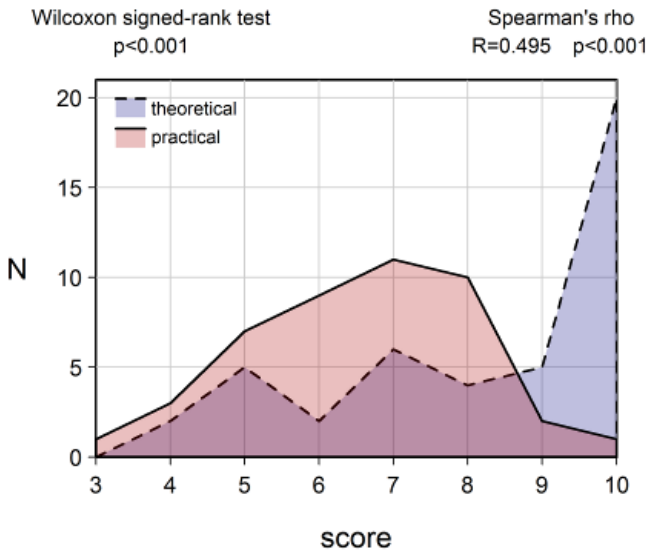

Figure 1 – Outcomes of assessing the "battle order" assignment
Рис. 1 – Результаты оценивания задачи «боевой порядок»
Слика 1 – Резултати оцењивања задатка "наређење за борбу"

On the other hand, the combat assignment called "fire control" did not show statistically significant difference between the outcomes of practical and theoretical parts (see Figure 2). The outcomes of all parts illustrated strong correlation (r = 0.621), which means that those soldiers who were successful in the theoretical part were successful also in the practical fulfilment of this task. Thus it may be assumed that the theoretical preparation for the fulfilment of this task is appropriate, because it increases soldiers´ chances to succeed in practice. Squad commander fire control has very clearly determined rules and order of given tasks and, in the case of the battle order, it is much easier for the students to master this task in theory than to implement the acquired knowledge in practice. Fire control is not such a complex activity as the issuing of the battle order and it can be carried out without a direct contact with subordinates (each squad member has his/her role in the formation and the squad commander controls fire just by issuing clearly determined orders). Moreover, this assignment does not include so high requirements for students´ expression capabilities as in the case of the battle order.

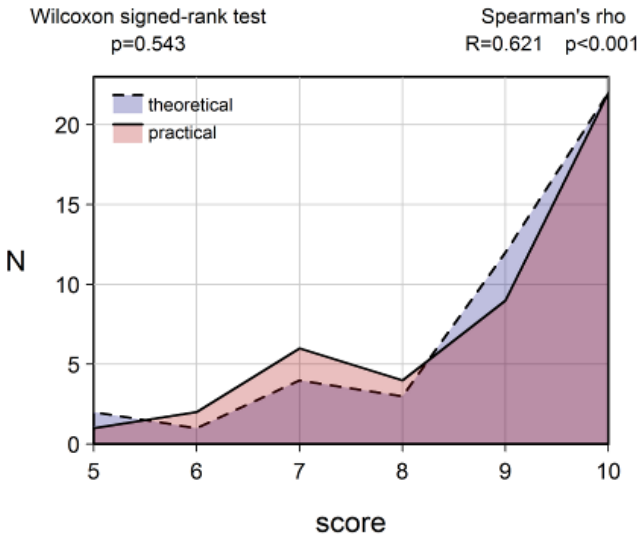

Figure 2 – Outcomes of assessing the "fire control" assignment
Рис. 2 – Результаты оценивания задачи «управление огнем»
Слика 2 – Резултати оцењивања задатка „управљање ватром"

The outcomes in the "radio operation" assignment are similar to those in the "fire control" assignment. No statistically significant difference was monitored between the outcomes of practical and theoretical parts. In contradistinction to the "fire control" assignment, there was only a weak correlation between the outcomes of theoretical and practical parts in the case of the "radio operation" assignment. Despite this fact, this correlation is statistically significant ($p = 0.031$) on the 0.05 significance level. The above mentioned correlation illustrates the fact that it was not difficult for the assessed soldiers to master the "radio operation" assignment. Practical fulfilment of such assignment is not pre-conditioned just by theoretical preparation, but other factors are involved as well. The theoretical mastering of radio-communication is a significant prerequisite for successful practice, in the same way as in the case of the "fire control" assignment. Moreover, the students carry out this activity usually not in the presence of the whole squad. Thus, radio-communication is not demanding as far as the performance in front of subordinates is concerned. Radio-communication has clearly set rules and routine terminology, so the theoretical mastering makes it easier to communicate through radio station. It is easy to handle a radio station, because it does not require any special technical knowledge.

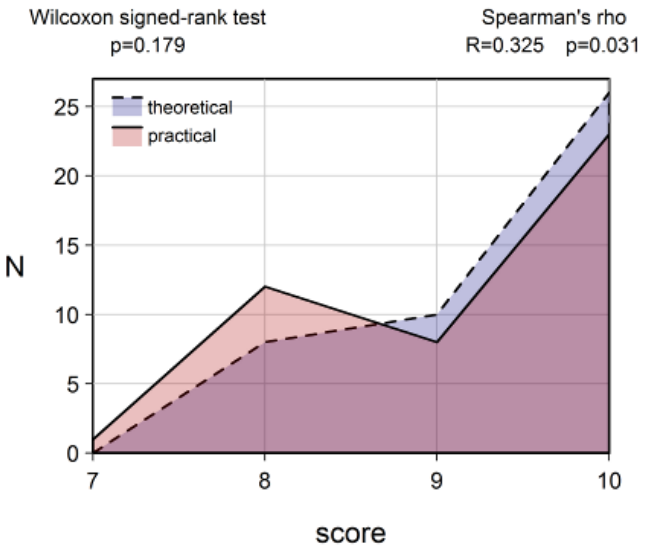

Figure 3 – Outcomes of assessing the "radio operation" assignment
Рис. 3 – Результаты оценивания задачи «организация радиосвязи»
Слика 3 – Резултати оцењивања задатка "комуникација путем радија"

Conclusion

It may be stated on the basis of the acquired outcomes that the assessment of theoretical solutions of selected combat assignments fulfilled by future squad commanders may be used for the prediction of how successful the management of such assignments may be in practice. Significant correlations between the outcomes of theoretical and practical solutions were recorded mainly in the case of the "fire control" assignment. Certain discrepancy between the outcomes in both parts was monitored in the case of the "battle order" assignment, as the students achieved systematically worse outcomes during the practical fulfilment. Such an outcome is probably pre-conditioned by the complexity of this assignment, which is not only about learning individual steps, but also about the students´ abilities to perform the roles of commanders. Fulfilment of such assignment requires, besides theoretical preparation, considerable personal experience, which the future commanders gain only through practice. Nevertheless, a medium-strong correlation between the assessment outcomes of theoretical and practical fulfilment of this assignment has been recorded even in that case.

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ПРОЦЕСС ПРИНЯТИЯ РЕШЕНИЙ ПРИ ВЫПОЛНЕНИИ ВОЕННЫХ ЗАДАЧ

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ОБЛАСТЬ: военные науки
ВИД СТАТЬИ: оригинальная научная статья
ЯЗЫК СТАТЬИ: английский

Резюме:

Предметом настоящей статьи является процесс принятия решений в кризисном управлении, с особым акцентом на Вооруженные силы Чешской Республики (курсанты Университета обороны в г. Брно). Исследование основано на наблюдениях за поведением 44 курсантов в различных тактических ситуациях, происходящих во время сложных трехнедельных полевых учений. Курсанты должны были выполнить следующие боевые задачи: управление огнем, боевой порядок и организация радиосвязи. До начала учений курсанты заполняли анкету-опросник, содержащий вышеупомянутые задачи. На основании полученных результатов можно утверждать, что оценивание теоретических решений отдельных боевых задач, которое будущие командиры подразделений привели в опросниках, может быть использовано при прогнозировании успешности управления анализируемыми боевыми задачами на практике.

Ключевые слова: Вооруженные силы Чешской Республики, солдат, пехотные подразделения, принятие решения, кризисная коммуникация.

ПРОЦЕС ОДЛУЧИВАЊА ТОКОМ ИЗВРШАВАЊА ЗАДАТАКА У ВОЈСЦИ

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ОБЛАСТ: војне науке
ВРСТА ЧЛАНКА: оригинални научни чланак
ЈЕЗИК ЧЛАНКА: енглески

Сажетак:

Чланак се бави процесом одлучивања у кризном менаџменту с нагласком на војску Републике Чешке (кадети на Универзитету одбране у Брну). Током истраживања, посматрана су 44 кадета у различитим тактичким ситуацијама током сложене тронедељне вежбе на терену. Од њих се тражило да изврше следеће борбене задатке: управљање ватром, наређење за борбу и комуникација путем радија. Пре тренинга, кадети су попунили упитник са питањима која су одговарала горе поменутим задацима у пракси. На основу добијених резултата, може се тврдити да оцена теоријског решавања изабраних борбених задатака међу будућим командирима јединица може да се користи за предвиђање успешности руковођења таквим задацима у пракси.

Кључне речи: Војска Републике Чешке, војник, јединица пешадије, процес одлучивања, кризно комуницирање.

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ПРЕГЛЕДНИ ЧЛАНЦИ

ОБЗОРНЫЕ СТАТЬИ

REVIEW PAPERS

CHARACTERISTICS OF POLYURETHANE AND ELASTOMER PARTS FOR SHOE INDUSTRY PRODUCED BY LIQUID INJECTION MOLDING TECHNOLOGY

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FIELD: Chemical Technology
ARTICLE TYPE: Review Paper
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Abstract:

This paper presents the characteristics of the materials used in footwear industry, with a particular emphasis on polyurethane materials for making soles. The role, purpose and design of soles are also discussed, as well as the requirements this part of the shoe should satisfy.

The manufacturing of polyurethane soles by liquid injection molding technology (LIM technology) is described, namely its two procedures. In the first one, the sole is obtained by pouring polyurethane into an open tool, and the second one is direct injection of polyurethane on the shoe upper in a closed tool, thus completing the production of finished footwear.

The results of testing the specimens cut out from three sole samples show that almost all quality requirements under technical specifications for this part of the shoe are met. The tested sole samples do not meet the formal requirements for tensile strength, although the values of this characteristic in a sample made of a polyurethane-rubber combination and a sample made of elastomeric material are very close to the set quality requirements.

Key words: polymeric materials, shoe soles, liquid injection molding technology, quality.

Introduction

Footwear, in one form or another, has been around for a long time. In ancient times, the simplest way to protect the foot was to use handy materials such as bark, leaves, grass and vines wrapped around the foot. The drawings in the caves of Spain originating from more than 15000 years ago show people with their feet wrapped in animal skin and fur. But since the time of ancient Rome to the present day, many types of footwear have survived, indicating that there were much more types of footwear than anyone could have expected. Therefore, the intensive development of production technology of footwear continues today, due to technical and technological solutions in the production of a variety of footwear (Groover, 2001).

In terms of technology, production is the application of physical and chemical processes in order to change the geometry, properties and/or appearance given to raw materials to produce parts or products. Production also includes completing more parts to create the product.

There are different types of materials used in footwear industry. The main materials used for making footwear are leather, synthetic polymers, rubber, plastics, textile materials, knitted materials, wood, cork and in some cases metal materials (http://www.publications.theseus.fi).

Polymers have become the main specialized materials for footwear industry. Simply put, polymer is a chemical compound composed of small molecules arranged in a simple structure to form larger molecules, or to the full definition, this is a chemical compound or a mixture of compounds obtained by polymerization and consisting essentially of repeating structural units (http://www.merriam-webster.com).

The importance of polymers in footwear industry is a result of efforts to use only the highest quality raw materials. This is very important because it is directly related to human health. This material is almost always in contact with human skin. Manufacturers of both plastic and elastomeric materials co-operate with manufacturers of footwear in order to develop new materials that must meet the requirements of today's shoes (Melo, Cavaco, 2012).

In short, footwear consists of an upper and a lower part. The footwear parts are shown in Figure 1. For the production of shoe uppers, leather is commonly used. Different polymeric materials are used to create lower parts of shoes - soles.

The lower part usually consists of the sole, the insole and the tread. To create soles, high-quality leather (vegetable rack) is used, while the production of insoles applies slightly less quality leather (vegetable part). For tread soles, different polymeric materials are commonly used. Polymeric soles should satisfy a number of requirements in order to achieve the best possible protection of footwear, being the footwear part in direct contact with the ground on which a person moves.

Figure 1 – Components of shoes (boots)
Рис. 1 – Составные части обуви (ботинка)
Слика 1 – Саставни делови обуће (чизме)

Soles, which are in contact with the ground, should meet the following requirements:

- Good adhesion to various substrates (soil, paving, asphalt, etc.)
- Good flexibility during walking,
- Low wear, which ensures a long service life of shoes,
- Good mechanical characteristics, which allow the strength and flexibility of the sole, depending on the physical and mechanical properties of the material used (tensile strength, elongation, etc.)
- Resistance to splitting, which may occur in contact with sharp objects (stones, nails, etc.)

– Slight, almost insignificant slipping on wet surfaces, ice and other slippery surfaces,
– Structural solution that enables easy separation from water, mud, stones, snow and reduce slippage,
– Medium hardness material that provides flexibility and comfort when walking, with less fatigue,
– Good and easy adhesion to the upper with the highest possible soleupper adhesion force when using standard adhesives,
– Low weight, and low-density materials,
– Tightness of the sole-upper bond.

Polymeric materials for footwear industry

It is considered that the durability of a material is directly proportional to its density. This attitude has a lot of exceptions, but it can be accepted as a simplified rule shown graphically in Figure 2.

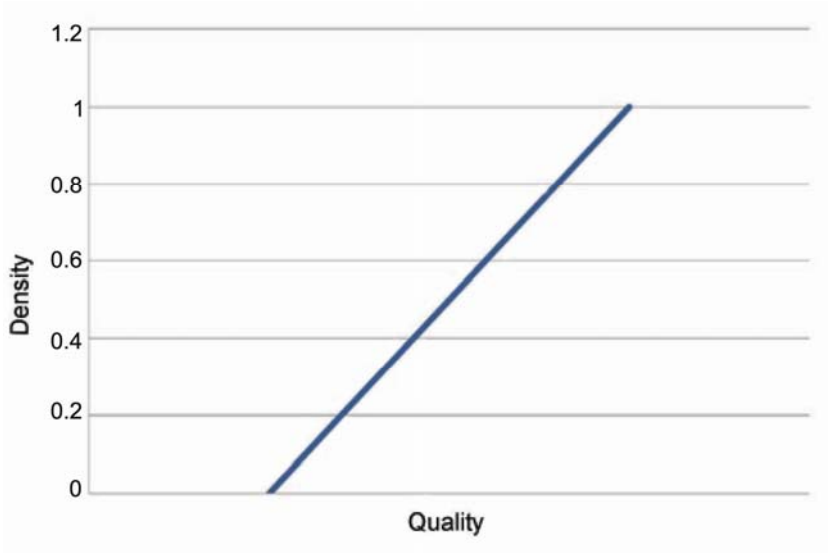

Figure 2 – Simplified quality-density dependence
Рис. 2 – Упрощенная взаимозависимость качество-плотность
Слика 2 – Упрошћена зависност квалитет–густина

A compact material of a relative density value of 1 or greater (relative density is the ratio of material density and water density) practically has no holes in it and is a "complete" material feature. If we look at, for example, abrasion resistance – particularly sole abrasion, this material will withstand

an abrasive contact for a long time because there is no place on the surface where material abrasion could begin.

A material the density of which is lower than the density of water must have a cell structure. Cells can be larger or smaller in size, they may be more or less connected to each other, i.e. materials may have open or closed cells. Figure 3 shows open cell (magnification 15×) and closed cell (magnification 35×) expanded materials - materials with a cellular structure (https://www.linkedin.com).

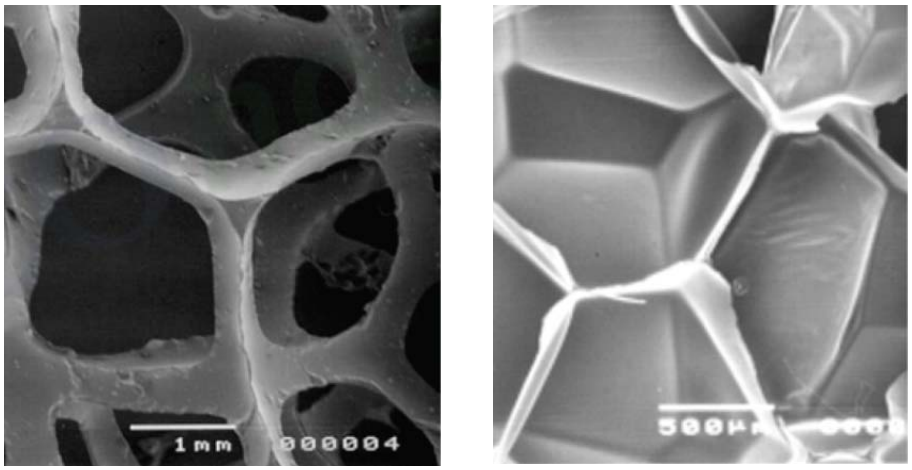

Figure 3 – Open cell (a) and closed cell (b) expanded materials
Рис. 3 – Открытые ячейки (а) закрытые ячейки (б) экспандированного материала
Слика 3 – Отворене ћелије (а) и затворене ћелије (б) експандираног материјала

The essence of the reduction in density of a material whose relative density is always greater than 1 is nothing more than making a cellular structure in which there are many gaseous components. It is important that there should be a lot of empty space (filled with a gas, regardless of whether it is air, carbon dioxide, or something else), so that the whole structure has less mass than water and therefore lower relative density. For example, if the abrasion resistance of different materials (from compact materials to materials of lower density) is shown in the form of a diagram, it will not be a straight line as in the simplified dependency, but more like a so-called point cloud, as shown in Figure 4.

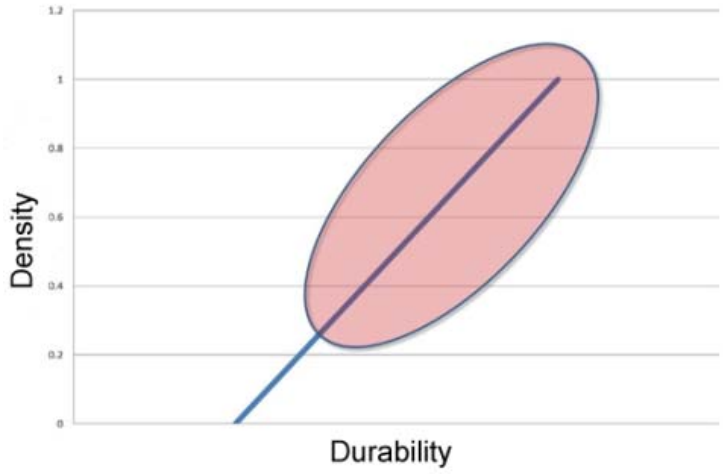

Figure 4 – The so-called cloud quality – density dependence
Рис. 4 – «Облачная» взаимозависимость качество-плотность
Слика 4 – Тзв. облак зависности квалитет–густина

If the aforementioned procedure is repeated for other features, there will be a similar graphical dependency. These data are the basis for assessing the quality of the materials for making shoe soles.

When it comes to compact materials, it is necessary to consider leather and vulcanized elastomeric materials. Although soles made of compact leather have their advantages, they also have certain drawbacks (lack of durability, decreased water resistance, poor insulation, problems with the design, etc.). Vulcanized elastomer materials have begun to be used as a material for soles about 50 years ago and represent a major technological achievement - rubber soles are waterproof and allow the foot to be warm and dry even in winter months (Mills, 2007).

The entire group of compact polyurethane materials (for example, thermoplastic polyurethanes) may have the characteristics listed as good features of the two aforementioned compact materials.

Polyurethanes are an important class of polymers resulting from a polycondensation reaction between different polyols, isocyanates and additives, which allows obtaining a wide range of polymers of various properties and applications.

As for durability, compact polyurethanes have a significant advantage in relation to compact materials, vulcanized rubber and leather, which is visible in Figure 5.

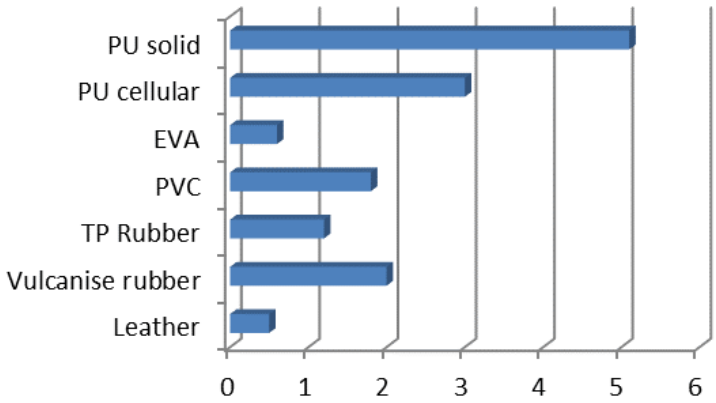

Figure 5 – Specific durability of materials for shoe soles
Рис. 5 – Удельная прочность материалов для подошв обуви
Слика 5 – Специфична трајност материјала за ђонове обуће

As far as materials of lower density are concerned, cellular, ie. expanded polyurethanes cover a wide range of density, starting from a compact high density material (density of about 0.9 g/cm^3 to 1 g/cm^3), through a common density of 0.6 g/cm^3 to 0.5 g/cm^3 for high-quality soles, from 0.5 g/cm^3 to 0.4 g/cm^3 for thicker and less quality soles for women's shoes, from 0.4 g/cm^3 to 0.3 g/cm^3 for lower quality soles for home shoes or slippers, to low density of 0.3 g/cm^3 to 0.2 g/cm^3 for insoles of sports shoes or flexible soles for comfortable footwear.

People often stop wearing particular shoes because they are not modern any more, but due to polyurethane durability, they still have value as used goods. Even if thrown away as waste, such footwear may be used with other solid waste as a fuel source.

Different polymeric materials (plastics, rubber materials, a combination of elastomeric materials - plastic materials, expanded materials, etc.) are used for sole production. The main reason to use the mentioned materials is the fulfilment of a large number of requirements; however, costs of both materials and the production technology must be taken into account.

In practice, the most commonly used elastomer materials are natural rubber (NR), thermoplastic rubber (TPR), styrenbytadien rubber (SBR) and bytadienakrylonitrile rubber (NBR).

The most commonly used plastic materials are polyurethane (PUR) and polyvinyl chloride (PVC), etc.

Lately, the soles of polyurethane systems, combined rubber-polyurethane soles, have been used for making sports shoes and boots. In addition to having the proper physical and mechanical characteristics, the lower part of the combined material (rubber) provides good adhesion to the substrate, and the upper part (polyurethane) provides the necessary strength of the bond with rubber and leather uppers. Often the upper part of the polyurethane mid-sole is constructively resolved so that, besides cementing, it is possible to stitch the sole and the upper, thus resulting in a stronger sole-upper adhesion force and a longer service life. In sports shoes, weight, design and elasticity are significant, while in protective footwear the emphasis is on comfort, durability and protection.

Polyurethane systems

Polyurethanes are plastic materials obtained by combining polyol and isocyanate; the basic chemical process of this system was discovered by Otto Bayer in 1937(http://www.polyurethanes.org).

Polyurethanes are prepared by the exothermic reaction between an alcohol with two or more reactive hydroxyl (-OH) groups per molecule (diols, triols, polyols) and isocyanates, which typically have two or more reactive isocyanate groups (-NCO) per molecule (e, diisocyanates, polyisocyanates). The basic process is the reaction of the polyurethane system; for example, a diisocyanate with a diol shown in the following Figure (Bayer, 1947, pp.257-272).

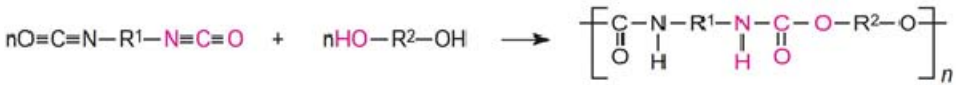

Figure 6 – The basic reaction of the polyurethane system
Рис. 6 – Базовая реакция полиуретановой системы
Слика 6 – Основна реакција полиуретанских система

The group obtained by the reaction of these two molecules is known as the "urethane bond" and represents an important part of the polyurethane molecule.

For the production of polyurethane shoe soles, the mentioned principle is used to control systems that comprise two components. One component is a polyol with terminal hydroxyl groups, and the other is a multifunctional diisocyanate. If necessary, color is added to the polyol component (Rosato et al, 2000).

Polyurethane systems for shoe soles can be based on polyester or polyether polyol or a polyol. These two systems have specific features; a choice of a system depends on the end use of shoes with such soles.

Polyester systems are, generally speaking, more reactive due to the fact that they are solid at room temperature and it is necessary to warm them up prior to use. Due to the fact that it is necessary to apply a high temperature in order to maintain polyester polyols in a liquid form, the manipulation of this component is somewhat difficult. As the system expands, material is heated and the temperature of the tool is reduced as well as the curing time. However, soles based on polyester systems are less durable and are subject to biological influence, ie. the effects of bacteria and fungi. These features are quite adequate for the footwear market with fast-changing designs and models (Yutaka et al, 2009, pp.3722-3742).

The largest number of isocyanates to be used for the production of polyurethanes have two or more isocyanate groups per molecule. The most commonly used isocyanates are aromatic diisocyanates, methyl benzene diisocyanate (better known as toluene diisocyanate TDI) and methylene diphenyl diisocyanate MDI (Urethanes Technology International, 2015).TDI was developed first, but is now mainly used for the production of flexible foam of low density for furniture industry (pillows, etc.). A mixture of diisocyanates known as TDI consists of two isomers (Figure 7):

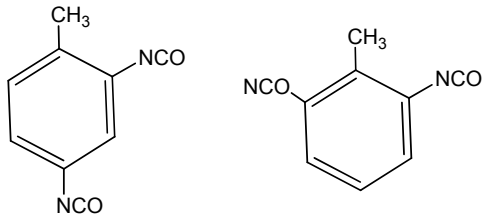

Figure 7 – TDI isomers
Рис. 7 – Изомеры TDI
Слика 7 – Изомери TDI

MDI is something more complex and allows a wider range of opportunities in polyurethane production in terms of technologies and end products. A mixture of MDI diisocyanate is commonly used for the production of rigid expanded materials. MDI includes the following diisocyanates, shown in Figure 8.

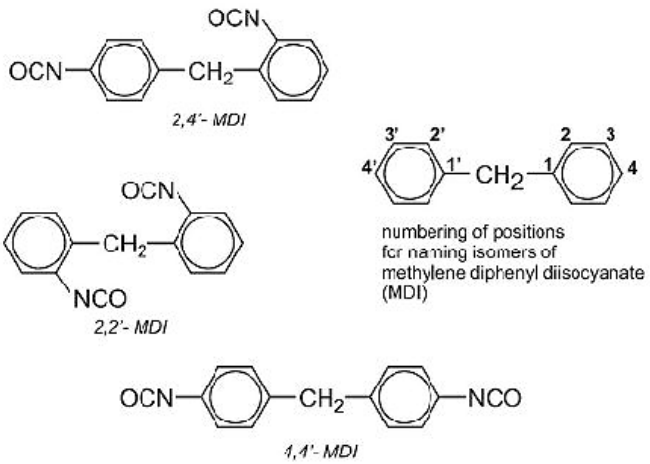

Figure 8 – A mixture of MDI
Рис. 8 – Смесь MDI
Слика 8 – Смеша MDI

The characteristics of the polyurethane material used for LIM (Liquid Injection Molding) technology for making soles are given in Table 1.

Table 1 – Characteristics of the polyurethane material for LIM technology
Таблица 1 – Характеристики полиуретанового материала для технологии LIM
Табела 1 – Карактеристике полиуретанског материјала за ЛИМ технологију

Characteristics	Testing method	Value
Density, g/cm^3	DIN 53420	0.62
Tensile strength, MPa	DIN 53455	10
Tensile elongation, %	DIN 53455	420
Tear resistance, kN/m	DIN 53515	20
Abrasion(mass loss), mg	DIN 53516	30
Hardness, HºSh A	DIN 53505	70
Resistance to folding	P-2 on 25ºC	> 20.000 foldings
Adhesion force of joint PUR sole-leather, N/cm	DIN 53530	50 ± 10

The production of polyurethane soles by liquid injection molding technology

Soles of polyurethane systems are produced by liquid injection molding (LIM) technology. It is an industrial production method that forms raw materials into a variety of products of a wide range of applications. This process includes weighing, mixing and pouring two liquid plastic components (http://www.chemtrend.com).

This technology is different from the standard process of reaction injection molding because it is based more on mechanical agitation than on forced stirring under pressure. In this way, a large number of parts with different characteristics can be produced.

Figure 9 shows the scheme of the equipment for liquid injection molding technology as well as the dependence of the viscosity on shear rate at characteristic locations of this equipment(http://www.xiameter.com).

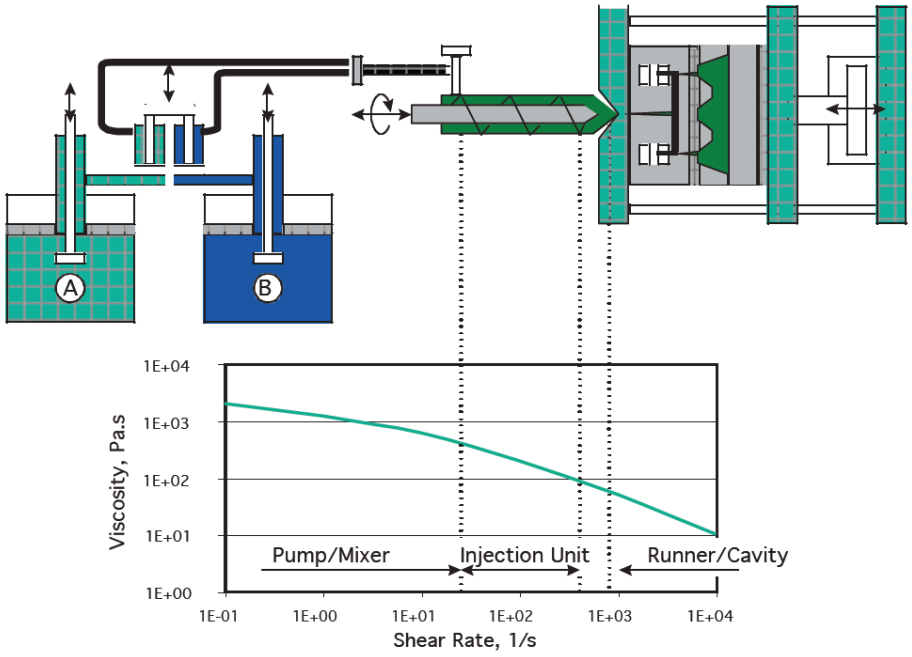

Figure 9 – Scheme of the equipment for injection molding technology
Рис. 9 – Схема оборудования для изготовления подошвы методом литья под давлением
Слика 9 – Шема опреме за технологију инјекционог обликовања

A photo of one type of an LIM technology machine is shown in Figure 10.

Figure 10 – One of the LIM technology machines
Рис. 10 – Машина применяемая в LIM технологии
Слика 10 – Једна од машина за ЛИМ технологију

The polyol component and the isocyanate component are mixed in the appropriate ratio and the resulting mixture is injected into a suitable tool mounted on an injection press. In these conditions, at the same time, the finished product is molded and the curing process occurs in the tool of proper temperature for a certain period of time. The tool is most frequently made of aluminium and its alloys.

For the production of polyurethane soles by the mentioned technology, two methods are commonly appled.

In the first method, a homogenised liquid mixture flows into the heated outdoor tool under low pressure, the tool closes, and after a certain time period, the tool opens and a sole is removed from the tool. Figure 11 shows the casting of the mixture into the tool, and Figure 12 - the extraction of the sole from the tool. This procedure produces lightweight soles which can be used for shoes, boots and sport shoes. Thus obtained polyurethane soles have better wear resistance than rubber soles and the possibility of colouring in the mass, so that they can be attached to nearly all kinds of shoes (http://www.essentialchemicalindustry.org).

Figure 11 – Casting mixture into the tool Figure
Рис. 11 – Заливка форм смесью
Слика 11 – Уливање смеше у алат

12– Removing the sole from the tool
Рис. 12 – Извлечение подошвы из формы
Слика 12 – Вађење ђона из алата

In Figure 13, soles of different designs are shown. Soles are attached to uppers by gluing and sometimes also by stitching to obtain higher bond strength.

Figure 13 – Polyurethane soles obtained by technology
Рис. 13 – Полиуретановая подошва, изготовленная методом LIM
Слика 13 – Полиуретански ђонови добијени ЛИМ технологијом

The second method is a method of direct injection of a polyurethane sole onto the shoe upper. Figure 14 shows the basic stages of this process in the manufacture of boots.

A boot upper placed onto the upper movable mold part slowly descends to the lower embossing tool (left top). After setting the boot upper onto the lower mold part (right top), the tool closes completely and the polyurethane system is injected to form a sole (right bottom). Depending on the applied PUR system, the size of the sole and the equipment used, the innjection time is from 15 s to 40 s. The temperature of the tool and the curing time also depend on the system used and the size of the polyurethane sole. The tool temperature is usually from 25 °C to 95 °C and the time of cementing the PUR sole with the boot upper in a compact unit is from 5 minutes to 8 minutes. After this time, the tool is opened and the boot is removed from the tool in about 10 seconds; the tool is then ready for the next cycle of this process (left bottom).

PUR soles are manufactured by the described procedures with equipment that may have dozens of complete tools and a system for injecting polyurethane system(http://www.medical.saint-gobain.com).

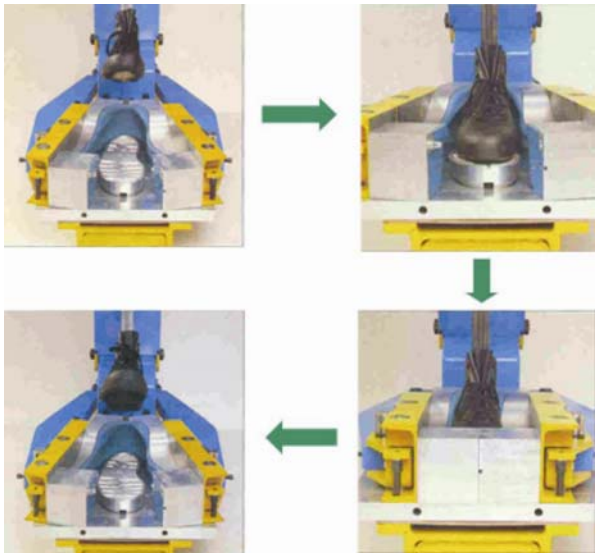

Figure 14 – Four stages of the process of direct polyurethane sole injection onto the boot upper
Рис. 14 – Четыре этапа процесса прямого литья полиуретановой подошвы на верх ботинка
Слика 14 – Четири фазе поступка директног убризгавања полиуеранског ђона на горњиште чизме

Quality requirements for soles

The quality requirements for boot soles with leather uppers in accordance with relevant technical specifications are listed in Table 2.

Table 2 – Quality requirements for boot soles
Таблица 2 – Требования к качеству подошвы для обуви высокого покроя
Табела 2 – Захтеви квалитета ђонова за чизме

Characteristics	Testing method	Quality demands
Density, g/cm^3	SRPS ISO 2781:1997	1.15 ± 0.03
Hardness,H°ShA	SRPS ISO 7619-1:2014	65 ± 5
Abrasion, mm^3	SRPS ISO 4649:2014	max135
Tensile strength, N/mm^2	SRPS ISO 37:2004	min12
Tensile elongation, %	SRPS ISO 37:2004	min280
Tearing resistance,N/mm	SRPS ISOG.S2.735	Min 27

Results and Discussion

In this paper, we tested the characteristics of a sole made of an elastomeric material (sample 1), a sole made of a combined rubber and polyurethane material (sample 2) and a sole made of a thermoplastic elastomer material (sample 3). The test results are given in Table 3.

Table 3 – Results of testing the soles
Таблица 3 – Результаты испытаний подошв
Табела 3 – Резултати испитивања ђонова

Characteristics*	Testing method	Quality demands	Sample 1	Sample 2	Sample 3
Density, g/cm^3	SRPS ISO 2781:1997	1.15 ± 0.03	1.25	1.13	1.16
Hardness,H °Sh A	SRPS ISO 7619-1:2014	65 ± 5	70	70	75
Abrasion, mm^3	SRPS ISO 4649:2014	max 135	93.8	142	78
Tensile strength, N/mm^2	SRPS ISO 37:2004	min12	11	11.6	8.3
Tensile elongation, %	SRPS ISO 37:2004	min280	550	775	450

Characteristics*	Testing method	Quality demands	Sample 1	Sample 2	Sample 3
Tearing resistance, N/mm	SRPS ISO G.S2.735	min27	39.8	33	53.4
Resistance to bending (De Mattia device, 130.000 cycles)	SRPS ISO 123:2014	No cracks	No cracks	No cracks	No cracks

* Test specimens for testing the characteristics were clipped off from the sole samples.

The analysis of the quality requirements and the obtained results of testing the specimens have shown:

- The lowest wear value (78 mm^3) occurs in sample 3, while sample 2 has the highest one (142 mm^3)
- Samples 2 and 3 have almost the same tensile strength (11 N / mm^2 and 11.6 N/mm^2), while sample 1 has a significantly lower value of this property (8.3 N / mm^2),
- Sample 2 shows the highest elongation value (775%), and sample 3 the lowest one (450%),
- Splitting resistance, which can be seen as structural strength, is highest in sample 3 (53.4 N/mm), and lowest in sample 2 (33 N/mm),
- The results of testing resistance to bending, hardness and density are similar for all three samples of the tested soles.

Conclusion

The characteristics of the materials used in footwear industry are given, with a particular emphasis on polyurethane materials for making soles. The characteristics of the components are described as well as the basic chemical reactions, processing technology and the physical mechanical characteristics of this system.

The materials that can be used in footwear industry, primarily for the production of shoe soles, have been presented. Also discussed are the role, purpose and design of soles, as well as the requirements that this shoe part should satisfy.The manufacture of polyurethane soles by liquid injection molding technology (LIM technology) is presented, two of its procedures in particular:

– The procedure of casting polyurethane material into the open tool and obtaining a sole as a component for further production, and
– The procedure of obtaining a sole directly by injecting polyurethane material onto the leather boot upper, which ends in a finished product.

The results of testing the specimens cut out from three sole samples show that almost all quality requirements from the technical specifications for this part of the shoe have been met.

The tested sole samples do not meet the formal requirements for tensile strength, although the values of this characteristic in the polyurethane-rubber sample and the elastomeric sample are very close to the set quality requirement.

The thermoplastic elastomer sole sample has a considerably smaller tensile strength and slightly higher hardness relative to the defined quality requirements for these two properties.

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ПОЛИУРЕТАНОВЫЕ И ЭЛАСТОМЕРНЫЕ ЧАСТИ ДЛЯ ПРОИЗВОДСТВА ОБУВИ МЕТОДОМ ПРЯМОГО ЛИТЬЯ ПОД ДАВЛЕНИЕМ

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ОБЛАСТЬ: химические технологии
ВИД СТАТЬИ: обзорная статья
ЯЗЫК СТАТЬИ: английский

Резюме:

В данной работе описаны характеристики материалов, используемых в производстве обуви, подчеркнута роль полиуретановых материалов в изготовлении подошв. Также описаны назначение, функция и конструкция подошвы, в том числе требования к качеству ее изготовления. Описаны производственные процессы полиуретановых подошв, изготовленных методом прямого литья под давлением (ЛИМ технология). В качестве иллюстрации приведено описание двух методов данной технологии. Первый метод подразумевает заливку полиуретана в открытую форму, а второй - жидкое формирование на затянутой заготовке верха обуви. Результаты анализа образцов, взятых с трех видов подошв, подтвердили соответствие требованиям к качеству, предписанных технической спецификацией по данному виду обуви. Несмотря на то, что испытанные образцы подошв формально не выдержали испытания на прочность, значения параметров образцов из комбинированного материала резина-полиуриетан и образцов из эластомерных материалов достаточно близки к установленным требованиям к качеству.

Ключевые слова: полимерные материалы, подошвы для обуви, технология прямого литья под давлением, качество.

ПОЛИУРЕТАНСКИ И ЕЛАСТОМЕРНИ ДЕЛОВИ ЗА ИНДУСТРИЈУ ОБУЋЕ ДОБИЈЕНИ ТЕХНОЛОГИЈОМ ТЕЧНОГ ИЊЕКЦИОНОГ ОБЛИКОВАЊА

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ОБЛАСТ: хемијске технологије
ВРСТА ЧЛАНКА: прегледни чланак
ЈЕЗИК ЧЛАНКА: енглески

Резиме:

У раду су наведене карактеристике материјала који се користе у индустрији обуће, са посебним освртом на полиуретанске материјале за израду ђонова. Размотрена је улога, намена и конструкција ђонова, као и захтеви које би овај део обуће требало да задовољи.

Описана је производња полиуретанских ђонова технологијом течног ињекционог обликовања (ЛИМ технологија).Описана су два поступка ове технологије. У првом се ђон добија уливањем полиуретана у отворени алат, а у другом директним убризгавањем полиуретана на горњиште обуће у затворени алат, чиме се завршава израда комплетне обуће.

Резултати испитивања епрувета, исечених из три узорка ђонова, указују на испуњење скоро свих захтева квалитета према техничкој спецификацији за овај део обуће. Испитивани узорци ђонова формално не задовољавају захтев за прекидну чврстоћу, мада су вредности ове карактеристике код узорка урађеног од комбинованог материјала гума-полиуретан и узорка од еластомерног материјала врло близу постављеног захтева квалитета.

Кључне речи: полимерни материјали, ђонови обуће, технологија течног ињекционог обликовања, квалитет.

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СТРУЧНИ ЧЛАНЦИ
ПРОФЕССИОНАЛЬНЫЕ СТАТЬИ
PROFESSIONAL PAPERS

DIESEL FUEL FILTRATION PROBLEMS WITH MODERN COMMON RAIL INJECTION SYSTEMS

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Summary:

Modern diesel fuel injection systems called "common rail systems" have been increasingly developing over the past two years. Along with the development of such systems it has been, at the same time, necessary to follow the development of ancillary systems used for their proper and efficient operation. This paper provides a detailed presentation of the

latest generation of common rail systems operating at high pressure together with problems regarding diesel fuel filtration.

Key words: common rail systems, pumps, maintenance, fuel filtration, diesel fuel, filters.

Introduction

Modern common rail systems designed for diesel fuel injection represent the main type of fuel distribution in diesel engines. The traditional conception of fuel injection with in-line or rotational piston pumps that operates at low working pressures is gradually abandoned due to high environmental requirements being introduced in industrial developed countries. Additionally, with imposition of very strict regulations with regard to environmental issues, manufactures of diesel fuel injection systems have to adapt to both the regulations and laws and the market itself.

Lately, on the global market of common rail system manufacturers, there have been several companies supplying the global automotive industry (passenger, freight, special purpose army vehicles, diesel-electric generators sets, etc).

Among the global suppliers of common rail systems, the major ones are: Cummins, Denso, Delphi, Bosch, Heinzmann, Ganser, Liebherr, Mercedes, Mitshubishi, MTU (Motoren Turbinen und Union-Germany), Perkins, Rollce Royse, Siemens, etc.

Denso, Delphi, Bosch and Siemens are the manufacturers of fuel injection systems designed primarily for passenger, light commercial and freight vehicles, while Cummins, HeinzmannPerkins, Mitshubishi, Rollce Royce, Ganser, Liebherr are primarily oriented to high-horsepower engines for heavy freight vehicles, off-road vehicles, navy, railways, etc.

Some manufacturers of modern common rail (CR) systems, such as Denso, have been continuously developing new designs, thus giving a new task to other manufacturers. Since the end of the first quarter of 2016, Denso has been planning the start-up of its latest common rail system design operating at 3000 bars (Hydac, 2015b).

Fuel injection systems operating at high working pressures require clean fuel with as few contaminants as possible, such as solid particles and water. The function of new fuel filtration systems is to maintain the quality of fuel at the required cleanliness level.

Development of CR systems and gas emission regulations

Many well-known international manufacturers of diesel engines and diesel engine components have been involved in design and development of CR systems. Among them are: Cummins, Denso, Delphi, Bosch (Fiat), Heinzmann, Ganser, Liebherr, Siemens and others. Since 1995, when the Japanese Denso introduced the first CR systems into commercial production (Denso, 2016), (240 landmarks of Japanese automotive technology, 2016), other international manufacturers have joined the race.

Some manufacturers have developed CR system generation operating at 2000 – 2500 bars, for low-horsepower engines (passenger vehicles and light commercial vehicles). The major ones of them are: Denso, Bosch and Delphi.

Back in 2002, Denso launched systems operating at 1800 bar working pressure, then in 2008, systems operating at 2000 bars, and finally in 2013 systems operating at 2500 bars appeared on the market (Denso, 2016).

Bosch develops their CR system designs in cooperation with the FIAT development centre who was among of the first ones to initiate the development of modern CR systems. Due to some difficulties, FIAT integrated with Bosch to start mutual development of fuel injection systems (Petruzzelli, 2013), (Robert Bosch GmbH, 2010). In 1997, Bosch developed a system operating at 1350 bar working pressure (Robert Bosch GmbH, 2009), in 1999 the working pressure was increased to 1400 bars (Robert Bosch GmbH, 2009), in 2001 to 1600 bars (Robert Bosch GmbH, 2009), (Robert Bosch GmbH, 2011a), and in 2007 with a new pump and injector generation the working pressure was increased to 2000 bars (Robert Bosch GmbH, 2009), (Robert Bosch GmbH, 2014). At the beginning of 2015, Bosch increased the working pressure to 2500 bars (Robert Bosch GmbH, 2011b) for passenger cars and light commercial vehicles, and to 2700 bars for heavy freight vehicles (Robert Bosch GmbH, 2015).

Delphi – the leading American manufacturer of CR systems was following the development of CR systems by other international manufacturers, to launch, at the end of the ‘90s, its own series of CR systems operating at 1400 bars, which resulted in the latest generations that operate at 2000 up to 2700 bars (Delphi France SAS, 2007), (Knight et al, 2012), (Meek et al, 2014).

Based on the above mentioned, we can conclude that the majority of international manufacturers have developed the latest generation of CR

systems operating at 2000-2700 bar working pressures, except for Denso and Delphi who have developed CR system designs operating at 3000 bars, which are currently being tested by engine manufacturers. We can emphasize that the latest CR system designs operating at 2500 bars, comparing to 2000 bars, show higher efficiency in fuel consumption up to 3%, decrease in solid particles in exhaust gasses even up to 50%, as well as decrease in nitrogen oxides from exhaust gasses up to 8% comparing to previous generation operating at up to 2000 bars (Denso, 2016). By increasing the working pressure in CR systems to higher levels, lower emissions of harmful compounds are obtained (primarily NOx) as well as lower soot emissions, i.e. solid particles in exhaust gasses. This is very important in respect to environmental regulations, laws and standards being currently in force and new regulations that will be even more stringent (new Euro 7 standard regarding gas emissions has been announced).

In the European Union, passenger cars and light commercial vehicles produce about 15% of the total quantity of CO_2 emissions, while heavy road vehicles produce about 20% of CO_2 emissions (European Comission, 2007), (http://ec.europa.eu, 2016).

There was sudden increase in relative CO_2 emission obtained from combustion of fossil fuels in road traffic, from 21% of the total quantity in 1990 up to 28% in 2004 (European Comission, 2007), (Mulvey, 2007), (Suellentrop, 2007). Although there were considerable improvements in engine manufacturing technologies during the past few years – especially regarding fuel consumption efficiency, which reflects in lower CO_2 emissions – they were insufficient regarding neutralization of the effect of increased traffic. EU – 25 directive relating to reduction of total gas emissions resulted in the reduction of the greenhouse effect by nearly 5% between 1990 and 2004; however, CO_2 emission from road traffic increased by 26% (European Comission, 2007).

Currently, hydrocarbons emission (HC), nitrogen oxides (NOx), nonmethane hydrocarbons (NMHC), carbon monoxide (CO) and particulate matter (PM) emissions, have been regulated by particular European norms for the majority of vehicle types, including cars, trucks, trains, tractors and similar engines, but excluding marine engines and airplanes. Different standards apply to each type of vehicles.

Newly produced models of vehicles have to fulfil current and planned standards. EU Regulative No. 443/2009 prescribes an average CO_2 target emission for new passenger cars at the level of 130 g/km, which was to be implemented in phases between 2012 and 2015. From 2015 to 2021, target emission is only 95 g/km and it will apply from 2021. For light commercial

vehicles CO_2 emission will be 175 g/km starting from 2017, and 147 g/km from 2020 (International Council on Clean Transportation, 2014).

According to the EU norms, allowed quantity of emissions of air pollutants is defined according to the emission standards relating to certain groups of vehicles classified according to their size and purpose. The emission standards for motor vehicles are classified in the following categories: passenger vehicles, light commercial vehicles (several categories depending on transport capacity), trucks and busses, large freight vehicles and off-road vehicles (agricultural, construction, mining and other vehicles).

Passenger vehicles and light commercial vehicles are the most used vehicles in road transport, so the following tables show the European emission standards for passenger and light commercial vehicles powered by diesel engines.

Table 1 – European emission standards for passenger cars (Category M), g/km*
Таблица 1 – Европейские стандарты выхлопных газов для легковых автомобилей (категория M), г/км*
Табела 1 – Европски емисиони стандарди за путничка возила (категорија M), g/km*

Tier	Date	CO	THC	NMHC	NOx	HC+NOx	PM	P[km]
Euro 1♣	July 1992	2.72 (3.16)	-	-	-	0.97 (1.13)	0.14 (0.18)	-
Euro 2	January 1996	1.0	-	-	-	0.7	0.08	-
Euro 3	January 2000	0.64	-	-	0.5	0.56	0.05	-
Euro 4	January 2005	0.5	-	-	0.25	0.3	0.025	-
Euro 5a	September 2009	0.5	-	-	0.18	0.23	0.005	-
Euro 5b	September 2011	0.5	-	-	0.18	0.23	0.005	$6x10^{11}$
Euro 6	September 2014	0.5	-	-	0.08	0.17	0.005	$6x10^{11}$

* Before Euro 5, passenger vehicles>2500 kg were type approved as light commercial vehicles N_1-I
♣ Values in parentheses are conformity of production (COP) limits

For light commercial (transport) vehicles from N_1-I category, the allowed level of some particles according to the Euro standards is the same as in the previous Table relating to passenger vehicles. It can be seen from the notes in Table 1, where passenger vehicles up to Euro 5 norm are classified as light commercial vehicles.

Table 2 – European emission standards for light commercial vehicles 1305–1760 kg (Category N_1-II), g/km
Таблица 2 – Европейские стандарты выхлопных газов для легких коммерческих автомобилей 1305 -1760 кг (категория N_1-II), г/км
Табела 2 – Европски емисиони стандарди за лака комерцијална возила 1305–1760 kg (категорија H_1-II), g/km

Tier	Date	CO	THC	NMHC	NOx	HC+NOx	PM	P[km]
Euro 1	October 1994	5.17	-	-	-	1.4	0.19	-
Euro 2	January 1998	1.25	-	-	-	1.0	0.12	-
Euro 3	January 2001	0.8	-	-	0.65	0.72	0.07	-
Euro 4	January 2006	0.63	-	-	0.33	0.39	0.04	-
Euro 5a	September 2010	0.63	-	-	0.235	0.295	0.005	-
Euro 5b	September 2011	0.63	-	-	0.235	0.295	0.005	$6x10^{11}$
Euro 6	September 2015	0.63	-	-	0.105	0.195	0.005	$6x10^{11}$

Table 3 – European emission standards for light commercial vehicles >1760 kg max 3500 kg. (Category N_1-III & N_2), g/km
Таблица 3 – Европейские стандарты выхлопных газов для легких коммерческих автомобилей >1760 кг макс. 3500 кг. (категория H_1-III & H_2), г/км
Табела 3 – Европски емисиони стандарди за лака комерцијална возила >1760 kg макс. 3500 kg (категорија H_1-III & H_2), g/km

Tier	Date	CO	THC	NMHC	NOx	HC+NOx	PM	P[km]
Euro 1	October 1994	6.9	-	-	-	1.7	0.25	-
Euro 2	January 1998	1.5	-	-	-	1.2	0.17	-
Euro 3	January 2001	0.95	-	-	0.78	0.86	0.1	-
Euro 4	January 2006	0.74	-	-	0.39	0.46	0.06	-
Euro 5a	September 2010	0.74	-	-	0.28	0.35	0.005	-
Euro 5b	September 2011	0.74	-	-	0.28	0.35	0.005	$6x10^{11}$
Euro 6	September 2015	0.74	-	-	0.125	0.215	0.005	$6x10^{11}$

After Euro 2, EU regulations introduced different emission limits for petrol and diesel engines. Diesel engines have more stringent CO_2 standards but are allowed higher NOx emissions.

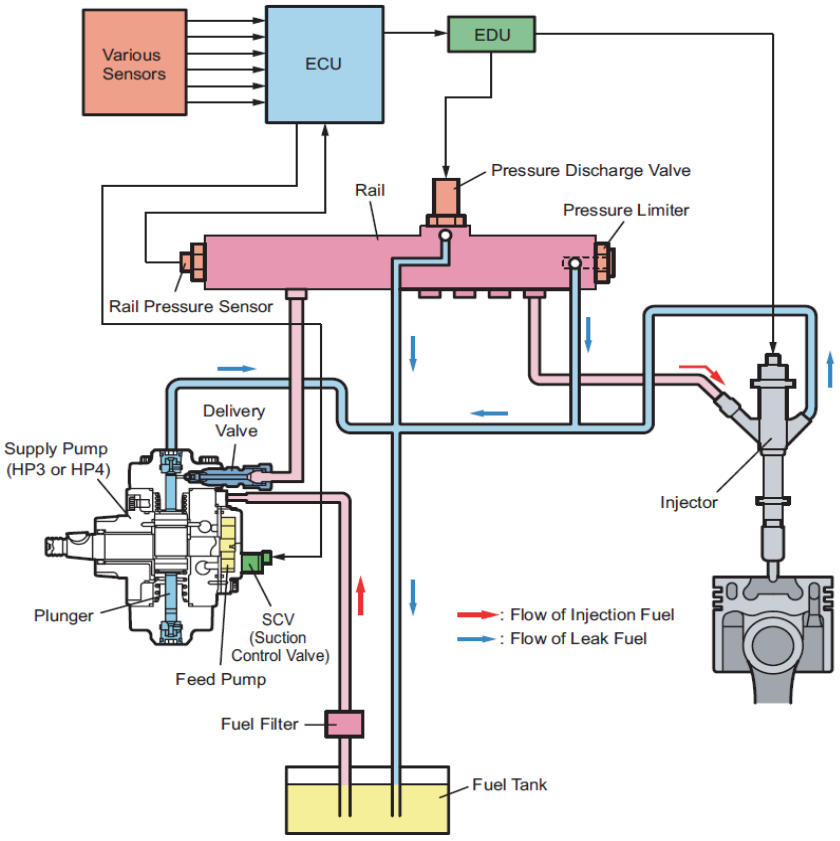
The above presented Tables 1, 2 and 3 show that diesel-powered vehicles with direct injection are subjected to limited emissions of 0.005 g/km according to Euro 5 and Euro 6 norms that were introduced in 2010-2014, depending on the type of vehicle (passenger or light commercial vehicles of certain transport capacity) (Macaudière & Matthess, 2013), (Emission Standards European Union, 2015), (The European Parliament and the Council of the European Union, 2007).

Based on European norms and standards, the majority of manufacturers of direct injection diesel engines have decided on development of engines with minimum emission of harmful substances. In order to achieve that, leading manufacturers of diesel injection systems are trying to improve the existing direct injection systems by developing new designs of injection systems and their accompanying components such as filtration systems, which enable their efficient and reliable operation. Additionally, development of new common rail systems is aimed towards gradual abandoning of Diesel Particulate Filters (DPF), which in the exhaust section of the system cause certain problems during the engine exploitation due to accumulation of soot particles.

Modern CR systems

Figure 1 shows a Denso fuel injection system of older generation. The system consists of the driving part of the system, where two pumps have been connected to the same drive shaft.

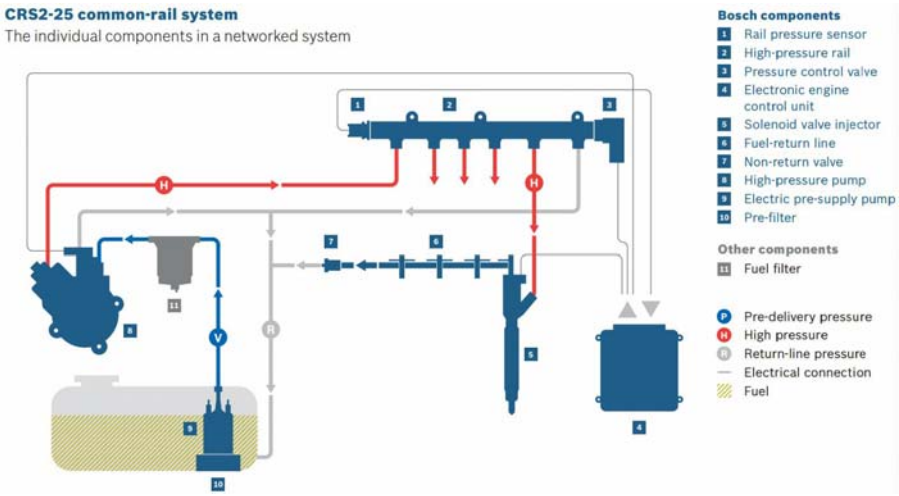
The first pump (SCV) is the supply pump that supplies fuel from the tank up to the distribution pump which distributes the fuel further into the system through the delivery valve up to the high-pressure accumulation reservoir. From the accumulation reservoir, the fuel under high pressure (approx. 2000 bars), is distributed up to the injector that contains electronically controlled valves controlled by an electronic control unit (ECU and EDU). The excessive fuel that appears during the injector operation or because of transgression of the preset pressure of the accumulation reservoir will be returned through the return lines directly into the reservoir.



Picture 1 – CR system example (Denso, 2007)
Рис. 1 – Пример системы common rail (Denso, 2007)
Слика 1 – Пример једног common rail система (Denso, 2007)

Modern generation of CR systems, manufactured by Bosch and Rolls Royce, are shown in Figures 2 and 3. Bosch modern injectors CRS3-27 are built around fast-switching piezo injectors that always inject the optimum amount of fuel into the cylinders for clean and economical combustion.

The CRI3-27 piezo injectors lead the way in multiple injection technology due to their capability for smallest pilot injection quantities, fast injection sequences, and low injection quantity drift over system lifetime.

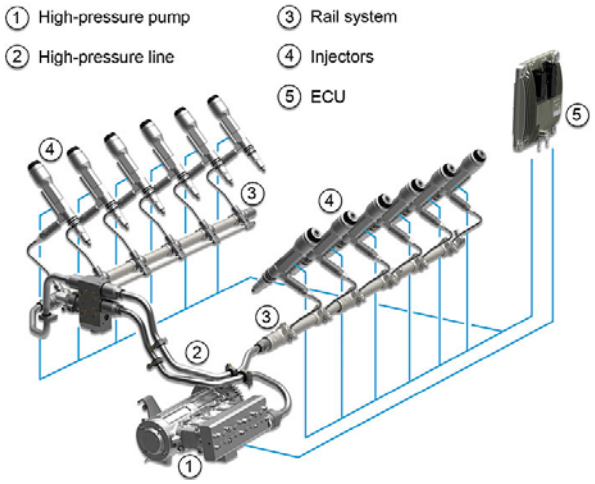


Picture 2 – Example of a modern CR system (Robert Bosch CRS 3-27, 2015)
Рис. 2 – Пример современной системы Bosch common rail (Robert Bosch CRS 3-27, 2015)
Слика 2 – Пример савременог Bosch common rail система (Robert Bosch CRS 3-27*, 2015)*

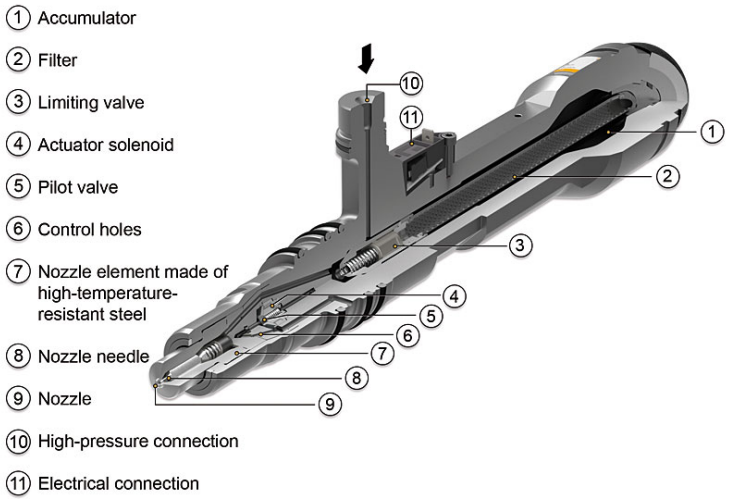
Because the piezo actuator is integrated into the injector body, the injectors are slim and require much optimized packaging than their solenoid valve counterparts. Due to their robust piezo principle, the injectors are compatible with various fuel qualities for various fuel qualities. The piezo actuator generates approximately ten times the force of solenoid valves. Therefore, the piezo injector is less sensitive against particle contaminated fuel.

Rolls Royce CR system with fuel accumulator injectors (see Figure 3*).* Because of its performance capabilities, the CR system has established itself as standard equipment on car diesel engines in the course of the last few years. The version of the system as described is also well suited for use in small capacity industrial engines. In the case of engines with larger cylinder capacities, however, the conventional CR system is now revealing its limitations, since these require a relatively large quantity of fuel to be injected into the cylinder for each ignition stroke. This produces pressure pulsations in the CR system's fuel reservoir that can interfere with the subsequent injection sequences. Since 2000, MTU has used an advanced version of the common rail system for the Series 4000 and 8000 engine, and since 2004 for the Series 4000 as well, in which the fuel injectors have an integrated fuel reservoir (see Figure 4). This permits the fuel lines between the injectors and the CR to have a relatively small cross section.

During an injection sequence, all that happens is that the pressure in the injector's own fuel reservoir drops slightly. This prevents pressure fluctuations in the common rail system and, therefore, a momentary undersupply or oversupply of fuel to the injectors.



Picture 3 – Example of a modern MTU Rolls Royce CR system (Kech, 2014)
Рис. 3 – Пример современной системы MTU Rolls Royce common rail (Kech, 2014)
Слика 3 – Пример савременог MTU Rolls Royce common rail система (Kech, 2014)

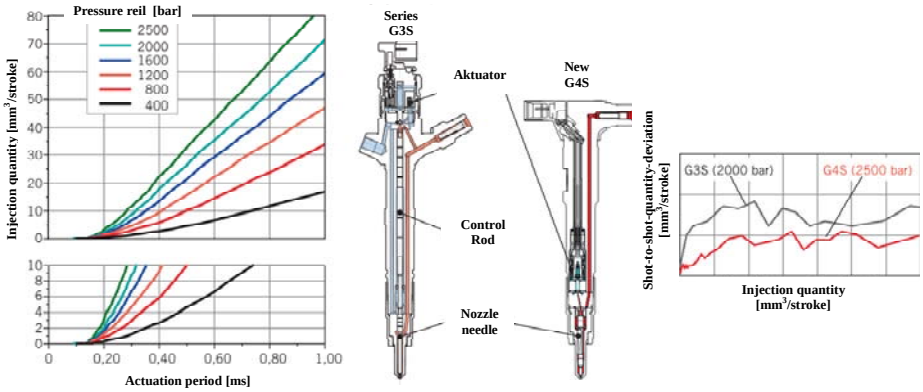


Picture 4 – Injector with the integrated fuel reservoir (Kech, 2014)
Рис. 4 – Форсунка со встроенным топливным аккумулятором (Kech, 2014)
Слика 4 – Инјектор са интегрисаним акумулатором горива (Kech, 2014)

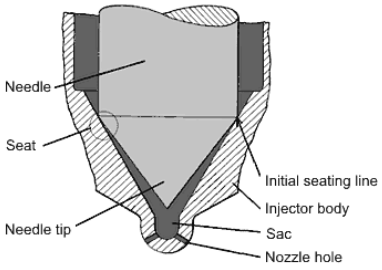
Modern injectors of the last generation, operating at 2000-2500 bars, have 100 – 200 μm nozzles at the injector discharge line for the purpose of producing an optimum fuel spray and mist out of the minimum fuel quantity, which again creates a problem regarding the quality and cleanliness of the fuel.

Figure 5 shows a new generation injector G4S produced by Denso, which, comparing to earlier injector types, performs a faster injection cycle along with smaller fuel consumption.

Modern injectors have contact surface clearances between the needle and the seat of 2-5 μm, so that care must be taken that the working fluid is clean. Figure 6 shows the cross section of the injection part of the injector and the needle; the needle moves up and down performing the distribution of fuel into the nozzle part of the injector.



Picture 5 – Comparison of the old (G3S – 2000 bar) and the new (G4S – 2500 bar) injector generation (*Matsumoto et al, 2013)*
Рис. 5 – Сопоставление старых образцов форсунок (Г3С – 2000 бар) с новыми (Г4С – 2500 бар) (Matsumoto et al, 2013)
Слика 5 – Поређење инјектора старије (Г3С – 2000 бар) и новије генерације (Г4С – 2500 бар) (Matsumoto et al, 2013)



Picture 6 – Cross sectional view of the top of the fuel injector
Рис. 6 – Изображение поперечного сечения наконечника форсунки
Слика 6 – Приказ пресека врхног дела инјектора

Figure 7a shows the nozzle part of the injector when it is new, Figure 7b shows it during the exploitation and Figure 7c shows it after it has been damaged due to improper maintenance and fuel filtration.

a b c

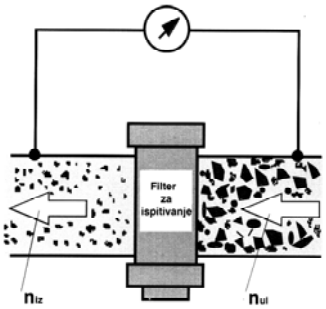
Picture 7 – Look of the damaged nozzle (Common rail Injectors FAQ – triplet diesel injection – Waco, 2011)
Рис. 7 – Изображение поврежденного сопла форсунки (Common rail Injectors FAQ – triplet diesel injection – Waco, 2011)
Слика 7 – Приказ изгледа оштећене млазнице (Common rail Injectors FAQ – triplet diesel injection – Waco, 2011)

Based on all of the above mentioned regarding the fuel distribution system presented in Figure 1, we may conclude that all CR systems represent small hydraulic systems. If we take a more detailed look, the system contains positive displacement pumps of the same design as in a hydraulic system. The design of the SCV supply pump consists mainly of different designs of gear or vane pumps, while in the supply section radial-piston pumps are used. One of the good features of supply pumps is their ability to achieve high working pressures, which particularly relates to radial-piston pumps. However, operation of pumps at high working pressures requires the use of fluid of a specific level of cleanliness, in our case diesel fuel. Diesel fuel as working fluid must fulfil certain requirements regarding lubrication features as well as regarding the minimum content of contaminants. Contaminants mostly present in the fuel are solid particles and water. Designers of hydraulic systems have already noticed these issues in hydraulic components of older generations (primarily with pumps, but also with other hydraulic components sensitive to the presence of contaminants). Modern hydraulic systems in transport vehicles such as CR fuel injection systems also require so-called working fluid ”treatment” regarding the necessary level of fuel filtration and water separation, the same as with the aforementioned hydraulic systems.

Fuel filtration issues with CR systems

The majority of the manufacturers of filtration media supply the market with filter elements that enable fuel filtration up to the cleanliness level of 4 $\mu m_{(c)}$ with 95% water separation degree; however, they do not mention solid particles separation levels.

Solid particles separation levels, or better, filtration efficiency, is defined by the beta factor (β_x) – meaning the relation between the number of particles of size (x) in oil, before and after filtration. Figure 8 shows a filter with the number of particles at the filter entrance and exit.



Picture 8 – Filter separation of solid particles (Jocanović, 2015)
Рис. 8 – Фильтрирование твердых частиц (Jocanović, 2015)
Слика 8 – Издвајање чврстих честица помоћу филтера (Jocanović, 2015)

As an example, we have shown a simple simulation of filter elements operation with the beta factor 100 and 99% solid particles filtration degree.

If we suppose that the filter presented in Figure 8 requires 4 $\mu m_{(c)}$ filter element, i.e. the filter separates particles of 4 $\mu m_{(c)}$ and bigger, it means that the filter efficiency regarding solid particle separation is equal to the beta factor $\beta 4$. If the filter element is marked with $\beta_4 = 100$ and if at the filter entrance there is the following number of particles (quantities of particles taken as an example):

n_{ul} = 1000 of solid particles equal to or bigger than 4 $\mu m_{(c)}$ in 1 ml of oil sample,

then the following number of particles will appear at the filter exit:

n_{iz} = 10 of solid particles equal to or bigger than 4 $\mu m_{(c)}$ in 1 ml of oil sample,

then the efficiency of separation of 4 $\mu m_{(c)}$-sized particles is equal to:

$$\beta_x = \frac{n_{ul} \geq x(\mu m)}{n_{iz} \geq x(\mu m)},$$

i.e. for the previous example:

$$\beta_4 = \frac{1000}{10} = 100.$$

The beta factor is defined by filter manufactures, and it can be defined for other particle sizes of 4, 6, 14... $\mu m_{(c)}$, regardless of their specified filtration degree.

The solid particle filtration degree is defined in relation to the measured value of the beta factor (β_x) in percentage relation:

$$S = 100 - \frac{100}{\beta_x}[\%].$$

Based on the β_x factor and the solid particle separation degree, their comparative review can be performed as shown in Table 4.

Table 4 – Comparison of βx and the adequate solid particles separation degree
Таблица 4 – Сравнение β_x фактора с соответствующей степенью выявленных твердых частиц
Табела 4 – Поређење β_x фактора и одговарајућег степена издвајања чврстих честица

$\beta_x$factor	Solid particles separation degree[%]
20	95
75	98.66
100	99
200	99.5
500	99.8
1000	99.9

Based on the previously shown example, we can conclude (taught by experience and work with modern hydraulic systems where the pumps and small clearance systems (like servo systems) operate with 2 – 5 μm clearances), that we can draw a parallel between hydraulic and modern CR systems. In order to have modern injection systems operating smoothly and without damage in the form of wear of the pump and injector working components, lately, the filter manufacturers have understood the issues and started producing filters that will be used for fuel filtration in this case. All major filters manufacturers (Hydac, Parker, Pall, Fleetguard, etc.)

have already started the production of filters that should satisfy the fuel cleanliness requirements according to standards imposed by CR system pump and injector manufacturers. According to Table 5, the manufacturers of fuel filters for common rail systems require certain levels of fuel cleanliness regarding the allowed quantity of solid particles according to ISO 4406/99. According to this standard, in 1 ml of fuel, the allowed quantity of 4, 6 and 14 μm-sized solid particles is observed (ACEA, 2013).

Table 5 –The required purity class fuel according to the requirements of manufacturers of CR systems (Hydac, 2015a)
Таблица 5 – Класс чистоты топлива, в соответствии с требованиями производителя системы common rail (Hydac, 2015a)
Табела 5 – Класе чистоће горива према захтевима произвођача common rail система (Hydac, 2015a)

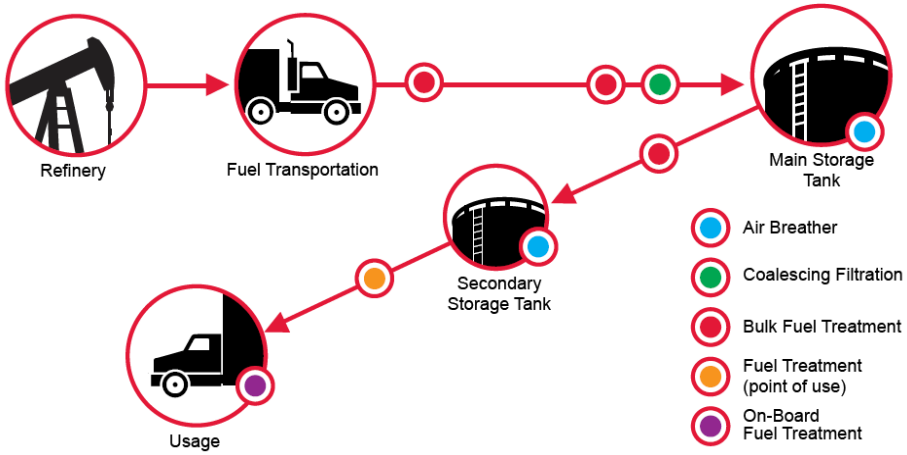
Organization	Particulate ISO 4406	Water
Bosch	11/8/6 at injector	< 200 ppm
CAT	18/16/13 at storage	200 ppm
CUMMINS	18/16/13 at storage 15/13/10 at vehicle tank 12/9/6 at injector	< 200 ppm
Worldwide Fuel Charter	18/16/13	No free emulsified, dissolved < 200 ppm

With regard to the Worldwide Fuel Charter adopted in 2013 (ACEA, 2013), Table 5 shows that fuel cleanliness criteria have been made more stringent by CR system manufacturers even by 6 or 7 times since then. Modern injectors cannot operate with 18/16/13 fuel cleanliness levels when for a proper operation cleanliness levels 11/8/6 are required. Table 6 shows a practical example of comparison of these two cleanliness classes with the number of particles present in the fuel sample.

Table 6 –Comparison of classes of fuel cleanliness according to ISO 4406/99 standard
Таблица 6 – Сравнительная таблица классов чистоты топлива, в соответствии со стандартами ИСО 4406/99
Табела 6 – Упоредна табела класа чистоће горива према ИСО 4406/99 стандарду

ISO 4406: 1999 Hydraulic Fluid Power Solid Contamination Code		
ISO Code	Number of Particles per 1 ml of Fluid	
	More Than	Up To and Including
At storage		
18	1300	2500
16	320	640
13	40	80
At injector		
11	10	20
8	1.3	2.5
6	0.32	0.64

Comparison of two different fuel cleanliness classes shows that the need for fuel cleanliness in injectors is much bigger comparing to the number of particles present in fuel distributor tanks. Cleanliness level 11, related to 4 $\mu m_{(c)}$-sized particles, is by 130 times cleaner comparing to level 18, while cleanliness level 8, related to 6 $\mu m_{(c)}$-sized particles, is even by 246 times cleaner comparing to level 16 than the fuel being stored in fuel distributor storage tanks. From the above presented example, we can conclude that the need for new filtration technologies for new types of CR systems is much bigger comparing to older generations. Some filter manufacturers, such as Hydac, are leading other manufacturers who have already started developing certain filtration units for fuel used in modern diesel engines. According to their studies, it is necessary, at each step of the fuel transport, to provide a corresponding filtration level in order to satisfy the required fuel cleanliness level regarding the presence of particles and water as contaminants. Figure 9 shows all fuel filtration levels for the purpose of maintaining the required fuel cleanliness level.

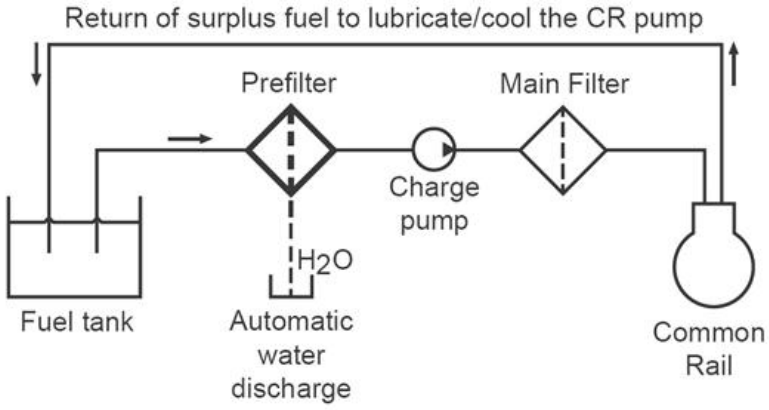


Picture 9 – Fuel filtration treatment locations from refineries to the final consumer (Hydac, 2015b)
Рис. 9 – Уровни фильтрирования топлива от нефтеперабатывающего завода до конечного пользователя (Hydac, 2015b)
Слика 9 – Нивои филтрирања горива од рафинерије до крајњег потрошача (Hydac, 2015b)

In America and some European countries, fuels coming out of refineries are already being treated in this way. What we must specially take care of is fuel filtration performed right in vehicles, which is called “Onboard Fuel Treatment”. This method of filtration includes pre-filtration

and final filtration. The pre-filtration process is performed by the filtration unit designed in two parts. One part is designed for rough separation of water by warming-up of fuel and fine separation of water by the filtration medium, while the second part of the filtration medium performs the filtration of solid particles. Such filter units are commonly installed in the pipeline between the fuel tank and the supply pump.

The second filtration part relates to the so-called main – final filters that are installed in a location between the supply pump and the high pressure pump. Main - final filters provide high level of fuel cleanliness with a solid particles separation level of 99.9 % and the beta factor βx=1000. The aim of the filtration procedure is to provide proper operation of high pressure pumps and sensitive parts of the CR system, i.e. the injectors themselves. Figure 10 shows a modern system, consisting of the fuel tank, the pre-filter whose task is to separate water and bigger particles in the system, the supply pumps, the main – final filter, the CR system and the return line through which the fluid overflow returns. The overflow fluid serves for lubrication and cooling of the distribution – the radial piston pump.



Picture 10 – Fuel filtration system with pre-filtration and main-filtration (Hydac, 2015b)
Рис. 10 – Система фильтрирования топлива с предварительным и главным фильтром *(Hydac, 2015b)*
Слика 10 – Систем за филтрирање горива са претфилтером и главним филтером (Hydac, 2015b)

Fuel pre-filtration units

Figure 11 shows a modern solution of the filtration unit for fuel prefiltration.

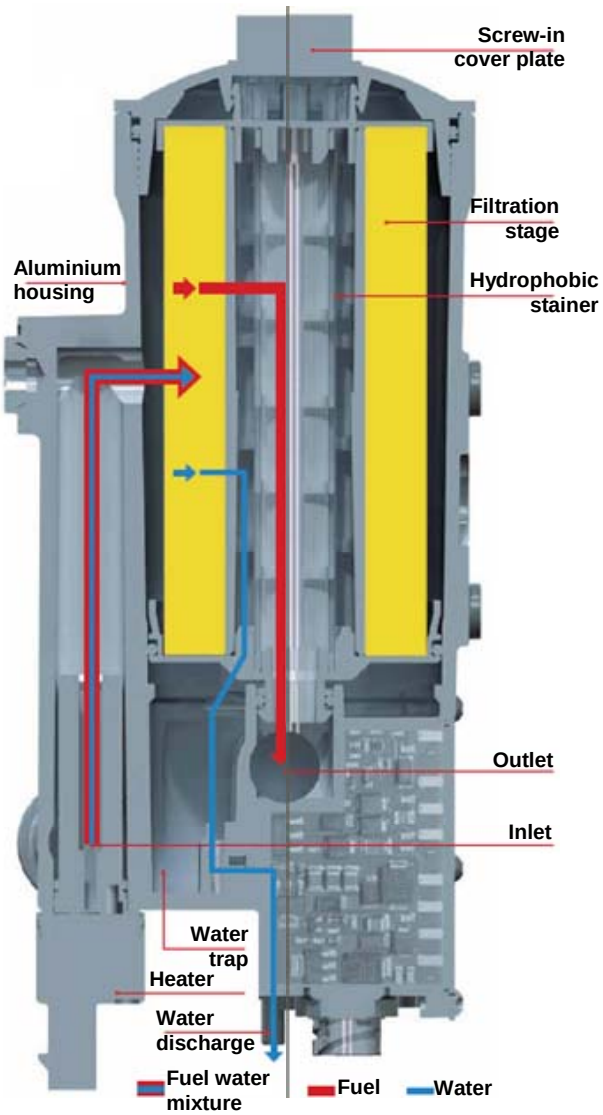
It consists of an aluminium housing containing the following parts:

- Filter element – a synthetic medium having excellent hydrophobic features for water and solid particles separation;
- Heating unit – for heating of fuel at the start-up and during the operation in order to provide optimum water separation;
- Water presence detection sensor – for signalling the presence of water in fuel.

Different water separation media operate under different principles. *Hydrophobic barrier media*, such as silicone treated cellulose, reject water and causes it to bead up on the upstream surface. As the beads become larger, they run down the face of the element into a cup under the force of gravity. *Hydrophilic depth coalescing media*, such as glass micro-fibre, have high affinity for water. The water in the fuel associates with the glass fibres and over time as more water enters from the upstream side, massive droplets are formed. The water moves through the filter with the fuel and on the downstream side, falls out of the fuel flow into a collection cup.

Increased use of surface active fuel additives and fuel components such as biodiesel have rendered conventional separating media less effective and filter manufacturers have needed to develop new approaches such as composite media and ultra-high surface area coalescing media (Stanfel, 2009), (Pangestu & Stanfel, 2009), (Bessee & Hutzler, 2009). Methods of quantifying fuel/water separation performance have also been affected (Stone et al, 2009).

Fuel filters can also contain additional features such as fuel heaters, thermal diverter valves, de-aerators, water-in-fuel sensors, and filter change indicators.



Picture 11 – Cross section of the pre-filter (Hydac, 2012)
Рис. 11 – Поперечное сечение устройства для предварительного фильтрирования (Hydac, 2012)
Слика 11 – Пресек уређаја за претфилтрацију горива (Hydac, 2012)

A fuel preheater helps to minimize the accumulation of wax crystals that can form in the fuel as it cools to low temperatures. Common heating methods use electric heaters, engine coolant or recirculated fuel.

The filter medium is designed in several combinations of synthetic medium, of which the most efficient combination is glass/synthetic, which removes solid particles, in the pre-filtration process, to the level of 6 $\mu m_{(c)}$, and water with an efficiency of 95% (Schroeder Industries, 2016).

Filter elements for main – final filtration

This group of filter elements was used for fuel filtration in CR systems before. However, due to the presence of water in modern diesel fuels (resulting form addition of biodiesel which is hydroscopic) it became nearly impossible to filter the fuel in the mixture of particles and water that were saturating the filter elements very quickly. Accordingly, old filter elements did not have to achieve a high level of separation of solid particles, with the beta factor within the range of 100 – 200 and the efficiency level of 99 – 99.5%.

However, new CR systems operate at very high pressures amounting to 2000-2500 bars, with even 3000 bars in the future, so that the working fluid – diesel fuel in our case, must have the maximum fluid cleanliness. For this reason, the idea about pre-filtration was born, leaving the final filtration to be performed with filters of a higher level of separation of solid particles and water.

For this reason, it will be necessary to use high separation filter elements that will be able to satisfy very high criteria, especially regarding the separation level of solid particles required for 11/8/6 fuel cleanliness standard. In order to achieve this, a CR system will use, as the main – final filter element, the filter elements of high separation levels 99.8 to 99.9%, or the beta factor $\beta x = 500$ up to $\beta x = 1000$. That this topic is not new and was considered before, prove the research described in the paper by von Stockhausen (von Stockhausen et al, 2009). These research works, however, were done for the systems operating at lower working pressures and with slightly bigger clearances in injectors.

Modern CR systems equipment, which is required to solve problems related to filtering quality, is very expensive. If we know that the passenger car injector can have a price range from a couple of hundreds to a couple of thousands of Euros, (high pressure pumps prices can be even higher), then the filtering problem cannot be ignored. Activities like diagnostics, adjustments, reparation or replacement of CR system components (such as injectors, pump, pressure regulation valves, flow regulation valves, ECU, etc.) must be carried out by qualified personnel.

Conclusions

Passenger cars, off-road vehicles, freight vehicles, disel-electric generator sets and others are subject to the heaviest exploitation conditions. In order to provide proper and efficient operation of the injection CR system, as well as of the engine itself, which, of course, produces effects on the vehicle exploitation features, it will be necessary to provide high quality diesel fuel. Modern CR systems have subsystems which monitor engine and CR system condition and exploitation performances. Based on collected data, central computer controls engine operation, in order to reduce emission of harmful gases and to achieve better fuel economy (Cummins Engines, 2016).

This paper presents some of the currently used CR systems, as well as some that will be used in the future and require high cleanliness fuel regarding the presence of contaminants, i.e. solid particles and water. We have specified current requirements of manufacturers of CR systems equipment regarding the fuel cleanliness and allowed water presence. Additionally, we have compared the allowed levels determined by manufacturers with the old Worldwide Fuel Charter levels, and based on the comparison, we have defined the necessary levels of the efficiency degrees for both pre-filtration and the main – final filter elements, in order to determine sufficient quality levels for both current and future CR systems.

Also, modern CR systems that are being used in the vehicle engines subject to Euro 5 and 6 norms regarding exhaust gas quality, require the diesel fuel cleanliness class to be minimum 12/9/6, or better according to ISO 4406/99 standard regulating the presence of solid particles. It means that fuel should be filtered through the top quality filtration media providing the fuel cleanliness level in injectors in respect of solid particles not bigger than 4 $\mu m_{(c)}$, or even smaller with the solid particle separation level being minimum 99.9% and the beta factor of the filter $\beta x \geq 1000$.

However, modern multi-purpose filters commonly used in modern diesel engines do not satisfy the required quality level and are not designed to provide the sufficient and required fuel quality level for modern CR systems and injectors.

With the application of modern solutions for pre-filtration and final filtration, the required quality level of fuel can be achieved for modern fuel injection systems.

The advantages of pre-filtration systems to be used in vehicles are as follows:

- the possibility of automatic water separation;

- the possibility of installation of fuel heaters and installation of sensors for water presence detection;
- high flexibility regarding the position of installation in relation to the entrance and exit of fuel;
- continuous water separation during the whole exploitation life of the filter element;
- economical and reliable operation of the filter element, easily replaceable;
- easy detection of the presence of other contaminants in fuel (metal, other deposits, etc.) that can be detected visually and sent to analysis;
- water filtration with an efficiency level of >95%;
- separation of solid particles up to the size of 6 $\mu m_{(c)}$.

Filter elements for main – final filtration have completely different concept – they are mainly intended for separation of solid particles from fuel with the minimum quantity of residual water from the pre-filtration process.

This filter group is produced in different designs (replaceable elements with housing or more commonly, spin-on design) with the following characteristics:

- easy to install and uninstall;
- absolute fluid filtration (declared level of contaminant separation degree);
- fuel filtration of particles of 4 μm(c) and smaller;
- solid particles separation level equal to or higher than 99.9% with $\beta_x \geq 1000$.

It is only this method of filtration that can provide quality and safe operation of modern CR systems and diesel engines, preventing high costs of maintenance that could occur as a consequence of poor or insufficient quality of diesel fuel, which is commonly manifested in the form of frequent defects in the pumps and CR system injectors. In addition to its reliability in exploitation, the aim is to achieve the engine operation with the lowest possible emission of harmful matter, which the manufacturers of engines and injection systems have to satisfy.

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ПРОБЛЕМЫ ФИЛЬТРИРОВАНИЯ ДИЗЕЛЬНОГО ТОПЛИВА В СОВРЕМЕННОЙ СИСТЕМЕ ВПРЫСКА COMMON RAIL

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ОБЛАСТЬ: машиностроение
ВИД СТАТЬИ: профессиональная статья
ЯЗЫК СТАТЬИ: английский

Резюме:

За последние годы заметно возросло развитие современных систем впрыска дизельного топлива, под названием „common rail“. Наряду с развитием данных систем необходимо одновременно следить за соответстующим развитием вспомогательных систем, которые обеспечивают их правильную и эффективную работу.

В данной статье подробно описаны последние поколения common rail систем, которые работают под высоким давлением, а также обсуждаются вопросы фильтрирования дизельного топлива, и подчеркнута проблема загрязнения окружающей среды от промышленного топлива.

Ключевые слова: common rail системы, технологические процессы фильтрирования, дизельное топливо, обслуживание, насосы, фильтры.

ПРОБЛЕМ ФИЛТРИРАЊА ДИЗЕЛ-ГОРИВА КОД САВРЕМЕНИХ COMMON RAIL СИСТЕМА УБРИЗГАВАЊА

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ОБЛАСТ: машинство
ВРСТА ЧЛАНКА: стручничланак
ЈЕЗИК ЧЛАНКА: енглески

Сажетак:

Савремени системи за убризгавање дизел горива, под називом „common rail" последњих неколико година се нагло развијају. Упоредо са развојем ових система потребно је истовремено пратити и одређени развој помоћних система који се користе за њихов правилан и ефикасан рад. У раду је детаљно описана последња генерација common rail система који раде са високим радним притисцима. Наведен је и проблем филтрирања дизел-горива и издвајања непожељних контаминаната у погонском гориву.

Кључне речи: common rail системи, технолошки процеси филтрирања, дизел-горива, одржавање, пумпе, филтери.

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IMPROVING THE RECTIFICATION OF OPTICAL DEVICES WITH LASER POINTERS

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FIELD: Logistics, Maintenance of Technical Means
ARTICLE TYPE: Professional Paper
ARTICLE LANGUAGE: English

Summary:

This paper is based on the observations of prescribed actions during the maintenance of artillery weapons and immediately prior to the execution of combat firing. Adjusting the parallelism of the axes of the optical devices and the axis of the artillery barrel directly affects shooting accuracy.

With a new method of parallel axes alignment, based on the use of laser pointers, the axis parallelism deviation is reduced to a minimum, which improves the precision of artillery firing. Reliable, easier and faster check of the axes parallelism is enabled as well as axes alignment with the artillery barrel axis.

Keywords: rectification, optical axes, laser pointer.

Introduction

A new method for checking the parallelism of the axes[1] of optical devices and the axis of the field artillery weapon H-122mm D30 (J) was applied in the study. Shooting from this weapon is realized using the following optical sight devices:

– the optical sight ON-122-M78, intended for direct shooting at targets up to a distance of 2000 meters,
– panoramic sight (panorama) P-M78, indirect target shooting to a distance of 16,000 meters.

[1] Checking the parallelism of the axes of optical devices and the artillery weapon barrel axis as well as their alignment (cancellation of deviations in parallel) is called rectification.

Figure 1 – Field weapon - 122mm howitzer D30
Рис. 1 – Изображение орудия сухопутной артиллерии Гаубица 122мм Д30
Слика 1 – Приказ земаљског оруђа хаубица 122 мм Д30

Sighting devices, regardless of their precise adjustment in production, must be checked and adjusted during use. These devices stop being adjusted during use due to wear and tear of moving parts, shocks during shooting and transport, which causes deviation from the axis parallelism and increases the error in weapon accuracy regarding distance and direction.

The aim of the research is the implementation of a new method for checking and adjusting optical axes and the barrel axis, based on the precision of a laser beam emitted by a laser pointer. In this way, the deviation of axes from the parallel is reduced to the minimum value, or zero.

The existing method of checking axes parallelism, on the basis of which further adjustments are made[2], is directly dependent on the gunner, which leads to different types of errors. One of them is parallax which occurs due to aiming through the barrel bore and the crosshair on the muzzle brake. Also, the existing method is also dependent on the hair/fiber thickness, from which the crosshair is made and mounted on the muzzle brake. It is used for aiming at distant targets and / or at a rectification board. It is clear that the existing method is dependent on human abilities so it does not provide complete reliability due to subjective errors.

According to technical documentation, checking the parallelism of the optical sighting axis with the barrel axis is always performed after mounting the optical sight (OS) on the weapon. Considering the high perio-

[2] Under further adjustment, it is understood that the axes of the optical devices are aligned with the axis of the weapon barrel.

dicity of repeating paralellism tests, it is necessary to facilitate and accelerate the method. This is enabled by the proposed method of checking axes parallelism using a laser beam (pointer), which makes the method fully reliable.

Existing method of checking axis parallelism according to technical documentation

Checking axes parallelism means checking the parallel of the three axes (Državni sekretarijat sa narodnu odbranu, Tehnička uprava, 1969):

– optical sight axis,
– optical panoramic sight axis,
– H-122mm D-30 barrel axis.

The goal is that there is no deviation from the parallelism of the imaginary axes of the optical devices and the weapon barrel. In this way, ideal conditions are provided, enabling the accuracy of the sighting devices and the weapon accuracy.

The weapon is placed in a combat position on a flat and hard surface. The barrel is brought into a horizontal position by means of a tilt mechanism, and in the direction towards the rectification board or a remote target.

Checking and adjusting the parallelism of the panoramic sight axis with the barrel axis

Checking the parallelism of the P-M78 panoramic sight axis and the axis of the weapon barrel, as well as the adjustment of the axis to ”ideal” parallelism is performed in two ways:

– using a selected target point at a distance of 1000 *m* ,
– using a rectification board at a distance of 50 *m* from the barrel muzzle.

At the muzzle brake, a hair from the crosshair[3] is tightened into the existing notches[4]. An aiming point is selected at a distance of 1000 *m* from the muzzle (Figure 2). The firing mechanism parts are disassembled

[3] Hair of the crosshair - it is made of a fiber of certain thickness. In the tool kit, there is a fiber of about 2 mm in thickness, red, so that it can be easily visible at aiming at a target or at a cross on the rectification board.

[4] The notches on the muzzle (gas brake) are embeded in the production after the weapon is shot.

from the breechblock. Aiming through the opening for the firing mechanism probe tip over the crosshair on the muzzle brake, the gunner locks the weapon barrel at a chosen target point. The barrel is moved using a gun laying mechanism. Aiming through the panoramic sight, the gunner adjusts the device until the crosshair of the panoramic sight overlaps with the chosen target and the indices are in the ”0” position.

If there is no suitable target point in the vicinity and if visibility is limited, checking the parallelism of the optical axis of the panoramic sight with the barrel axis is done using a rectification board (Figure 3). The board is placed at a distance of 50 *m* from the howitzer muzzle, vertically and perpendicularly to the barrel axis.

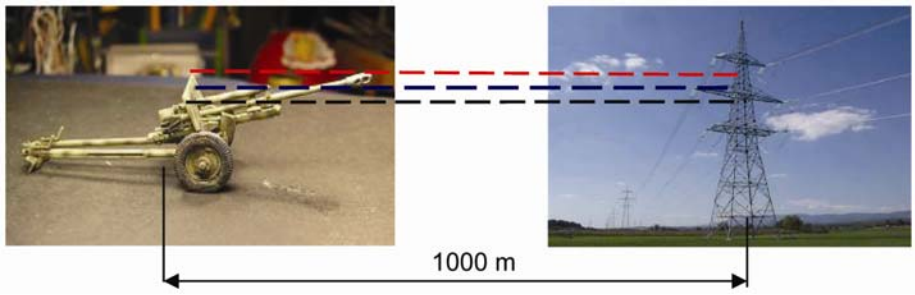

Figure 2 – The process of rectification to the remote selected target
Рис. 2 – Метод спрямления траектории при наведении по выбранной дальней цели
Слика 2 – Поступак ректификације на удаљени изабрани циљ

As seen in Figure 3, there are three crosses on the board[5], whose layout and distance corresponds to the position of the optical devices (panoramic sight and optical sight, red and blue cross, respectively) and the axis of the weapon (black cross) in the 3D space.

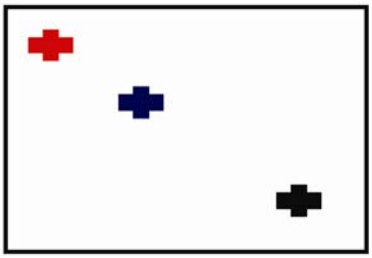

Figure 3 – H-122 mm howitzer D30 rectification board
Рис. 3 – Бортовой баллистический вычислитель Х-122 мм гаубицы Д30
Слика 3 – Табла за ректификацију хаубице Х-122 мм Д30

[5] Crosses on the rectification board are referred to as aiming points.

The parallelism is checked in the following manner: aiming is performed through the bore axis (i.e.hairs of the crosshair) which is thus aligned with the crosss on the right side of the rectification board (Figure 4). The panoramic sight and the optical sight are used for aiming at the crosses on the left side of the rectification board. If the axes of the optical devices deviate from the centres of the crosses on the rectification board, their adjustment is necessary. In this way, the axes of the optical devices are brought into the center of the corresponding cross on the rectification board, which corresponds to the indices on the devices in the "0" position.

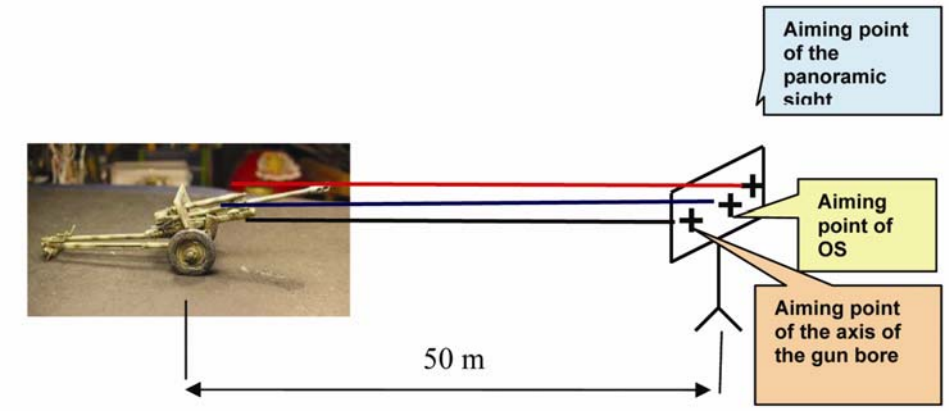

Figure 4 – The process of rectification with a rectification board
Рис. 4 – Метод спрямления прицела с бортовым баллистическим вычислителем
Слика 4 – Поступак ректификације са таблом за ректификацију

The technical documentation requires that such rectification be realized by 2 mechanics. The first one aims via the crosshair, aligns the bore axis with the chosen target or the cross on the rectification board and constantly controls the muzzle position. The other mechanic then adjusts the axes of the optical devices with the target or the crosses on the rectification board.

Permissible deviation, when taking the maximum firing distance with the panoramic sight, is 0-00.5 thousandths per direction (Savezni sekretarijat za narodnu odbranu, Tehnička uprava, 1987).

Checking and adjusting the OS axis parallelism with the barrel axis

The preparatory actions for the procedure for checking and adjusting the parallelism of the ON-122-M78 OS axis and the barrel axis are the same as the previously explained procedure for the panoramic sight. For the correct operation of the OS, it is necessary that its optical axis be parallel with the bore axis both in the vertical and the horizontal plane. Checking the parallelism of the OS axis and the bore axis is done at a minimum distance of 1000 *m* or using a rectification board at a distance of 50 *m* from the muzzle.

In the same way as with the panoramic sight (Figure 2), a target is aimed at a minimum distance of 1000 *m*, using a crosshair. Then, aiming through the OS eyepiece, the gunner determines the position of the top of the arrow in relation to the selected target point. If the OS is correct and properly set, then the top of the arrow will overlap with the remote selected point, and the horizontal line of the crosshair passes through the zero position of the distance scales. If this is not the case, it is necessary to carry out the OS adjustment.

When checking the parallelism of the ON axis with the bore axis using the rectification board (Fig. 4), the procedure for checking parallelism in the panoramic sight is repeated, and the allowed deviation is 0-01.5 thousandths per direction (Savezni sekretarijat za narodnu odbranu, Tehnička uprava, 1987).

Problems in the rectification procedure according to technical documentation

When implementing the described methods for checking the parallelism of the optical axes of the panoramic sight and the OS with the barrel axis, we face some problems that cause the measurement uncertainty of the method. Measurement uncertainty depends on the person's ability to precisely determine a target point and aim at it. In this way, a measurement error directly affects the accuracy of the optical devices and, indirectly, the accuracy of the weapon, and the method itself contains measurement uncertainty.

A procedure of aiming using the barrel axis

The considered method of checking and adjusting axes parallelism is prescribed by technical documentation. In the realization of the method for checking the axes parallelism, the crosshair is used to aim through the bore at a distant target or at the right cross on the rectification board. The success of aiming using the crosshair depends on the ability of the human eye to perform precise targeting, as well as on the thickness of the hair/fiber with which the target is aimed at. In the weapon STA[6] kit, there is a factory-standardised fiber which is placed on a gas brake and by which a target is aimed. Therefore, an error is inevitable since the success of the method depends on the human capability to perform the necessary aiming at the remote target or at the cross on the rectification board.

The effect of the thickness of the hair on the precise aiming is considered, assuming that the man has sufficient visual abilities to use a 0,5–2 *mm* thick fiber over the bore axis to aim at the right cross on the rectification board and the distant target. An example is given in Figure 5.

The rectification board is placed at a distance of 50 meters from the weapon muzzle. Three 10mm thick crosses are drawn on the board, for each of the axes of the optical devices and the weapon bore axis (as it corresponds to their position in the space).

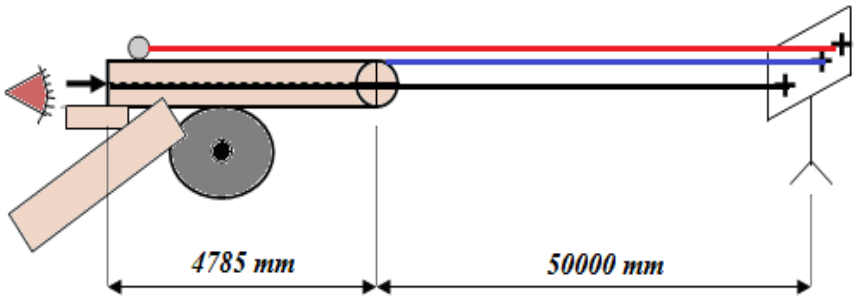

Figure 5 – The process of rectification using the rectification board
Рис. 5 – Метод спрямления наведения с помощью бортового баллистического вычислителя
Слика 5 – Поступак ректификације помоћу табле за ректификацију

To see how the thickness of the fiber affects the correct check of the axes parallelism, the fiber (hair of the crosshair) projection on the rectification board will be calculated. The projection of the fiber is the

[6] STA – Abbreviation of spare tools and accessories

shape and size of the fiber which the human eye sees on the rectification board when aiming using the crosshair. From the theorem on the similarity of triangles, it follows that (Kalezić, 2010):

$$L_C : d_K = L_U : x\,, \tag{1}$$

$$L_U = L_C + L_T\,. \tag{2}$$

where:

L_C – weapon bore length,

d_K – the thickness of the aiming fiber,

L_T –distance of the board from the weapon muzzle, and

x – projection of the fiber on the rectification board.

Using formula (1) gives the following: $4785 : 0.5 = 54785 : x$, where:

$$x = \frac{54785 \times 0.5}{4785} \Rightarrow x = 5.72\,mm\,. \tag{3}$$

It is concluded that the projection of the 0,5 *mm* thich fiber on the rectification board located at a distance of 50 *mm* is 5,72 *mm*[7]. This means that the crosshair on the gas brake has a projection on the rectification board as in Figure 6.

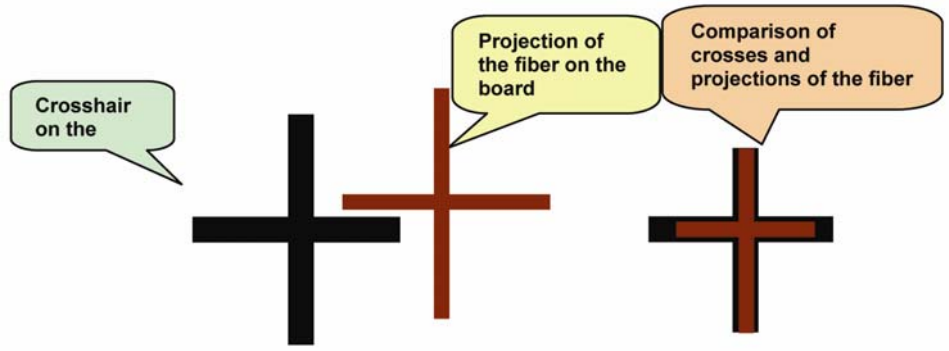

Figure 6 – The projection of the crosshairs on the board for rectification
Рис. 6 – Проекция перекрестия на бортовом баллистическом вычислителе
Слика 6 – Пројекција крста кончића на таблу за ректификацију

Figure 6 shows a projection of a 0.5 *mm* thick fiber. For the thickness of the fiber of 2 *mm*, which is actually used in practice, the projection is

[7] The projection of the fiber on the rectification board is a 5.72 mm thick cross, viewed horizontally and vertically.

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22.3 *mm*. In this case, the center of the crosshair on the rectification board will practically not be seen, which is a potential mistake in the realization of the adjustment of axes parallelism.

For the rectification method at a distant point (1000 *m*), the thickness of the projection of the fiber is: $4785 : 0.5 = 1000000 : x$, where:

$$x = \frac{1004785 \times 0.5}{4785} \Rightarrow x = 105mm. \tag{4}$$

The projection of a 0.5 *mm* thick fiber at a distant chosen target located at a distance of 1000 *m* amounts to 105 *mm*. The projection of the crosshair of the thickness of 0.5 *mm* at a distant target can be presented as in Figure 7.

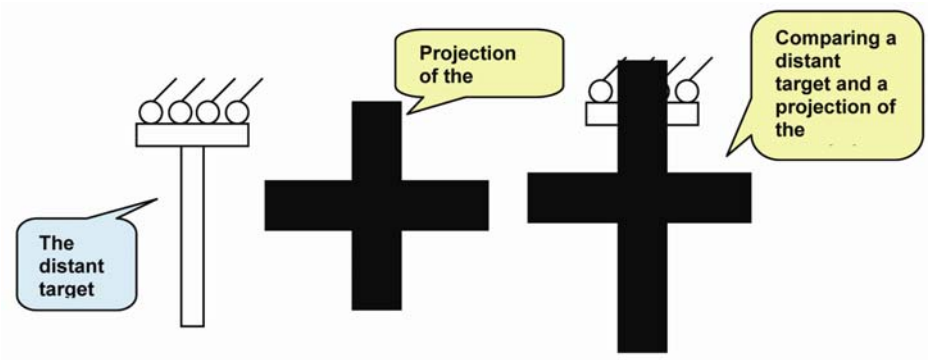

Figure 7 – Example of the projection of the crosshairs on a distant target
Рис. 7 – Пример проекции перекрестия по дальней цели
Слика 7 – Пример пројекције крста кончића на удаљени циљ

Figure 7 shows that, due to the projection of the fiber on a distant target, the distant target is practically hidden behind the projection, and the precise alignment of the axes is difficult (aiming with the bore axis). For the case of the thickness of the fiber of 2 *mm*, the case is more pronounced as the projection of the fiber to the distant target is 420 *mm*. Table 1 shows an overview of the fiber thickness and its projections for different rectification modes.

Table 1 – Comparative overview of the fiber thickness and its projections on the target
Таблица 1 – Сравнительный обзор толщины перекрестия и его проекции на цель
Табела 1 – Упоредни приказ дебљине конца и његове пројекције на циљ

	PROJECTION	
Thickness of the fiber	**A rectification board - 50 *m***	**The distant target – 1000 *m***
0.5 mm	**5.72 mm**	**105 mm**
2 mm	**22.3 mm**	**420 mm**

Table 1 clearly identifies a problem caused by the fiber thickness when aiming at a distant target or at a cross on the rectification board (aiming point). Namely, the projection of the fiber thickness makes it difficult to accurately aim the bore axis at a distant chosen target and the rectification board, because the projection is much bigger than the target, so the fiber projection hides the target, i.e. the target point. In this way, the accuracy of the method depends on the skill of the mechanic who performs aiming. Something more precise is aiming at the rectification board, because the thickness of the projection, in some cases, is slightly smaller than the thickness of the cross on the rectification board.

It is concluded that, according to technical documentation, the method of checking the parallelism of the axes of optical devices and the weapon bore is based on the unreliable method of bringing the axes to the distant target or the cross on the rectification board. Unreliability leads to the impossibility of precisely locating the selected distant target or the center of the cross on the rectification board, which leads to an error in determining the deviation of the individual axes from the imaginary parallel lines. The result is an unreliable way of rectification and insufficient accuracy of aiming devices, which directly affects the weapon precision during firing.

Parallax

Parallax is a shift of the target in relation to the crosshair when we move our head up or down as we look through the optics (Državni sekretarijat za narodnu odbranu, Tehnička uprava, 1969ab). Parallax occurs when the target does not fall on the same plane as the crosshair. A parallactic error occurs when aiming at long distances. The error in this case is a maximum of one thickness of a crosshair fiber or 0-00.5 thousandths. Since parallax occurs when aiming at targets at long distances, axes parallelism should be checked using a rectification board.

Calculation of the axes deviation and impact on the aiming accuracy

Based on the shown method for checking the parallelism of the axes of the panoramic sight and the weapon bore, according to technical documentation, the allowed deviation from the parallel is 0-00.5 thousandths. Also, the allowed deviation of the optical sight axis from the barrel axis is 0-01.5 thousandths. These allowed deviations are manifested in the aiming accuracy and the firing accuracy as seen in Figure 8 and the accompanying tables below.

From the given calculation, for the allowed deviation of the panorama axis from the barrel axis, at a distance of 16 *km*[8], the aiming error amounts to 8 *m*. Proportionally, by reducing the distance to the target, the error decreases (Table 2).

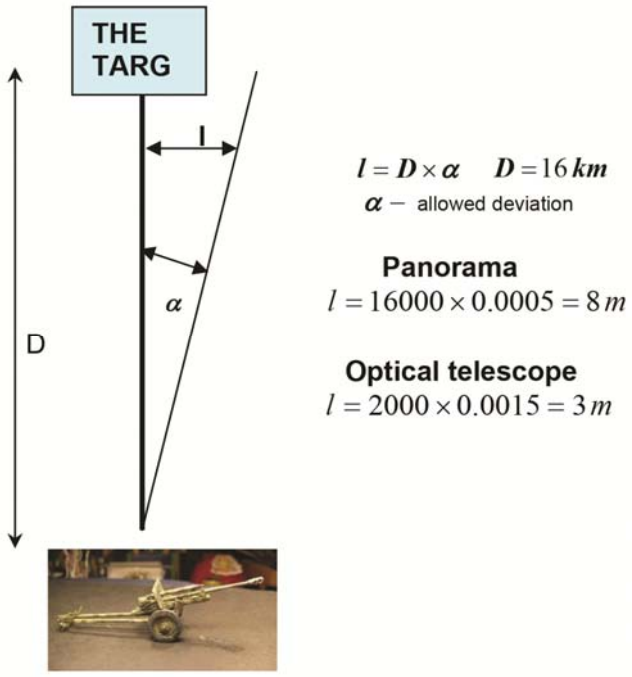

Figure 8 – Example of the error calculation
Рис. 8 – Пример расчета погрешностей
Слика 8 – Пример прорачуна грешке

[8] Maximum shooting distance.

Table 2 – Calculation of aiming errors according to the technical documentation – panorama
Таблица 2 – Расчет погрешностей наведения по технической документации - панорама
Табела 2 – Прорачун грешке нишањења према техничкој документацији – панорама

Distance to destination (m)	Permissible deviation of the panorama axis	Aiming error in the horizontal plane (m)
16 000	0-00.5 thousandths	8
8 000	0-00.5 thousandths	4
4 000	0-00.5 thousandths	2
2 000	0-00.5 thousandths	1
1 000	0-00.5 thousandths	0.5

The calculation shows that for the permitted deviation of the axis of the optical sight from the barrel axis, at a distance of 2000*м*, the aiming error is 3 *m*. Proportionally, by reducing the distance to the target, the error decreases (Table 3).

Table 3 – Calculation of aiming errors according to the technical documentation - telescope
Таблица 3 – Расчет погрешностей наведения по технической документации – телескоп
Табела 3 – Прорачун грешке нишањења према техничкој документацији – дурбин

Distance to destination (m)	Permissible deviation of the OS axis	Aiming error in the horizontal plane (m)
2 000	0-01.5 thousandths	3
1 000	0-01.5 thousandths	1.5
500	0-01.5 thousandths	0.75

The values of the aiming error in the horizontal plane displayed in Tables 2 and 3 represent the maximum deviation values according to the technical documentation, and in real conditions they are higher. This will be demonstrated by the application of the proposed method, where the obtained deviation values will be compared, based on which it can be concluded that in real conditions the deviation is higher.

The aiming error value in the vertical plane, based on the permissible deviation from the parallelism of the axes of the barrel and the aiming devices, decreases with the range increase. At the maximum range, the error is negligible.

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Improving the rectification method using a laser pointer

On the basis of the performed analysis of aiming errors in real conditions due to the thickness of the crosshair fiber, parallax and the axes parallelism checking skills during the application of the rectification method according to the technical documentation, measurement uncertainty occurs in the realization of the parallelism checking method. The application of the proposed rectification method based on the use of a laser pointer eliminates the influence of the human factor on the measurement procedure (aiming with the crosshair and parallax).

Rectification method using a laser pointer

The rectification procedure using a laser pointer is the following:
- laser pointer is held with the appropriate clamping tool,
- the clamping tool with the laser pointer is placed at the place of the 122 mm artillery primer,
- at the muzzle (gas brake), an appropriate circular mesh with a cross in the center is placed[9] (Figure 9),
- rectification board is placed at a distance of 50 *m* from the muzzle,
- the laser pointer is activated and the clamp tool sets the laser beam to pass through the center of the circular mesh (through the cross),
- the circular mesh is removed from the gas brake and by gun laying, the laser beam is directed onto the right cross of the rectification board,
- the deviation of the optical devices from the corresponding crosses on the rectification board is measured and necessary adjustments are made.

In order to determine the real deviation of the optical axes on the basis of which the calculation of the aiming error will be carried out the proposed rectification method using a laser beam was applied to an overhauled H-122 mm D30 artillery piece. Once again, the parallelism of all axes was checked using the method prescribed by the technical documentation[10] (Savezni sekretarijat za narodnu odbranu, Tehnička uprava, 1987), followed by the rectification based on the proposed method with a laser pointer.

[9] The circular mesh is of a round shape with a cross in the middle, as shown in Figure 9. The circular mesh is an integral part of the fire control tool of the computing department.

[10] Aiming at the rectification board was done using 2 mm thick fibers of the crosshair placed on the notches of the gas brake, for easier and more accurate aiming.

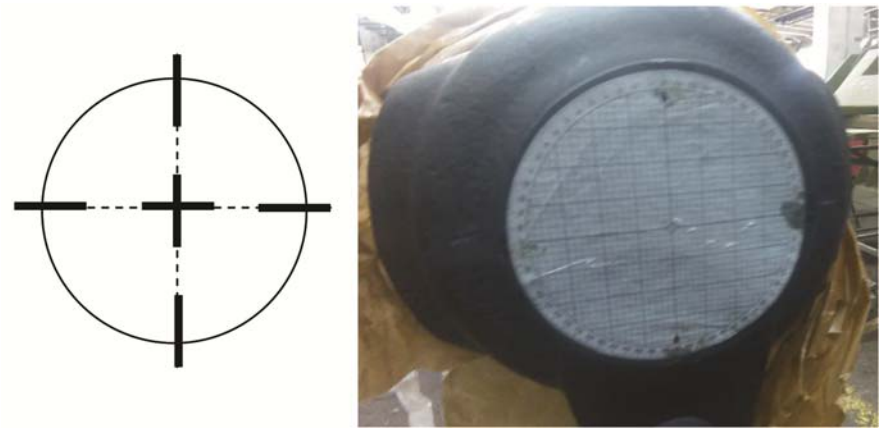

Figure 9 – Circular mesh
Рис. 9 – Изображение прицельной сетки
Слика 9 – Приказ кружне мреже

The laser beam was directed to the center of the circular mesh in the manner described above (Figure 10) and then to the corresponding cross on the rectification board. The following deviations of the panorama axis and the optical sight axis were obtained after the rectification was performed, in relation to the piece barrel axis:

– Panorama:
  • 2 thousandths in the direction and
  • 4 thousandths per elevation,
– Optical sight:
  • 2 thousandths in the direction.

The checking and adjusting the optical axes of the panorama and the OS was repeated by the method prescribed in the technical documentation and once again the same results were obtained, i.e. the same deviations. As all the requirements of the measurement method were met, it is obvious that the technical documentation method has certain measurement uncertainty. Measurement uncertainty was a result of a lack of a method that depends on the subjective factor (the human eye), the crosshair fiber thickness and the parallax. Measurement uncertainty directly causes aiming error, and indirectly firing inaccuracy as shown in Tables 4 and 5.

Figure 10 – Laser beam directed at the center of the circular mesh
Рис. 10 – Изображение лазерного целеуказателя, направленного в центр прицельной сетки
Слика 10 – Приказ ласерског снопа усмереног у центар кружне мреже

Aiming errors in artillery pieces, based on the obtained deviations in the parallelism of the axes of optical devices, are calculated in Tables 4 and 5.

Table 4 – Calculation of the aiming errors using the laser pointer - panorama
Таблица 4 – Расчет погрешностей наведения с помощью лазерного целеуказателя - панорама
Табела 4 – Прорачун грешке нишањења применом ласерског обележивача – панорама[11]

Distance to destination (m)	Permissible deviation of the panorama axis	Aiming error in the direction (m)
16 000	0-00.5 thousandths	32
8 000	0-00.5 thousandths	16
4 000	0-00.5 thousandths	8
2 000	0-00.5 thousandths	4
1 000	0-00.5 thousandths	2

The values obtained in Tables 4 and 5 represent real aiming errors that occur in the horizontal level with the H-122 mm D30 piece. As it can be seen, there are errors in the parallelism of the axes and they are higher than those prescribed by the technical documentation (Savezni sekretarijat za narodnu odbranu, Tehnička uprava, 1987), (Table 2 and 3).

[11] Aiming error leads to an error in firing elements determination and, consequently, to the deviation from the average impact point.

Table 5 – Calculation of the aiming errors using the laser pointer - optical telescope
Таблица 5 – Расчет погрешностей наведения с помощью лазерного целеуказателя - оптический телескоп
Табела 5 – Прорачун грешке нишањења применом ласерског обележивача – оптички дурбин

Distance to destination (m)	Permitted OS deviation	Aiming error in the direction (m)
2 000	0-01.5 thousandths	4
1 000	0-01.5 thousandths	2
500	0-01.5 thousandths	1

The obtained results show that the human factor has a dominant influence on the quality of the method of adjusting the optical axes. The only way to achieve quality results and a minimal deviation of the parallelism of the optical axes from the bore axis is to exclude the human factor and improve the rectification method.

This is achieved by the proposed rectification method using a laser pointer, which is based on the fact that the laser beam propagates in a straight line to the aiming point on the rectification board, thereby contributing to the method accuracy. This method eliminates the unreliability of aiming with crosshairs and the parallax of the human eye, since the influence of a man from the critical part of the measurement method is eliminated. This reduces the method measurement uncertainty. In addition, the proposed method is implemented by one artillery crew member, unlike the previous one where two members were necessary. A reduced number of staff affects the reduction of norms, which directly increases capacity.

Description of the proposed method

The proposed rectification method, i.e. the verification of the parallelism of the optical axes with the bore axis, uses a laser beam of a laser pointer in order to increase the accuracy of aiming at the cross on the rectification board. After aiming with the laser beam, the deviations of the optical axes are checked and corrected.

The rectification method using a laser pointer is given previously while the subsequent corrections on optical devices are described and implemented according to the method given in the technical documentation (Savezni sekretarijat za narodnu odbranu, Tehnička uprava, 1987).

The clamping tool used to hold the laser pointer is shown in Figure 11.

Figure 11 – Clamping tool with a mounted laser pointer
Рис. 11 – Изображение зажимных деталей с лазерным целеуказателем
Слика 11 – Приказ стезног алата са постављеним ласерским обележивачем

Figure 12 shows the components of the clamping tool. The components allow the mounting and fixing of the laser pointer, as well as its shifting along the X and Y axes when directing the laser beam.

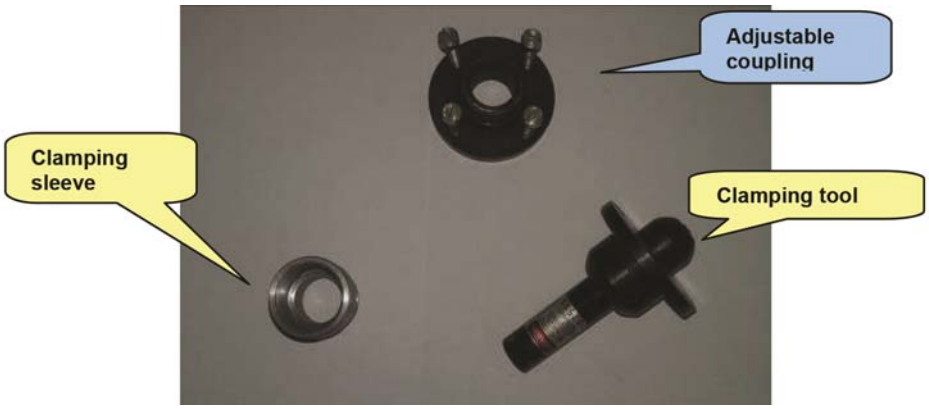

Figure 12 – Parts of the clamping tool for the laser pointer
Рис. 12 – Зажимные детали лазерного целеуказателя
Слика 12 – Делови стезног алата ласерског обележивача

After placing the laser pointer in the clamping tool, the clamping tool is fastened to the technological sleeve (Figure 13). In the center of the sleeve, in the opening in which the primer is placed, there is a thread by means of which the clamping tool for the laser pointer is fixed, which allows the laser beam to overlap the bore axis. An appropriate opening is made on the sleeve to check the direction of the laser beam.

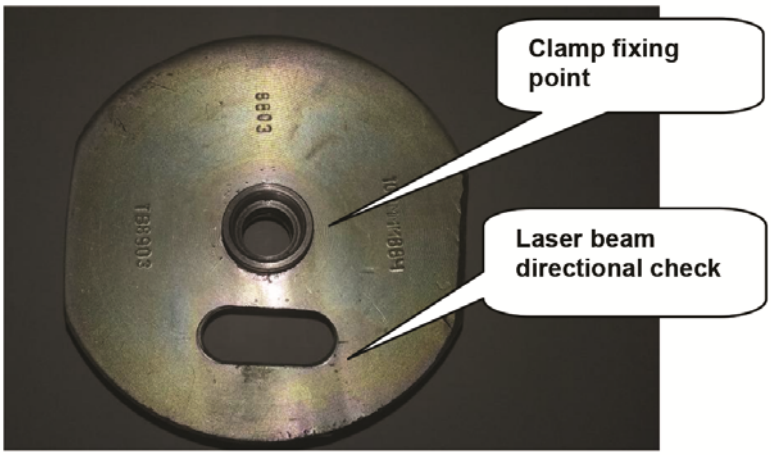

Figure 13 – Technological sleeve
Рис. 13 – Изображение технологической гильзы
Слика 13 – Приказ технолошке чауре

Alignment is performed by adjusting the clamping tool on the X and Y axes (with four screws on the adaptive coupling, two screws for each axis) so that the laser beam is directed to the center of the circular mesh located on the gas brake on the muzzle. The edge of the technological sleeve is removed from the place where the extruders come in so that breech is open and accessible.

Figure 14 shows a technological sleeve with a mounted clamping tool and a laser pointer.

After directing the laser beam into the center of the circular mesh, it is considered that the laser beam matches the imaginary axis of the weapon bore. The circular mesh is removed from the gas brake and by the rotating the barrel in direction and elevation, the laser beam is directed to the lower right-hand cross of the rectification board placed at a distance of 50 *m* from the muzzle (Fig. 15). In this way, the laser beam represents a prolonged bore axis towards the aiming point of the rectification board.

After bringing the laser beam to the aiming point of the rectification board, it is possible to read the deviations of the optical axes of the panorama and the OS from the corresponding aiming points (crosses) on the rectification board and to correct them. The correction is done in such a way that they are set up to have their optical axis at the appropriate aiming points of the rectification board and adjusting the scale according to TU-I. The parallelism of all three axes is thus achieved, which ensures the accuracy of the optical devices and weapon precision when shooting at a remote target.

Figure 14 – Clamping tool with a laser pointer on the technological sleeve
Рис. 14 – Зажимной инструмент с лазерным целеуказателем на технологической гильзе
Слика 14 – Стезни алат са ласерским обележивачем на технолошкој чаури

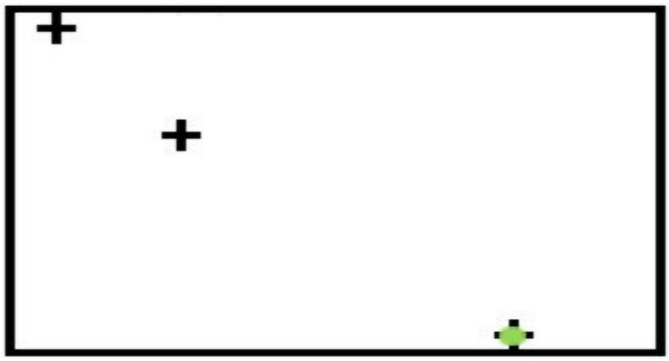

Figure 15 – Layout of the rectification board with the laser beam at the aiming point of the weapon barrel axis
Рис. 15 – Изображение на бортовом баллистическом вычислителе с лазерным указателем в точке прицела ствола орудия
Слика 15 – Изглед табле за ректификацију са ласерским снопом на нишанској тачки осе цеви оруђа

The proposed rectification method with a laser pointer can be applied to any artillery piece or weapon in day and night conditions, provided there is an appropriate technology sleeve, the clamping tool and the rectification board.

Structure of tools and working tools with economic indicators

Table 6 lists the data on the necessary tools and means for implementing the method of rectification with the laser pointer, as well as the necessary funds and their sources.

Table 6 – Data on the necessary resources and tools for the method application
Таблица 6 – Сведения о необходимых ресурсах и инструментах для применения данных методов
Табела 6 – Подаци о потребним средствима и алату за примену методе

r/b	Name of tools and means of work	Quantity	Source	Approximate price (RSD)
1	Laser pointer *	1	Procurement from the market	1 200,00
2	Technological sleeve	1	The Army of Serbia (Finalisation in the Institute)	-
3	Clamping tool for a laser pointer	1	Production at the Institute	800,00
4	Circular mesh	1	The Army of Serbia	-
5	A rectification board	1	The Army of Serbia	-
IN TOTAL:		1 set	TOI Čačak	2 000,00

The data listed in Table 6 refers to the tools and means of work for one type of artillery pieces, except for those marked with an asterisk that can be used for all types of artillery weapons. The product in position 2, a technological sleeve, needs to be upgraded in the Institute, by making a hole for fixing the clamping tool to carry the laser pointer (Figure 11). The tool in position 3 is made in the Institute.

The total cost per one set, for one piece type, is about 2,000 RSD.

Conclusion

The aim of the research was to improve the existing method of rectification of the axes of optical devices in order to achieve better precision of shooting with the current weapons. The goal is achieved by applying a new rectification method based on the use of laser pointers.

The description of the method of rectification of optical devices based on the use of the laser pointer and its application in the process of general

overhaul of the H-122mm howitzer D30 at the Technical Overhauling Institute Čačak, as well as the obtained results by measurement, show the following advantages of the proposed method:

- the subjective factor in the realization of the method is eliminated,
- it provides accurate data on the deviation of the optical axes, allowing their correction and harmonization,
- the aiming accuracy and the firing accuracy are achieved,
- measurement uncertainty of the rectification method is reduced to a minimum, which ensures the reliability of the rectification method,
- much shorter technological time required to check the alignment of the optical axes and the weapon barrel axis,
- checking the alignment of the optical axes and the barrel axis is carried out by one person, which reduces the necessary technological capacity envisaged for these procedures,
- a uniform rectification quality is achieved in each repeatition of the axes alignment check,
- rectification is solely done using a rectification board located at a distance of 50 *m* and in this way the method does not depend on climatic conditions, the time of the day or night, and the possibilities of determining a distant target by which the TU-I method is implemented. Also, since rectification is done at small distances, the parallax error is avoided.

Further research in this area can be directed to the application of the proposed method of rectification with a laser pointer to all artillery pieces up to 155mm caliber, including the M84 tank. Also, research can be applied to weapons using a periscope for rectification.

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СОВЕРШЕНСТВОВАНИЕ МЕТОДОВ СПРЯМЛЕНИЯ НАВЕДЕНИЯ ОПТИЧЕСКИХ УСТРОЙСТВ С ПРИМЕНЕНИЕМ ЛАЗЕРНОГО ЦЕЛЕУКАЗАТЕЛЯ

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ОБЛАСТЬ: логистика, техническое обслуживание
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ВИД СТАТЬИ: профессиональная статья
ЯЗЫК СТАТЬИ: английский

Резюме:

Данная статья основана на наблюдениях за выполнением предписанных действий, осуществляемых на артиллерийском орудии во время содержания и сервиса непосредственно перед выполнением боевых стрельб. Согласованность параллельности осей оптических приборов и оси ствола артиллерийского орудия напрямую влияет на точность прицела и стрельбы. С помощью нового метода согласования параллельности осей, основанного на применении лазерного целеуказателя, отклонения от параллельности осей сведены к минимуму, тем самым повышая точность стрельбы артиллерийского орудия. Разработан быстрый, легкий и надежный метод сверки параллельности осей, согласованных с осью ствола артиллерийского орудия.

Ключевые слова: спрямление наведения, оптические оси, лазерный целеуказатель.

ПОБОЉШАЊЕ МЕТОДЕ РЕКТИФИКАЦИЈЕ ОПТИЧКИХ СПРАВА ПРИМЕНОМ ЛАСЕРСКОГ ОБЕЛЕЖИВАЧА

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ЈЕЗИК ЧЛАНКА: енглески

Сажетак:

Рад је настао на основу сагледавања прописаних радњи, које се реализују на артиљеријском средству, у току одржавања средства и непосредно пре извођења бојевих гађања овим средством. Усаглашавање паралелности оса оптичких справа и осе цеви артиљеријског средства директно утиче на прецизност гађања средством.

Radonjić, V. et al, Improvement of the method of reactifying optical applications by applications by application of laser sensitivity, pp.994-1016

Новом методом усаглашавања паралелности оса, заснованој на коришћењу ласерског обележивача, одступање паралелности оса своди се на минимум, чиме се побољшава прецизност гађања артиљеријским средством. Такође, омогућава се поуздана, лакша и брза провера паралелности оса и њено усаглашавање са осом цеви средства.

Кључне речи: ректификација, оптичке осе, ласерски обележивач.

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NOISE, SOURCES OF NOISE AND ITS INFLUENCE ON THE QUALITY OF WORK AND LIVING ENVIRONMENT

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Summary

Fast technological development has made noise an inevitable part of everyday life. The main sources of noise are: machines, factories, traffic and noise from the neighbourhood. As a mixture of sounds of different charcteristics, noise can be permanent, nonpermanent and impact with different levels, duration and time distribution. Due to the harmful effects of noise on human health, it is necessary to undertake steps which will conrtribute to the reduction of noise levels. Noise pollution and activities for the protection against noise have been analysed in this paper.

Keywords: acoustics, noise.

Introduction

Noise is most often defined as undesirable sound, and in that sense, it obeys all laws of acoustics as a special part of physics which studies generation, propagation and perception of sound.

Sound representes a type of a mechanical wave which can be detected by the sense of hearing (Georgijević, 2005, pp.253-257). It is created by oscillating, in other words, by compression and spreading of air molecules travelling under the influence of an external force. As every mechanical wave, sound is determined by two basic physical parameters - wavelength and frequency. Wavelength is a distance between two neighbouring condensations, as well as two neighbouring attenuations of

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the medium through which sound travels. Frequency is the number of oscillations produced in one second and is measured in the unit called Hertz (Hz). A normal human ear can hear frequencies in the range from 20 to 20 000Hz. Every sound below a frequency of 20 Hz is called infrasound and every sound under 20 000 Hz is called ultrasound; they have wide application in medicine and technology. Certain animals (such as dogs, cats, bats, etc.) have a much wider spectrum of hearing sounds (Figure 1).

Figure 1 – Range of audibility in animals (http://www.znanje.org/i/i25/05iv08/05iv080911fll/zvuk.htm, 2016)
Рис. 1 – Диапазон слышимости животных (http://www.znanje.org/i/i25/05iv08/05iv080911fll/zvuk.htm, 2016)
Слика 1– Спектар чујности код животиња (http://www.znanje.org/i/i25/05iv08/05iv080911fll/zvuk.htm, 2016)

Sounds are, according to their characteristics, divided into two main groups: murmurs and tones. A murmur is a sound which appears by irregular oscillations of a sound source where the frequency is constantly changed. A tone appears by regular oscillations of a sound source where the frequency is constant.

Intensity of noise

Like every other type of a mechanical wave, a sound is determined also by its intensity, which represents the amount of sound energy passing through the surface area unit (Vučić & Ivanović, 2000, pp.301-303). Also, every sound source possesses certain power which is equal to the energy which in the time unit passes through the surroundung space and is expressed in Watts (W). The ratio of power and intensity of a sound wave is given by the following expression (Sas, 2007, pp.6-7):

$$P = 4\pi r^2 * I[W] \quad (1)$$

where:

P – source power

I – sound intensity on the surface of the imaginary sphere

r – radius of the imaginary sphere

A direct application of the linear scale for measuring sound intensity would lead to very big numbers which are, therefore, very difficult for manipulation. Besides, the human ear does not respond to sound stimulations linearly but logarithmically. For that reason, the concept of subjective sound intensity is introduced in practice as (Sas, 2007, pp.7):

$$L = 10\frac{\log I}{I_0}(dB) \tag{2}$$

where:

I – objective sound intensity for the given subjective

I_0–objective sound intensity for the referent intensity (threshold of hearing -10^{-12}W/m^2)

The unit for this logarithmic ratio is decibel (dB).

A mechanical wave which has an intensity of about 10W/m^2 is not experienced as a sound, because it produces pain in the ear. This value is called the limit of pain. Subjective intensity of sound at the threshold of hearing is 0 dB, whereas subjective intensity of sound at the limit of pain is 120 dB (Georgijević, 2005, p.283). However, depending on the type of sound, the feelings of pleasantness and unpleasantnessare not directly connected to sound intensity. Some examples of sound intensity levels for certain cases are given in Table 1 (Georgijević, 2005, p.283).

Table 1 – Levels of sound intensity for characteristic cases
Таблица 1 – Уровень громкости звука характерных источников
Табела 1 – Ниво јачине звука карактеристичних извора

Sound intensity level	Examples from the environment
130	jet engine at a distance of 20m
120	loud rock music
110	compression drill at a distance of 2m
100	motorcycle without silencers
90	car horn at a distance of 5m
80	loud shouting, heavy traffic
70	playing the piano, noisy restaurant
60	conversation, office
50	normal conversation, quiet street
40	quiet conversation, quiet music
30	very quiet surroundings
20	very quiet garden outside the town
10	rustling of leaves in the quietest wind
0	threshold of hearing

Sources of noise

Noise represents an important, undesirable pollutant of the environment. The level of noise depends on sound source power, soundpath propagation length, i.e. on the distance from the emitter to the sourounding of the recipient (Cvetković & Praščević, 2005, pp.111-117). The main sources of noise in urban areas are traffic noise, noise from the neighbourhood and industrial noise (Belić et al, 2009, p.5), (Damjanović & Mitić, 2015, pp.19-21). Traffic noise is present in most of the cities. It is estimated that,duringa rush hour in city streets with heavy traffic, sound intensity varies from 80dB onwards. A special threat to the population from noise represents the proximity of airports wherethe level of noise in adiameter of 1km is estimated to be 90dB and higher. As for the noise from the neighbourhood, which includes playgrounds, schools, kindergardens, etc., its general estimation is difficult and it mainly depends on a concrete case. A pleasant place for living is considered to be a place in which its intensity does not exceed 60dB at a distance of 25m from the sound source.Industrial plants have different influence depending on working places, but in most cases they represent a source of so-called constant noise which appears in the uniform work regime. Particularly harmful to health are sound sources representing different types of very fast impacts or explosions (less than 1s). They are, by the rule, differently categorised in order to determine their impact on the human health.

Influence of noise on the human health

Contemporary processes of urbanization and industralization are constantly increasing the number of noise sources so that today there is almost no working place or settlement not exposed to noise. Noise is among physical agents harmful to health and, besides hearing damage, it has a number of nonauditive effects (Nikolić & Nikolić, 2013, pp.93-96), (http://www.b92.net/zdravlje/prevencija.php, 2016).

Disruption of sleep is considered to be the basic and the most important one because it further leads to mood swings, feeling of tiredness, apathy, decrease in working ability, headache and pronounced nervosis. A number of field studies have indicated that sleeping is particularly badly affected by heavy vehicles and trains. For a good night's sleep, it is desirable that noise doesnot exceed 30dB. It is considered that noise of about 65dB can cause anxiety, irritability or headachein very sensitive persons. Noise of about 90dB can affect hearing and cause neurovegetative problems (hypertension, endocrine and metabolic disorders). When the level of noise exceedsa value of 90dB, permanent damage of hearing occurs as well as serious neurovegetative problems.

Noise protection measures

Since today noise often disturbs basic human activities such as work, rest and sleep and can also be a cause of permanent hearing damage, different protection measures are introduced in order to reduce noise levels to the permitted values. In order for the problem of noise level reduction to be solved in a proper way, it is necessary to provide reliable noise measurements. Noise measuring represents obtaininga precise sound intensity value which further determines which sound can cause potential damage and which protection measures should be undertaken in order to improve the acoustics of dwellings, industial plants, music and movie halls, etc.

Nowadays, there are a number of standard methods for measuring the physical parameters of noise which are relatively simple for use; their purpose is to assess the level of damage in accordance with the rules and norms for certain conditions. The basic instrument for noise level determination is a phonometer (soundmeter, measurer of the noise level) (Bruel & Kjaer, 1984, pp.10-15). It is presented at Figure 2.

Figure 2 – Phonometer (http://www.3me.rs/portfolio-item/db-200-profesionalni-merac-nivoa-buke-sa-pc-interfejsom, 2016)
Рис. 2 – Фонометр (http://www.3me.rs/portfolio-item/db-200-profesionalni-merac-nivoa-buke-sa-pc-interfejsom, 2016)
Слика 2 – Фонометар (http://www.3me.rs/portfolio-item/db-200-profesionalni-merac-nivoa-buke-sa-pc-interfejsom, 2016)

A phonometer is often equiped with a filter (octave, one-third octave) which can determine the noise amplitude spectrumas well.

If a place is affected by a number of different noise sources (n), then the equivalent noise level can be obtained by the expression (Sas, 2007, pp.21):

$$L = 10\log\left(10^{\frac{L_{p1}}{10}} + 10^{\frac{L_{p2}}{10}} + \ldots + 10^{\frac{L_{pn}}{10}}\right) \quad (3)$$

Table 2 gives an overview of several annual noise levels at several different locations in the city of Belgrade (Damjanović & Mitić, 2015, pp.73-74):

Table 2 – Overview of the noise level in the city of Belgrade
Таблица 2 – Обзор уровня шума в городе Белград
Табела 2 – Преглед нивоа буке у граду Београду

Measuring place	Time of day	2003.	2005.	2010.	2013.
Bul. Despota Stefana	day	73	75	82	71
	night	67	70	76	66
Bul. Kralja Aleksandra	day	64	65	69	69
	night	59	61	60	65
KBC	day	55	55	66	49
	night	49	47	54	51
Zeleni Venac	day	68	74	72	72
	night	66	70	61	69
Jurija Gagarina	day	65	59	60	60
	night	63	49	55	55
Kalemegdan	day		64	54	52
	night		51	46	49
Narodnog Fronta	day	67	67	66	68
	night	62	62	64	66
Ustanička	day	65	64	66	65
	night	56	52	57	59
Vojvode Stepe	day	68	62	75	68
	night	62	60	71	64
Zemun, Glavna	day	78	75	73	72
	night	73	68	69	67

The measured values indicate that the levels of communal noise are very high and mostly exceed prescribed values.

The main noise protection measure is the reduction of noise at its very source. New and silent technologies allow that certain machines are quieter than conventional equipment. The noise protection measures are divided in two main groups: individual and group protection measures (Sas, 2007, pp.38-48). Individual protection implies wearing different types of earsets, helmets and earplugs providing protection power in the range from 15 to 30dB, even more. Collective or general protection measures present raising different walls, obstacles and absorption elements (trees, etc.) along sound waves propagation paths in blocks of flats, hospitals, schools and other objects where people dwell. (Cvetković & Praščević,

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2005, pp.159-179). It is important to highlight that even small holes in such obstacles reduce their efficiency. In residential areas, problems with noise can be solved by relocating roads out of such areas or by building underground traffic. And finally, if noise is not reduced at its source, the only way left to decrease its influence is on the way from the emitter to the recipient. This protection method is realised through: spatial planning, the layout of the rooms in the building, construction of partitions of certain characteristics, construction of walls and windows in accordance with defined norms and fixing house installations in accordance with the norms for noise protection (JUS U.J6.201, 1990).

Social-legal aspects of noise protection present different types of technical regulations about noise measuring methods, about permitted noise levels, as well as the ways of controlling and sancioning noise polluters. Harmful effects of noise at working places in our country were for the first time defined in the document „Pravilnik o opštim merama i normativima zašite na radu od buke u radnim prostorijama“ (Službeni list SFRJ, 21/92). The maximum allowed levels of noise in the environment are given in the document “Pravilnik o dozvoljenom nivou buke u životnoj sredini” (Službeni glasnik RS,54/92). The document “Zakon o zaštiti od buke u životnoj sredini“, (Službeni glasnik RS, 36/09, 88/10) defines the most important obligations within the framework of protection against noise and vibrations.

Conclusion

Noise is an indispensable part of modern living. It is considered to be every undesirable, disturbing sound, which means that not every sound is regarded as noise. In the past few decades in industrially developed countries, noise has become one of the main sources of disturbance of many different human activities but also a cause of complex damage to the human health. In order to monitor harmful effects and undertake certain protection measures in the concrete conditions, it is necessary to determine the noise level by measurements. In practice, it is often the case that the level of noise varies, more or less in time. In order to protect people, in most of the countries, a lot of attention is paid to defining the highest allowable noise level, which, depending on the type of the activity, can be between 35dB and 90dB. This can be mainly achieved by so-called ecological protection measures which imply the use of the best spatial layout in order to decrease noise effects.

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ШУМ, ИСТОЧНИКИ ШУМА И ИХ ВОЗДЕЙСТВИЕ НА КАЧЕСТВО РАБОЧЕЙ И ОКРУЖАЮЩЕЙ СРЕДЫ

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ЯЗЫК СТАТЬИ: английский

Резюме:

Вследствие технологического развития в современном мире, шум стал неотъемлемой частью повседневности. Основными источниками шума являются различные машины, станки, фабрики, заводы, транспорт и прочие звуки из окружения. Как совокупность различных звуков шум может быть стационарным и нестационарным, постоянным и непостоянным, колеблющимся, прерывистым и импульсным, отличаться по уровню и периоду воздействия. Так как шум оказывает негативное воздействие на здоровье человека, необходимо принять все возможные меры по снижению уровня шума. В данной статье представлен анализ негативного воздействия шума и описаны меры и средства по защите от шума.

Ключевые слова: акустика, шум.

БУКА, ИЗВОРИ БУКЕ И ЊЕН УТИЦАЈ НА КВАЛИТЕТ РАДНЕ И ЖИВОТНЕ СРЕДИНЕ

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ОБЛАСТ: акустика, бука, заштита животне средине
ВРСТА ЧЛАНКА: стручни чланак
ЈЕЗИК ЧЛАНКА: енглески

Сажетак:

Убрзаним технолошким развојем савременог човечанства бука је постала неизбежан део свакодневног живота. Основни извори буке су машине, фабрике, саобраћај, као и звуци из суседства. Као мешавина звукова различитих карактеристика бука може бити трајна, испрекидана и ударна, промјенљивих нивоа, различитог трајања и временске расподеле. Због њеног штетног утицаја на људско здравље потребно је предузети одређене активности

Korica, S. et al, Noise, sources of noise and its influence on the quality of work and living environment, pp.1017-1026

ради редуковања нивоа буке. У овом раду анализирана је загађеност буком и делатности на плану заштите од ње.

Кључне речи: акустика, бука.

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CONCEPT OF LOGISTICS PREVENTION DEVELOPMENT IN A DEFENCE SYSTEM

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Abstract:

Logistics prevention should be viewed as a system (composed of subsystems and components), as a function (group of related tasks grouped according to certain criteria) and as a process (course of arranged events in time). Logistics prevention is a part of the overall defence system logistics suport which prevents the infringe of projected and present performances of a supported system. Logistics prevention, as a function, includes all measures and activities planned by logistics authorities and implemented by logistics authorities and non logistics personnel. They are aimed at preventing the occurence of phenomena and processes that negatively affect the ability and performances of a defence system. At a time of intense defence system organisational changes, the approach to logistics prevention should be systematic and adequately dealt with due to its significance. The principles related to design, preparation and operation of the whole defence logistics also relate to design, preparation and implementation of logistics preventive.

Key words: military logistics, system, logistics prevention.

Introduction

If a defence system is to perform assigned tasks successfully, achieve results and high set goals and fulfill assigned missions, it is essential to have high-quality logistics support, an important segment of which are logistics prevention activities within all functions of logistics support. Logistics prevention implies a set of measures and procedures planned and organised by logistics administrative authorities, and realised by logistics units and nonlogistics personnel in the defense system, or, if necessary, appropriate entities outside the defense system. Preventive measures and procedures of logistics administrative and executive bodies are focused on preventing the occurrence of adverse events and processes that can act negatively on the ability of the defense system as a complex organisational and multilevel organisational system, in order to reduce the consequences of such events and processes. Prevention in the context of this work involves a holistic approach. It consists of prevention activities carried out by holders of logistics support (LoS) functions (health care, infrastructure, maintenance, supply, transportation, general logistics), prevention activities in the framework of joint LoS functions (planning, purchasing, sales, handling and disposal of material assets, payment services to third parties, etc.), and prevention of logistics character in the preparation and use of supported systems (preparation, equipment based on merit, development, use). Only in this way it is possible to approach prevention globally and act locally, ensuring maximum defense system readiness with optimised costs.

Logistics prevention has been treated differently by bearers of logistics functions. Therefore, achievements are different in each of the logistics functions. There was no common wiev on logistics prevention management among logistics functions as shown below in Table 1.

Examples of logistics preventive application in practice

There are many examples of intensifyng measures and procedures when logistics-related objects face some kind of unwanted state (Atanasković et al, 2012a, pp.191-199), (Atanasković et al, 2012b, pp.69-78).

In such situations, the organisation system performaces become vulnerable. In all logistics functions, there are many examples of implementing prevention activities since they have numerous benefits, some of which are shown further on in the paper.

Table 1 – Review of prevention activities related to logistics functions
Таблица 1 – Обзор развития профилактических мероприятий по функциям логистики
Табела 1 – Преглед развоја превентивних активности по функцијама логистике

SUPPLY	MAINTENANCE	COMMISSARIAT
1	2	3
I LEVEL (batallion) – requisition, – warehousing, – guarding, – proposal of a renewal plan, – dispersion of material reserves, – professional soldier training.	I LEVEL (batallion) – basic maintenance, – technical maintenance (I, II technical inspection), – professional soldier training.	I LEVEL (batallion) – feeding, – water supply, – dressing, – bathing, – haircutting, – periodical inspection of equipment, – professional soldier training.
II LEVEL (brigade) – procurement for stock management, – budget and echelonment, – warehousing, – guarding, – stock renewal, – dispersion of material reserves, – professional soldier training.	II LEVEL (brigade) – basic maintenance, – technical maintenance (I, II technical inspection), – assistance to the lower maintenance level, – professional soldier training.	II LEVEL (brigade) – disposal, – professional soldier training.
III LEVEL (operation unit level) – procurement for stock management, – warehousing, – guarding, – stock renewal, – dispersion of material reserves, – professional soldier training.	III LEVEL (operation unit level) – professional soldier training.	III LEVEL (operation unit level) – disposal, – professional soldier training.
IV LEVEL (Headquarters level) – procurement for stock management, – warehousing, – guarding, – stock renewal, – dispersion of material reserves, – reserves maneuver – professional soldier training.	IV LEVEL (Headquarters level) – professional soldier training.	IV LEVEL (Headquarters level) – disposal, – professional soldier training.

TRANSPORT	INFRASTRUCTURE	HEALTH CARE
4	5	6
I LEVEL (batallion) – making requirements for transportation, – professional soldier training.	I LEVEL (batallion) -regular maintenance of facilities	I LEVEL (batallion) – medical inspection, – triage, – water control, – request for deration, desinfection and disinsection, – professional soldier training.
II LEVEL (brigade) – making transportation plans, – making march plans - professional soldier training, – assistance to lower units, – professional soldier	II LEVEL (brigade) – making inspection and verification plans (lightning conductors, measuring equipment, etc.).	II LEVEL (brigade) – assistance to the lower health care level, – sending requests for deration, desinfection and disinsection, – professional soldier
III LEVEL (operation unit level) – making transportation plans, – making march plans, – I and II level motion control, – professional soldier training .	III LEVEL (operation unit level) – forwarding inspection and verification plans (lightning conductors, measuring equipment, etc.) to the fourth level.	III LEVEL (operation unit level) – systematic inspection of peoples and animals, – preventive medical labaratory analysis, – deration, desinfection and disinsection, – professional soldier training.
IV LEVEL (Headquarters level) – approvaling of petrol consumtion quotas, – main motion control.	IV LEVEL (Headquarters level) – approval of inspection and verification plans (lightning conductors, measuring equipment, etc.) and controlling their realisation	IV LEVEL (Headquarters level) – professional soldier training.

The result of friction and corrosion processes is wear and tear of materials. According to (http://www.harco.rs/o-podmazivanju.htlm/, 2015), friction, wear and corrosion cause reduction of GDP for 4.5%. This amount is 3.5 mil. euros in the case of Federal Republic of Germany (mostly in energy). Tribology deals with finding solutions for losses caused by friction, wear and corrosion.

If tribology knowledge is applied in all phases of industrial processes, saving is possible. Saving is manifested through (Figure 1):

- reducing energy spending due to friction reducing;
- reducing costs of lubricants;
- reducing maintenance costs;
- fewer losses caused by failures;
- increasing equipment efficiency and work time.

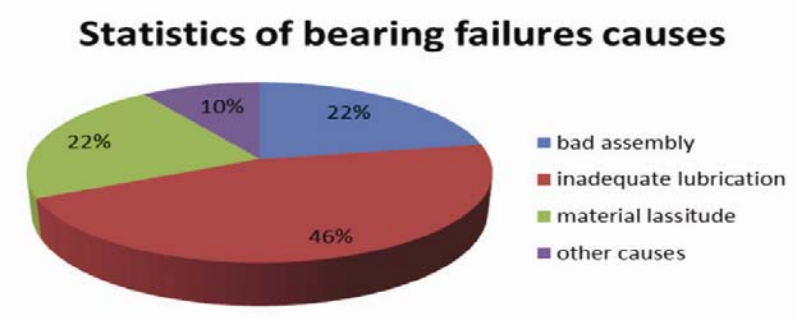

Figure 1 – Statistics of possible causes of bearing failures (http://www.harco.rs/o-podmazivanju.htlm, 2015)
Рис. 1 – Пример причины отказа подшипников (http://www.harco.rs/o-podmazivanju.htlm, 2015)
Слика 1 – Пример узрока отказивања лежајева (http://www.harco.rs/o-podmazivanju.htlm, 2015)

Motor vehicles are machines exposed to wear and tear. Today's motor vehicles are sofisticated computer-controlled machines which need less care by consumers and have higher levels of reliability than their precursors. Regular periodical maintenance is important for reliable performances and saving on the road. Because of that, most of big companies sign maintenance contracts in the same time when purchasing new motor vehicles (http://autobusi.net, 2015).

A large number of failures, especially in industries, lead to enormous costs. Saving is significant due to the implementation of infra red thermography (IRT) (http://www.termografija.rs, 2015). Today, IRT is implemented in all areas of the human life (medicine, crime investigation, biology, mechanical engineering, everyday life). Infra red thermography is very important for technical systems diagnostics as a method which does not require halting working processes. Furthermore, IRT can be used for diagnostics of the state of the following equipment:

– electricity and power supply equipment;
– mechanical equipment;
– building constructions;
– industry machines;
– transport infrastructure.

Infra red thermography can discover potential damage on buildings (Figure 2), and enable repair at favorable moments for consumers. In that manner, large scale damage can be avoided.

Figure 2 – Thermal images of the Saint Sava's Temple in Belgrade and a Boleč Church (suburb of Belgrade) (http://www.termografija.rs, 2015)
Рис. 2 – Тепловое изображение Храма Святого Саввы и церкви в п. Болеч (http://www.termografija.rs, 2015)
Слика 2 – Термовизијска слика Храма Светог Саве и цркве у Болечу (http://www.termografija.rs, 2015)

Everyday life and powers of the nature point to the necessity to implement logistics prevention (http://studiob.rs, 2015): "Frequent floods on the left Danube river bank are a consequence of uncleaned canals (Figure 3). In order to prevent this, their cleaning has began (http://studiob.rs, 2015)."

Figure 3 – Human carelessness and neglect of nature (http://studiob.rs, 2015)
Рис. 3 – Небрежное и безответственное отношение человека к природе (http://studiob.rs, 2015)
Слика 3 – Људска небрига и немар према природи (http://studiob.rs, 2015)

Preventive reactions are also very important in the logistics field of health care. Regular preventive inspection enables detecting diseases in their initial phase and gives greater chances for full and permanent recovery. Inadequate preparation of medical staff and a lack of complete information about the injured could have unforeseeable consequences, as confirmed by the death toll after the Russian special forces action in the Dubrovka Theater in 2002.

Given the fact that a human life is priceless, we can emphasise that safety and health at work represent a group of activities which, besides having a human character, contributes significantly to material saving.

The improvement of the present state of defence logistics, as described in this paper, is reflected in the fact that military logistics and its prevention activities should function in accordance with the systematic approach to the management principles and logic of large organisation systems, taking into account particularities of individual logistics functional areas, time requirements and achievements in domestic and world practice as stated above.

The main aim of logistics prevention implementation is to recognize and preemt user requirements.

Development of the logistics prevention concept

Logistics prevention contributes to raising the level of awareness of logistics service users and contributes to creating conditions for less logistics resources involvement. In that manner, the whole logistics support of the defence system becomes cheaper.

The concept of development of logistics prevention is influenced by the present state of logistics services and numerous factors such as:

- physionomy of contemporary challenges, risks and threats;
- legal and system documents in the defence field;
- structure and size of the army, its organisation and functioning mode;
- achieved level of development of weapons and military equipment;
- achieved level of development of the logistics infrastructure and task execution technology in logistics functions;
- level of logistics culture in the defence system;
- characteristics of logistics requests;
- defence policy.

Logistics prevention should be constantly adjusted to supported system requests; on the other hand, supported systems must be designed taking into account logistics prevention requests. Supported systems also need to adapt to the possibilities of logistics systems (Atanasković et al, 2009, pp.127-139), (Pamučar et al, 2016).

The principles related to design, preparation and functioning of defence logistics also relate to design, preparation and functioning of logistics prevention.

Certain elements of logistics prevention are already built in the defence logistics system in order to perform its tasks shown below in Table 2.

Table 2 – Logistics prevention elements implemented in the system of logistics support design process
Таблица 2 – Элементы профилактических мероприятий, которые необходимо ввести в систему логистической поддержки при проектировании
Табела 2 – Елементи логистичке превентиве које треба уградити при пројектовању система логистичке подршке

NAME OF LOGISTICS FUNCTION	ELEMENTS OF LOGISTICS PREVENTION
ACQUISITION	Logistics prevention is implemented in the aquistion process by regulating this area by means of laws, standards and principles, by creating favorable organisational culture, by defining the organisation and technology for which it is implemented and by ensuring transparency in procurement. The quality of the ordered products and services is controlled by the purchaser.
SALE	Logistics prevention is implemented in the sale process by regulating this area by means of laws, standards and principles, by creating favorable organisational culture, by defining the organisation and technology for which it is implemented and by ensuring transparency in sale.
SUPPLY	The correct expression of the need for equipment; establishing the standards, criteria and norms for rations; research of the market and supply sources; defining the focus and priorities, monitoring, inventory management of stored materials.
MAINTENANCE	Application of maintenance systems for all classes of equpment, taking into account their particularities Basic maintenance (daily inspections, periodic inspections, operation, exploitation measurements); Technical maintenance (the first inspection and the second inspection, inspection of less complex equipment, conservation, maintenance assistance in the performance of basic periodic inspections); Medium repair (medium repair of components and aggregates taking into consideration time and exploitation resources, conservation, assistance to maintenance technical inspections); General overhaul (general overhaul of components and aggregates taking into consideration time and exploitation resources, conservation, assistance to medium repair; Revision (equipment, components and aggregates); Checks Inspections (all activities prescribed in technical instructions).
TRANSPORT	Movement control and the use of communications in the zone of operations; regulation and control of military traffic participants (movement control for motorized military motorcades, and sometimes for individual vehicles in public transport and the regulation and control of the movement of military participants in public transport and closed military areas). Application of security measures in movement and transport.Personnel transport and cargo transport. Obligations in equipping and use of equipment from the functional competence.

NAME OF LOGISTICS FUNCTION	ELEMENTS OF LOGISTICS PREVENTION
HEALT CARE	Medical support (preventive medical care: hygiene and prophylactic measures, anti-epidemic measures, medical measures for anti-radiation, hemical, and biological protection; specific measures of medical care and evaluation of sanitary-epidemiological situation. Using equipment from the functional competence. Veterinary support (veterinary - sanitary inspection of animals for slaughter and foodstuff of animal origin, health care of ungulates, isolation of wounded and sick ungulates).
GENERAL LOGISTICS	Services to feed the personnel. Services for the purpose of dressing. Communal services. Energy services. Furnishing facilities and production and service plants. Accommodation and service activities (accommodation of personnel, laundry and dry cleaning equipment, bathing and dressing, barber, tailoring and shoemaking services, payment services for the provision of energy products and electricity, maintenance and production of general logistics equipment). Service standards of general logistics services. Other general logistics needs. Elements of the quality of life.
INFRASTRUCTURE	Planning spatial development and alignment with the needs of defense system. Management of real estate and rights related to real estate. Current and investment (capital) maintenance. Preventive and corrective maintenance of thermal power plants.

Logistics prevention involves two groups of tasks:
– tasks of preparing logistics prevention;
– tasks of implementing logistics prevention.

The phases of logistics prevention organisation and common tasks realised within the frame of logistics functions are shown in Table 3.

Table 3 – Logistics prevention phases and tasks
Таблица 3 – Этапы и задания логистической профилактики
Табела 3 – Фазе и задаци логистичке превентиве

TASKS OF LOGISTICS PREVENTION	
PHASES OF PREPARING LOGISTICS PREVENTION	PHASES OF IMPLEMENTING LOGISTICS PREVENTION
Quality design and dimensioning of logistics systems dealing with logistics prevention, its elements and processes.	Practical application of specific measures and actions of logistics prevention.
Identifying threats to logistics prevention and chances that can facilitate the realization of logistics prevention.	Coordination of measures and activities of logistics prevention to give coordinated action and homogeneous treatment at the internal and external level.

TASKS OF LOGISTICS PREVENTION	
PHASES OF PREPARING LOGISTICS PREVENTION	PHASES OF IMPLEMENTING LOGISTICS PREVENTION
Identification and assessment of the needs for logistics prevention and quantification of logistics possibilities.	Control over the quality and quantity of applications of logistics prevention.
Planning logistics prevention (planning tasks, manpower, material support, financial support, if needed, intelligence and security support) in all elements of logistics systems, stages in the life cycle of the Army and hierarchical levels of organisation of the Army, taking into account all aspects of the logistics prevention (spatial, time, organisational and technological aspect).	Application of the prescribed measures and activities (individual and collective) in accordance with the prescribed time and exploitation resources, principles, standards and technology.
Education of logistics personnel in the field of logistics prevention.	Monitoring the key performance indicators of logistics prevention and measuring business parameters to determine business performance.
Education of management personnel in the field of logistics prevention.	Practical application of acquired knowledge by improving the state of logistics prevention within one's functional jurisdiction.
Education of nonlogistics personnel in the field of logistics prevention and promotion of preventive culture.	Pactical application of acquired knowledge by improving the state of logistics prevention within one's functional jurisdiction.
Consideration of control measures in logistics prevention.	Control of realization of implementation of logistics prevention measures.
Identifying the requirements of compatibility in the field of logistics prevention.	Control of compliance with the applicable regulations of logistics prevention.
The study of legal acts, regulations and standards relating to the organisation and technology of logistics prevention.	Proposing amendments to logistics prevention regulations.
Training subordinates in the application of prescribed measures and activities (individual and collective) in accordance with the prescribed time and exploitation resources and other principles and standards.	Monitoring experiences and trends in the field of prevention in other organisations.
Monitoring the key performance indicators of logistics prevention and measuring business parameters to measure logistics prevention success.	Revisiting the representativeness of the key performance indicators of logistics prevention and methods for their measurement.

Preparation and implementation of logistics prevention should be considered regarding the levels of the defence system organisation and

structure (especially the Army as its most important part) and regarding the logistics system organisation and structure. In that process, all phases of the defence system life cycle and their respective tasks should be covered. A simplified model of a logistics prevention organisation in the defence system is shown in Table 4.

Tabel 4 – Model of logistics prevention organisation
Таблица 4 – Модель логистической профилактики
Табела 4 – Модел организовања логистичке превентиве

<table>
<tr><td rowspan="3">NAME OF LOGISTICS FUNCTIONS AND THEIR STRUCTURE BY THE LEVELS OF THE DEFENCE SYSTEM ORGANISATION</td><td colspan="6">PHASES IN THE ARMY LIFE CYCLE WHERE THE ARMY PERFORMS ITS TASKS, DELIVERS RESULTS AND ACHIEVES GOALS</td></tr>
<tr><td colspan="2">PEACE (including crisis and emergency situations)</td><td colspan="2">MOBILIZATION</td><td colspan="2">WAR</td></tr>
<tr><td>prep. of log. prev.</td><td>implem. of log. prev.</td><td>prep. of log. prev.</td><td>implem. of log. prev.</td><td>prep. of log. prev.</td><td>implem. of log. prev.</td></tr>
<tr><td>SUPPLY
.. subfunctions
..elements of the system which realizes the function...</td><td colspan="6" rowspan="6">WHO?, WHAT?, WHERE?, WHEN?, WITH WHAT AND WITH WHOM?, HOW AND HOW MUCH?, HOW MUCH IS THAT?, CONSEQUENCES OF LOGISTICS PREVENTION ABSENCE
(spatial, time, organisational and technological and financial aspects)</td></tr>
<tr><td>MAINTENANCE
.. subfunctions
..elements of the system which realizes the function...</td></tr>
<tr><td>TRANSPORT
.. subfunctions
..elements of the system which realizes the function...</td></tr>
<tr><td>HEALT CARE
.. subfunctions
..elements of the system which realizes the function...</td></tr>
<tr><td>GENERAL LOGISTIC subfunctions
..elements of the system which realizes the function...</td></tr>
<tr><td>INFRACTURE
.. subfunctions
..elements of the system which realizes the function...</td></tr>
</table>

Elements of the concept of logistics prevention development

Necessary elements of the concept of logistics prevention development are logistics functions performance indicators and quantitive indicators of logistics needs and abilities (number of members, surface area, volumes, time resources, exploitation resources, work ability, capacities, overhaul ability, etc.).

Design of logistics processes and dimensioning their resources (personnel, equipment, object, facilities) must be carried out for the most unfavorable system condition (extreme load). The degree of filling for a specific state is regulated by management decisions. The system's ability to move fast from one state to another must be taken into account (from peace to the state of war) where implementing its own transformation and the transformation of the supported system must be carried out at the same time.

Based on the aforementioned (Project "VA -TT/6/13-15", 2015), it can be concluded that the approach to the development of logistics prevention must be holistic. The elements that must be considered in the concept of logistics prevention development are as follows:

- Managing personnel (addmision in the logistics system, staff training management, necessary knowledge, skills, habits, attitudes, training, education and specialisation, leaving the logistics system);
- Equipment and supplies from the logistics jurisdiction (defining the scope and quality needs and ways for their procurement);
- Equipment and supplies necessary for logistics unit activities (defining the scope and quality needs and ways of their procurement);
- Logistics infrastructure (facilities, plants, installations, etc.);
- Peacetime and wartime organisation schemes of logistics bodies and units;
- Peacetime and wartime individual and material formations of logistics bodies and units;
- Logistics bodies jurisdictions and tasks in accordance with the army organisation levels;
- Optimising the implementation of logistics processes and information, material and energy flows in defence logistics;
- Logistics norms, logistics military literature and documentation;
- Logistics defence planning and logistics support planning;
- The principles of the constitution and functioning of logistics;

– Method of functioning of logistics bodies and units and the method of executing logistics tasks;
– Logistics support to logistics bodies and units;
– Logistics information system (Andrejić et al, 2010, pp.33-61);
– Degree of internal organisation within the logistics system and coordination of functioning of logistics bodies at different hierarchical levels;
– Degree of readiness (availability) and reliability of logistics services, bodies and units for the implementation of tasks in each of assigned missions;
– Army training for the preparation and execution of logistics operations;
– Resources required for the development of logistics services (by type, quantity and quality);
– Application of the concept of integrated logistics support in equipping the Army with armament and military equipment (Andrejić & Sokolović, 2009, pp.32-53);
– Improving logistics aspects of training, education and specialisation of nonlogistics personnel;
– Modeling of logistics units for usual (standard) and "ad hoc" tasks;
– Modalities of the reliance of logistics in the Army on the state logistics;
– Logistics interoperability;
– Control parameters and evaluation of achieved status, performance and quality of work of logistics units;
– Focal points and priorities in the theoretical and operational functioning of the logistics system,
– Management of the development and operation of logistics.

The developing concept of logistics prevention requires active work, energetic and coordinated actions of all logistics subjects in the defence system.

Investment in personnel, organisational and tehnological modernization, equipment, plants and installations modernization and management, should not be regarded as a cost but as investment for better future for logistics services and the overall defence system.

The concept of logistics prevention development as an intelectual and philosophical idea must be followed by a detailed logistics prevention operation plan. It must get answers to the following questions: What?, Who?, How? Until when?, Where?, Who with?, How?, With what and how to realise it?, How much does it cost? and Who provides resources?

Conclusion

The data reported in this paper, as a result of the observation of a real logistics support system, show that certain LoS functions have developed preventive actions and this characteristic makes them more effective in practice. In addition, there is still a lot of space for the existing state of the logistics prevention to become more perfect. Development and full implementation of the proposed concept of logistics prevention significantly contribute to the rationalization of many demands in appearance, optimising the structure and dimensioning of logistics elements, reducing the stress of the system, reducing costs and increasing efficiency and effectiveness.The overall quality of logistics prevention depends on the quality of the application at the place where logistics requirements appear, but also on the quality of the design of logistics prevention carried out at higher hierarchical levels of the logistics system organisation. The battle for a high level of readiness, availability and long life of the system (organisational, technical and biological) is won with high quality logistics prevention. Failures due to the imperfections of the logistics prevention system (poorly-designed) or due to insufficient quality functioning of logistics prevention generate significant negative consequences in the system in a form of unnecessarily high costs, failure to execute specific tasks or loss of life (Generalštab Vojske Srbije, 2009). During the design and implementation of organisational changes in defense logistics, all elements of the logistics system functions and processes should be viewed critically and in terms of benefits for the preparation and implementation of logistics prevention (Stanojević et al, 1999, p.651). One way of improving the quality of logistics prevention is timely recognition of user's requests and responses to them, based on an adequate information system and rapid transport (Andrejić & Ljubojević, 2009, pp.15-27). While searching for an optimal model of logistics prevention, what should be taken into account is logistics interoperability (both at the national and international level), developed in accordance with the dynamics of integrations in the field of defense and our real possibilities.

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КОНЦЕПТ РАЗВИТИЯ ПРОФИЛАКТИЧЕСКИХ МЕРОПРИЯТИЙ В ОБЛАСТИ ЛОГИСТИКИ В СИСТЕМЕ ОБОРОНЫ

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ОБЛАСТЬ: логистика
ВИД СТАТЬИ: профессиональная статья
ЯЗЫК СТАТЬИ: английский

Резюме:

Профилактические мероприятия в области логистики необходимо рассматривать как систему (включающую подсистемы и элементы), как функцию (группа однородных заданий, организованных по определенному критерию) и как процесс (порядок действий в течение определенного времени). Профилактические мероприятия являются неотъемлемой частью логистической поддержки в системе обороны, они способствуют предотвращению возможности нарушения запроектированных функций и деятельности системы и ее элементов (а также объектов деятельности), следовательно, они оказывают большое влияние на развитие функций системы в целом. Профилактические мероприятия как функция включают комплекс мероприятий, разработанных и организованных подразделениями Логистики. А в осуществлении данных мероприятий принимают участие как логистический персонал, так и сотрудники других подразделений. Цель данных мероприятий заключается в предупреждении явлений и процессов, которые могли бы неблагоприятно повлиять на функции системы обороны. Во время осуществления масштабных организационных перемен системы обороны роль профилактических мероприятий в области логистики особенно важна, поэтому их системной разработке необходимо посвятить особое внимание. В разработке профилактических мероприятий в области логистики применяются те же принципы и подход, как и в проектировании, подготовке и осуществлении логистической обороны в целом.

Ключевые слова: военная логистика, система, профилактические мероприятия.

КОНЦЕПТ РАЗВОЈА ЛОГИСТИЧКЕ ПРЕВЕНТИВЕ
У СИСТЕМУ ОДБРАНЕ

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ОБЛАСТ: логистика
ВРСТА ЧЛАНКА: стручни чланак
ЈЕЗИК ЧЛАНКА: енглески

Сажетак:

Логистичку превентиву треба посматрати као систем (сачињен од подсистема и елемената), као функцију (група сродних задатака груписаних по одређеном критеријуму) и као процес (ток

Epler, I. et al, Concept of logistics prevention development in a defence system, pp.1027-1043

уређених догађаја у времену). Логистичка превентива је део укупне логистичке подршке систему одбране који спречава да се нарушене пројектоване, у ствари постојеће перформансе система који се подржава и његових елемената (објеката деловања логистике), односно који утиче на унапређење перформанси система који подржава. Логистичка превентива, као функција, подразумева све мере и активности које планирају и организују логистички органи, а реализују логистички органи, јединице и нелогистичко особље. Оне су усмерене на спречавање наступања појава и процеса који негативно делују на способности и перформансе система одбране. У времену интензивних организационих промена у систему одбране, системском уређењу логистичке превентиве треба дати адекватан значај и посветити му нарочиту пажњу. Принципи који се односе на пројектовање, припрему и функционисање логистике одбране у целини односе се и на пројектовање, припрему и спровођење логистичке превентиве.

Кључне речи: војна логистика, систем, логистичка превентива.

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TYPES OF INFORMATION WARFARE AND EXAMPLES OF MALICIOUS PROGRAMS OF INFORMATION WARFARE

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Abstract:

The possibilities of the information management system are unimaginable. "Information warfare" (IW), defined as a targeted effort to undermine and neutralize hostile command and control systems for the purpose of protecting and coordinating the activities of command and control systems of friendly forces, is a frequently used term. Most of modern political and military systems of command and control are based on high speeds of computer-based communication. Hence, the information infrastructure is the "infomercial" arena in which information warfare is conducted. Every system or a person that forms part of this sphere is a potential target in IW. The form of information warfare is the way of its exposure and it is expressed through the structure of events and activities related to the processes that take place in it. This means that the form of information warfare is a special feature that distinguishes it qualitatively from other forms. It is evident that information warfare dramatically affects the mode of war, regardless of whether it is only an evolutionary period or represents a revolutionary development.

Key words: terrorism, systems, Internet, command and control systems, command and control.

Introduction

Every day we witness the incomprehensible capabilities of the information management system. For this reason, it is no wonder that in the daily conversation, "information warfare" (IW) is often mentioned. It is sometimes even regarded as a future cornerstone of the future military doctrines of some countries, even of those most developed ones.

Information warfare has enormous political, technical, operational, and legal implications for the military. Therefore, here we will try to define IW, identify potential military uses and applications, as well as the problems that are responsible for the implementation of this new doctrine.

What is information warfare?

Information Warfare (IW) is a targeted effort to undercut and neutralize the enemy's command and control system for the purpose of protecting and coordinating the activities of the command and control system of friendly forces (Blair, 2001).

Information warfare may include (Reisman & Antoniou, 1994):

- collecting tactical information,
- checking the accuracy of information,
- spreading propaganda and disinformation to demoralize or manipulate the opponent and the public,
- undermining the quality of opponent information,
- denying the opponent the opportunity to collect information.

Some governments spend billions of dollars to establish agencies that will collect and store information about potential threats to their security. Information is a strategic advantage (Campen, 2002).

This is a fact first understood by computer hackers, many of whom are currently serving long-term prison sentences, precisely because of attempts to alienate confidential information.

Types of information warfare

The form of information warfare is the way of its exposure and it is expressed through the structure of events and activities related to the processes that take place in it. This means that the form of information warfare is a special feature that distinguishes it qualitatively from other forms.

In the available literature dealing with information warfare, there are more views on the forms of its manifestation, the most widespread perceptions being those of eminent experts from that area Schwartau and Libbicky's.

Winn Schwartau classifies information warfare in three groups: 1) personal information warfare; 2) corporate information warfare; 3) global information warfare (Petrović, 2001).

According to Martin Libicki, information warfare occurs in the following forms: 1) warfare in the sphere of command and control; 2) intelligence

warfare; 3) electronic warfare; 4) psychological warfare; 5) hacker warfare; 6) economic-information warfare; 7) cyber warfare (Libicki, 1995). All of these forms are connected, especially hacker warfare and cyber warfare that are not completely disjunctive.

The official definition of the US Department of Defense on warfare in command and control is: ”Command and Control Warfare is a military strategy that applies information warfare on the battlefield in order to separate the command structure of the opponents’ from the units they command (the original English term is to be defeated) (Libicki, 1995). Defusing can be done by damaging the head (commander, command post) or door (communication), depending on different tactical and strategic purposes. Libicki believes it is much more important than finding the physical location of a commander finding a command post. Attacking the command positions, especially if it is timely adjusted, may have exceptional operational consequences and it is not necessary for the opponent to be ”beheaded”. In most situations, the command post is a knot in the entire structure of the opponent and its elimination is rarely missed if such a possibility is indicated.

It can be destroyed by classic bombs, but also by interrupting power supplies, electromagnetic interference, computer viruses, interrupting communications, etc. (Libicki, 1995). "Damage to the Door" means the intersection of communications by the enemy, which makes command and control incapacitated, which has a decisive influence on the final outcome of the conflict.

War in the sphere of command and control can be conducted offensively (C2 - attack) and defensively (C2 protect) (United States Department of the Army, 1993). Based on the above, it can be concluded that the aim of C2W is to degrade or destroy the opponents' potential for command and control while at the same time protecting their own C2 potentials from such activities.

Intelligence is an activity that aims at finding goals, evaluating combat actions, preventing surprises, etc. Primary intelligence sources can be classified into different categories: Human Intelligence (HUMINT), Signal Intelligence (SIGINT), Technical Intelligence (TECHINT) and others (Group of authors, 2000). In Brussels, on February 23, 2000, the European Parliament began a debate on a planetary spy network, called "Echelon". A network of 120 satellites covers the entire planet and makes a system that is able to control 2 billion messages daily, thanks to artificial intelligence and given key words. According to some western papers that are difficult to verify, the most commonly used keywords for automatic messaging devices in Echelon regional centers are: "kill the president", "anarchy", Glock-26 - a ceramic gun impossible to detect by metal detectors and other. The Echelon's satellite spy system, therefore, deals with the collection and analysis of various (political, security, economic,

technological, trade, etc.) data. The only control center in Gloucester (UK) employs 15,000 people who are involved in the analysis of collected data (Prvulović, 2002).

Electronic warfare is warfare in which electronic and other means directly affect the enemy's electronic means and systems as well as combat systems and weapons based on their use of electronics. Electronic warfare is also defined as a military activity that involves the use of electromagnetic and targeted energy in terms of dominating and managing events in the electromagnetic spectrum and in terms of an electronic attack on the enemy and its combat systems. Schlecher defines electronic warfare as ”a military action aimed at controlling the electromagnetic spectrum” (Schleher, 1999). According to a study by the Faculty of Electrical Engineering, University of Belgrade, electronic warfare is a set of military actions whose main goal is to control electromagnetic space, its domain. In the context of information and electronic war relation, electronic war is considered to be a subset of information warfare (Group of authors, 2000).

In FM-105 rule, electronic warfare is defined as ”any military action involving the use of electromagnetic and targeted energy to control the electromagnetic spectrum (EMS) or an attack on an opponent.” (United States Department of the Army, 1993). Electronic warfare is, in essence, the battle for the control of the electromagnetic spectrum.

In order to achieve the stated goal, activities that have an offensive character - Electronic Attack (EA) and defensive character - Electronic Protection (EP) are applied. In addition, Electronic Support (ES) represents activities aimed at collecting information for the needs of EA, EP, avoiding opponents’ actions, using their own combat resources (Group of authors, 2000).

An electronic attack is a part of electronic warfare involving the use of electromagnetic energy or targeted energy for an attack in order to degrade, neutralize or destroy the opponents’ combat potentials. Electronic jamming and deception are "soft kill" measures while "hard kill" measures are the effects of self-inflicted missiles on electromagnetic radiation (Anti-Radiation Missile – ARM) and action directed electromagnetic energy (Directed Electromagnetic Weapons - DEW). Electronic protection is a part of electronic warfare that encompasses activities aimed at protecting one's own people and means of the effects of electronic warfare by an opponent, and from unintentional emissions generated by own transmitters that can degrade, neutralize or destroy the combat potentials of their own forces.

Electronic support is a part of electronic warfare that includes activities of discovering, identifying, and location of sources of deliberate or unintentional radiation of electromagnetic energy to detect opponents" actions, to discover the location of targets, to plan and implement support for electronic warfare and other tactical activities. Information about an opponent collected through electronic warfare has a significant intelligence dimension, and then electronic warfare can be viewed as intelligence warfare. However, intelligence warfare is in the function of planning and conducting electronic warfare and, in particular, the formation of an electronic picture of the battlefield. Therefore, the relation between electronic and intelligence warfare best describes the term coordination, which is also characteristic of some other forms of information warfare (Vuletić, 2005).

Szafranski under psychological warfare involves the use of information against the human mind (Szafranski, 1995). The United States considers psychological warfare an integral part of any armed conflict. Due to the great importance given to this form of IW, many professional and scientific institutions, faculties, research centers, institutes are engaged in the USA. A comprehensive system of military authorities and units for psychological warfare has been developed in this country. They are smaller in composition and narrow-specialized (10-15 members) so they can be combined for specific tasks. In the US military rule FM-106, the notion of psychological warfare is reduced and, at the operational level, it is talking about psychological operations. This document states that "psychological operations have the goal of transmitting selected information and indicators intended for foreign listeners and viewers in order to influence their emotions, motives and objective reasoning and, ultimately, the behavior of foreign governments, organizations, groups and individuals to achieve their own interests and goals. "The main goal of a psychological operation in protecting one's own command and control system is to minimize the effects of opponent's propaganda and activities in order to disinfect their own strengths and the population. The goal of PSYOP (psychological operations) is to influence the attitudes and behaviors of those they are pursuing (United States Department of the Army, 1996). According to the American philosopher and political scientist from the late twentieth century, Noam Chomsky, this method of conducting psychological warfare plays an important role and affects about 20% of the population, relatively educated, who takes part in making certain decisions. Media action on this structure of people and their acceptance of doctrine is crucial because they can take part in the creation and implementation of politics. The other part or 80% of the population is merely an observer of events, they should execute orders, messages and tasks and not interfere with the affairs of decision makers. This part of the population is just becoming a target of mass media, whose goal is that these people are

mere observers of events and perpetrators, who should not be tired of what is happening in the world (Stokić, 1995).

Hacker Warfare is one of the forms of information warfare that are most often performed by individuals. A hacker attack is usually aimed at congestion and changing the content of the attacked web site. Because of their functional and physical characteristics, computer systems represent an ideal target for attackers. In order to check the resilience of its computer networks against attacks by hackers, in 1994 the Defense Information Security Agency (DISA) tested and formed its own hacker team and ordered them to attack Pentagon computer networks over the Internet. After completing the testing, DISA's official position is that they are not prepared to defend themselves from the "electronic version of Perl Harbur" and that their computer structure is not safe (Munro, 1995). In October 1994, a Pentagon warned against a growing threat that goes beyond isolated, though irritating and increasingly frequent hacking attempts. It is about organized attacks on a wider, coordinated basis with strategic implications. Behind these threats can be terrorist groups or some countries and it is very difficult to detect them. The use of hacker warfare depends to a large extent on the number of computers in use and the number of Internet users. The degree of integration of computer networks is inversely proportional to the effects of hacker warfare. In contemporary conflicts and technologically inferior countries, they have the opportunity to successfully conduct hacker warfare.

The term "economic-information warfare" is still not fully defined, but it is clear that this form of information warfare is guided by information of economic significance for the conflicting parties. Information of economic importance can be information about various contracts, development strategy of the company, internal structure and organization, marketing and production plans, investments and more. It is obvious that, in a global context, the ”conflict” of the economic and intelligence services is constantly present, around confidential information that would be used against its competitors in the interests of its companies. This "conflict" essentially constitutes an economic (or an industrial) espionage. Former CIA director George Tenet pointed out that the economy was the primary area of intelligence work in the 1990s. Foreign espionage, and after so many years after the end of the Cold War, remains a major threat to Russian national interests, said Nikolai Kovalyov, the then head of the Federal Security Service (FSB) of Russia. The case of a spyware attack on IBM (International Business Machines), which was carried out by some twenty people who worked for Japanese Hitachi, is known to have stolen confidential information worth between 750 million and 2.5 billion dollars over the course of three years. The operation was cut in 1982 by the FBI in its famous sting operation. In 1997, General Motors made a loss of $ 100 million just because one side company developed a vehicle based on data

stolen from its premises (Munro, 1995). After analyzing all the methods and techniques (legal and illegal) of economic and information warfare on the world market, especially due to the fact that most countries do not have technologically equipped and efficient economic intelligence systems, an idea of special agencies that can provide such professional services emerged. The agency's job can be offensive (to help break a certain company or state into the global market by revealing confidential economic information about a particular market and rival companies or to expel a competitor from the game by various techniques) or defensive (to protect a country or company from the theft of industrial and business secrets, to disclose the use of corruption or other illegal means by a competitor in a particular business, thereby hindering that business, etc.).

The growing dependence of the society on information and communication technology creates numerous weak points. Because of these critical points, as well as due to the accentuated complexity and strong interdependence, national infrastructures that connect, run and serve computers have become extremely sensitive. The connectivity of network communications increases their vulnerability, due to the greater possibility of accessing the information structure from various parts of the world. Cyberspace is an area that provides new opportunities for warfare. Arkville and Ronfield defined cyber warfare as a series of actions that break or destroy the opponents' information and communication systems (Arquilla & Ronfeldt, 1995). Cyber warfare can be conducted offensively or defensively. The object of cyber attack can be everything that connects, launches and serves computers (military computer systems, state administration systems, air and rail traffic control systems, gas, water and electricity supply systems, and others). Given their importance, purpose and number, especially in the developed countries of the West, it is evident that the information environment offers cyber attackers the right wealth of choices of highly valued goals. Recognizing the growing problem, in order to protect the national information infrastructure, the United Task Force on Computer Network Defense (JTF-CND) was formed in 1998 in the United States. Its task is to monitor all existing and potential attacks on the information systems of the US Department of Defense, to link all federal agencies to the unique network and national infrastructure protection center and, in the event of an attack, to enable a quick network recovery and respond adequately. In February 2003, the National Strategy for the Security of Cyberspace, which provides the basis for the protection of vital national infrastructure (United States Department of Defense, 2015), was adopted in the USA. Cyber attacks are more extensive, more sophisticated, better coordinated than hacking attacks and directed towards the enemy's significant goals. The use of cyber warfare depends to a large extent on the number of computers in use and the number of Internet users. In an armed conflict, computer attacks may only be carried

out by members of the armed forces with a careful assessment of the potential damage to the attacked target.

Examples of malicious programs of information warfare

Most of the modern political and military systems of command and control are based on high speeds of computer-based communication. Hence, the information infrastructure is the "infomercial" arena in which information warfare is conducted. Every system or a person that is part of this sphere is a potential target in IW. Therefore, it is necessary to first identify, isolate and analyze each element of the enemy infosphere. They then deny, destroy, or make useless data that should reach the opponent. It is even more harmful if false information is inserted, and in this way the enemy starts to make wrong decisions (Toffler, 1993).

In addition, IW can influence political, economic or military goals through: conferences for journalists of important personalities, sabotage of the economy, sabotage of development facilities and scientific research, sabotage of satellite communications, destruction of the information network (Leonhard, 2008).

Information operations are planned for the transmission of selected information to a foreign population in order to influence their feelings and objective judgment, and therefore the behavior of foreign governments, organizations and society. The purpose of information operations is to encourage or reinforce foreign attitudes and behaviors suitable for achieving the political and military objectives of the information operations initiators. In these operations, propaganda methods from the field of psychological warfare are often used, and such operations are often referred to as information-propaganda activities. An example of such an operation can be found in the use of the term Palestinian state, which was used by the PLO around 1964, although it never officially existed, which meant a non-Jewish, non-Israeli country. In this operation it was important to release certain information into circulation. After that, it was first used by journalists, then by public opinion, and finally by politicians (de Arcangelis, 1999).

A person who has an unauthorized access to computer and telephone systems is called a hacker, and the friker term may also be heard (Sterling, 1992).

Since the 1970s when they first appeared, they have repeatedly shown their talent in overcoming computer security systems for accessing information. Not only that. They even approached the databases of various corporations and agencies, and thus caused damage in millions of dollars (Schwartau, 1994).

In order to achieve this, certain funds are needed, so-called Weapons. They can be divided into four categories: software, hardware, electromagnetic systems, and other means (Baker, 1998). The software consists of programs designed to collect, alter, deny information or even destroy the hostile infosphere. Examples of such software have even exotic names: demons, viruses, Trojan horses or Trojans, logic bombs, etc. (Trainor & Krasnewich, 2009).

A demon is a program which, when installed or introduced into the system, records all commands that are entered. It can detect access codes, encryption keys, or similar information. A similar program is a sniffer.

Virus is a program that after attacking files files on the computer or those on the network. It extends to other files without any real damage or can make them unusable, causing deletion of files.

”Virus is a program or code that replicates itself in other files that it contacts. Any program, a boot sector, a document that supports macros can be infected and infected by changing the contents of that file and copying its code in it.

A computer virus usually consists of two parts.

– The first part is a self-copying code that allows the propagation of the virus
– The second part is useful information that can be harmless or dangerous.

Some consist only of a self-copying code. Sometimes a virus requires the interaction of a person to propagate such as launching a program that contains a virus or opening an infected file.The first true ancestor of today's virus was the Prevading animal that was able to access other programs on the UNIVAC 1108 computer system. The first confirmed finding of a computer virus was in 1981 and it was called Elk Cloner. This virus infected the BOOT diskette sector for Apple II computers. In 1988, it was the Jerusalem virus that erased all running programs, and in 1989 Datacrime was able to execute the low-lewel format of the zero path on the disk. In the same year, a real virus firm was activated in Bulgaria. At least 50 viruses including New Zealand and Michelangelo have been created so far.

A biological virus cannot reproduce itself, but it can capture the cells of another organism and use the reproductive mechanism of each host cell to make its own copy. New copies leave the host and look for new hosts to repeat the process. The software virus works the same way. It extends from a program to a program, or from a disk to a disk, and uses every infected program, file, or disk to make as many of its copies as possible. Virus software is usually hidden in the operating system of the computer or in application programs. Some viruses do nothing but playback, others

display messages on the computer screen while others destroy data or delete discs.

One of the most famous email viruses was the Melissa virus. Melissa spread like a fire among Windows systems, infecting 90000 systems in just a few days. Melissa was not designed to damage the systems, but suddenly a message burst out some email servers. The 30-year-old author of the Melissa virus, a resident of New Jersey,attracted by a Melissa player, was discovered and prosecuted (Milosavljević et al, 2013, p.281).

Viruses can be transmitted in many ways, and nowadays virtually all viruses are transmitted over the Internet, and can also be transmitted by diskettes, interchangeable hard disks, compact discs and other removable media.

Trojan horses in computer jargon are malicious programs that are ”masked” as useful or expanding ”attached” to other useful programs. ”Trojans” usually do unwanted actions in a computer, hidden in the "background". The most common of these unwanted actions is the disclosure of user passwords, bank information and other confidential information by ”eavesdropping” the data exchange or simply by reading those files, and reporting them to the ”owner” of theTrojan horse.

There are also Trojan horses in the police service dealing with the collection of information for the purpose of detecting a criminal offense (Remote Forensic Software). This form of citizen spying is enforceable in some countries and is carried out under a court order, in some, despite the conflict with the Constitution, in the preparation phase, while in some cases it has been rejected. Such Trojans are spread by installing or updating commercial operating systems and other software and hardware components of computers, as well as through Internet providers by infiltrating into existing data transfer mechanisms, which must, in their products and services, be provided at the request of the country concerned.

Famous Trojan horses

– Back Orifice
– Netbus
– SubSeven.

”Trojan horse is a program that can do something useful while simultaneously carrying out some secretly destructive work. As in the old story of a wooden horse that brought Greek soldiers through the gates of Troy, a software trojan horse hides the real enemy. These programs often have game-like names or user programs. When an inexperienced individual takes over and launches such a program, he can erase files, alter data, or cause another type of damage. Some network saboteurs use Trojan horses to pass secret information to other unauthorized users. One type of Trojan horse - a logic bomb is programmed to attack as a

reaction to a particular event or sequence of events. For example, a programmer can install a logic bomb designed to destroy data files if a programmer ever appears on a list released in the company's personal service file. A logic bomb can be activated when a particular user logs in, when he enters a special code into the database field, or when the user performs a certain order of actions. If a logic bomb is triggered by an event associated with a timer, it is called a timed bomb. There is a well-known virus with a logic bomb, programmed to destroy computer files with data on Michelangelo's birthday (Milosavljević et al, 2013, p.281).

Spyware is a broad category of malware created to partially intercept or take control of the computer without the knowledge or permission of the user. Although the name suggests that it is about programs that monitor the work of users, this name today denotes a wide range of programs that exploit the computer to gain benefits for a third party. The spy is different from virus and worm in that it usually does not reproduce itself. Like many new viruses, a spy is designed to exploit infected computers for commercial gain. Typical tactics are displaying pop-up ads, stealing personal data (including financial information such as credit card numbers and passwords), tracking online activities for marketing purposes, or redirecting HTTP requests to advertisement pages. In some cases, the spy is used to check compliance with the license terms for using the program.

Infection in most cases occurs when opening pages with illegal or pornographic content.

Computer worms are computer programs that multiply themselves. They use computer networks to copy to other computers, often without the influence of the man. Unlike viruses, they do not have to infect other programs by their actions. They can also be accessed as a file in the e-mail, and their access to the computer allows for gaps in operating systems and applications. Worms make the network more difficult, and can damage data and reduce computer security. Internet worms and viruses create problems for infected computers, but worms can do more damage due to network traffic that they generate when expanding the Internet. For example, SQL Slammer worm doubled in January 2003 the number of infected computers every 8.5 seconds.

The first known worm was made by a Kornel University student during an experiment in 1988. The worm was accidentally released onto the Internet and blocked 6000 computers across the United States. In the summer of 2001, a worm called Code Red appeared. Its target was Internet services that run under Microsoft servers. The US government and Microsoft have sent warnings about worms and made free software patches to protect the server (Miles et al, 2017).

Security and reliability issues are the most critical in military applications. For the successful implementation of the mission, the army must make sure that its systems are safe from spying and enemy attacks.

At the same time, many modern military applications are pushing the boundaries of information technology beyond what they have ever been. Huge assets are invested in the development of smart weapons - missiles that use a computerized guidance system to locate the target. Command guidance system allows the operator to control the missile path.

Self-powered self-propelled projectiles can monitor moving targets without human assistance, using infrared thermal self-leveling devices or ”visual pattern recognition” technology. Weapons using ”smart” guidance systems can be extremely precise in determining the exact position of enemy targets in many cases. One problem with high-tech weapons is that they reduce the time that people have to make a decision between life or death. As the time for making a decision decreases, the possibility of error increases.

An even more controversial possibility is for people to be completely excluded from the decision-making process. The trend in military research is clear about weapons that require almost immediate reactions - what only computers can do. An autonomous system is a complex system that can assume almost complete responsibility for the task without human data entry, verification or decision making. The automated defense system from the projectiles has been stirring up public hearings on false alarms. But for many who understand the limitations of the computer, the biggest question is the reliability of the software. Tavi systems require tens of millions of program code lines. The system cannot be fully tested in advance because there is no way to precisely simulate unpredictable global war conditions. In order to operate efficiently, the system should be absolutely reliable. A small mistake can lead to a major disaster. Many military experts suggest that future wars may not be conducted in the air, on land or in the sea. The front line of the future can be in the cyber space. Attacking connected computer networks, the enemy can damage telecommunications systems, power lines, banking and financial systems, hospitals and medical systems, water and gas supplies, oil pipelines and emergency government services without the use of conventional weapons (Milosavljević & Mišković, 2011).

Conclusion

The doctrine of IW has significant implications for modern military theories. Now an enemy soldier is no longer a big target. The effort is aimed at preventing communication between the command and the soldiers, in order to prevent the coordinated actions of the enemy. This can be achieved by breaking into the command and control system of the enemy and its infantry by using computer systems of weapons and

software attacks. Goals can be of military, political or economic significance. Still, many questions remain unresolved. Intelligence agencies need to evaluate the benefits of coordinated hacking and tampering and obtaining important information.

The nineties of the twentieth and the beginning of the twenty-first century will be recorded in the world history as a period of expansion of the applications of various forms of information warfare. Based on the above facts, it can be concluded that the application of a particular IW form depends on a number of circumstances (eg funds available) and is determined by the goals to be achieved. An analysis of the application of information warfare in contemporary conflicts provides an answer to the question of which the form of information warfare is permanent and which is a temporary companion of armed conflicts. Permanent forms of information warfare are C2W, EW and psychological warfare. Hacking, economic-information and cyber warfare are occasional and very often used forms of information warfare in contemporary conflicts. First of all, it takes a lot of studies and discussions to make the theory of information warfare a practical doctrine. It is evident that information warfare will dramatically affect the mode of war, regardless of whether it is only an evolutionary period or represents a revolutionary development. All in all, there are great efforts by individuals and groups of researchers that information warfare become a part of the military service in the 21st century.

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ФОРМЫ ИНФОРМАЦИОННЫХ ВОЙН И ПРИМЕРЫ ВРЕДОНОСНЫХ ПРОГРАММ В КИБЕРВОЙНЕ

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ВИД СТАТЬИ: профессиональная статья
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Резюме:

Неисчерпаемые возможности системы информационного управления с каждым днем становятся все более очевидны. Очевидно и их применение в так называемой «информационной войне» (ИВ), которая представляет собой целенаправленные действия, предпринятые для достижения информационного превосходства, путём нанесения ущерба , и противника при одновременной защите и управлении информацией, информационными процессами и информационными системами как своих собственных, так и дружественных сил. Большинство современных политических и военных систем управления и командования используют высокороскоростную связь при помощи компьютера. Таким образом, информационная инфраструктура или «инфосфера» стала ареной для кибервойны. Любая система или человек, находящиеся в зоне «инфосферы» являются потенциальной мишенью в информационной войне. Форма информационной войны проявляется в способах воздействия, включающих представление структуры событий и действий, связанных с процессами, которые происходят в ее рамках. Кибервойна по своей неординарной форме существенно отличается от других видов войн. Ее появление, безусловно, влияет на методы военного дела внося как эволюционной, так и революционной характер в развитие военной стратегии.

Ключевые слова: терроризам, системы, интернет, системы командования и управления, управление и контроль.

ОБЛИЦИ ИНФОРМАЦИОНОГ РАТОВАЊА И ПРИМЕРИ ЗЛОНАМЕРНИХ ПРОГРАМА КОМПЈУТЕРСКОГ РАТОВАЊА

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Сажетак:

Могућности система за управљање информацијама су несагледиве. Све чешће се помиње „информационо ратовање" (ИР) које се дефинише као усмерени напор да се изврши подривање и неутралише непријатељски систем команде и контроле ради заштите и координације активности система команде и контроле пријатељских снага. Већина модерних политичких и војних система команде и контроле заснива се на високим брзинама комуникације помоћу компјутера. Отуда је информациона инфраструктура, односно „инфосфера", арена у којој се води информационо ратовање. Сваки систем или лице који су део ове сфере представља потенцијалну мету у ИР. Облик информационог ратовања је начин његовог експонирања и исказује се кроз структуру догађаја и активности везаних за процесе који се у њему одвијају. То значи да је облик информационог ратовања посебна карактеристика која га квалитативно разликује од других облика. Евидентно је да информационо ратовање драматично утиче на начин ратовања без обзира на то да ли је оно само еволуитивни период или представља револуционарни развој.

Кључне речи: тероризам, системи, интернет, командни и контролни системи, команде и контроле.

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ИСКУСТВА ИЗ ПРАКСЕ

ПРАКТИЧЕСКИЕ ОПЫТЫ

PROFESSIONAL PRACTICE

ORGANIZATION OF ENGINEERING WORKS IN DEPLOYING A BRIDGE CROSSING POINT MADE OF CLASS 20 PONTOON MATERIAL

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Abstract:

When using pontoon material for deploying a bridge crossing point and/or some other type of crossing of water obstacles (ferry, landing), it is very important to organize works during the preparation, construction and disengagement of pontoon units and materials for the deployment and maintenance of already deployed crossing points. In the Serbian Armed Forces (SAF) there are specialized units for such works within military engineering, pontoon battalions, and within the River Flotilla (brigade units). The organization of engineering works given in the article represents a method for finding solutions to the use of movable assets and personnel in establishing bridge crossing points (BCPs) made of pontoon materials with a capacity of 20 t. The lack of contemporary literature in drafting the basic documents for the establishment of BCPs (existing literature dates from the 70s and 80s of the last century) is only one of the problems encountered when working in this area so, in the preparation of project documentation, experience from practice is heavily relied upon.

Key words: engineering units, engineering works, river crossing, pontoon materials.

Introduction

A place for crossing a water obstacle, in principle, is a part of a certain type of water barrier, bank and hinterland on both banks to be used in order to ensure a smooth and continuous delivery of people and movable assets (MAs) of all categories over any kind of water barriers (such as rivers, canals, or lakes).

The crossing point is different in size, type of crossing organized, conditions of access and exit roads to the river, forestation and camouflage conditions, units, number of MAs needed to be transferred to the other bank and a number of other factors. Depending on the ways of overcoming water obstacles, there are different crossing points as follows:

- ford crossing point,
- swimming crossing point,
- place of crossing the ice,
- amphibious crossing point,
- ferry crossing point,
- bridge crossing point (BCP),
- underwater crossing point (Pifat, 1980).

It is important to make a distinction between the terms *bridge* and *BCP.* The bridge is only one element of a BCP, namely just an artificial object on the water barrier, while a BCP is a regulated part of the river with its banks and the hinterland (part of the crossing section) where the river is crossed thus enabling continuous movement of units from one bank to the other. A BCP generally includes:

- starting (output) line,
- the access roads to the river,
- land or water points of pontoon material delivery,
- points of installation of bridge elements,
- axis of the bridge,
- upstream and downstream anchor lines,
- location for the deployment of empty cars,
- organs of control and protection services (CPSs) for BCPs,
- reserves of the crossing commander in crossing assets,
- fortified objects for the protection of personnel and resources,
- dams (barrier, obstacles) on the river for the protection of the bridge from vessels,
- group for building a bridge opening (only on navigable rivers),
- landmine obstacles at BCP access points (Generalštab JNA, 1974).

Commanders at a brigade level or higher have the right to decide on bridge elevation. A BCP can be organized immediately after the successful

completion of a violent crossing, deployed bridgehead, and when a BCP is out of reach of enemy fire. Bridge assembling starts, in principle, between 0.5 - 2 h after the start of fording water barriers.This de facto means that the bridge construction starts immediately after establishing a bridgehead and, for a specified time period, it is necessary to ensure that the bridge construction site is out of reach of enemy fire (from small arms or direct artillery). BCPs are generally established at night, while the crossing is performed during the daylight at ferry crossing points (FCPs). The bridge is disassembled for FCPs and the sections of the bridge are used as ferries. During the day, a bridge can also be displaced and tied to the bank, camouflaged until the end of daylight.

Pontoon bridges represent a kind of bridges on floating supports (pontoons). They are designed to overcome water obstacles where there are no permanent bridges. A pontoon itself is a vessel with a hull with the upper deck mainly closed. It is intended for the construction of floating support for pontoon bridges or some types of ferries. A set of a pontoon bridge consists of a certain number of floating elements with cars, road surfaces on cars, tugboats to tow cars, sets of auxiliary equipment, tools and spare equipment and motor vehicles for the pontoon transport. Their basic feature is the reinforcement of the upper surface of the pontoon that serves as a carriageway for traffic (Gardijan, 2001).

Modern pontoon bridges, which are found in the armed forces of almost all countries (including the armament of the Serbian Armed Forces), represent a structural version of the Soviet PMP pontoon bridge which the armed forces of Israel captured from Egypt in war in 1973. The Serbian Armed Forces have 3 sets of pontoon bridges (pontoon stock 3) which are arranged in 2 pontoon battalions, and in 6 pontoon companies (each company is responsible for 0.5 pontoon stock).

In order to establish a BCP, the activities of more specialties and units from a pontoon battalion must be engaged and synchronized, including: reconnaissance and diving, pontoon and road as well as certain parts of the logistics battalion.

The paper describes an example of organizing engineering works in deploying a BCP with a capacity of 20 t made of pontoon material, with the calculation of the necessary manpower, pontoon material, the required time and a dynamic parallel plan of deployment works.

Set of a pontoon bridge M71

The set of the pontoon bridge SPB M71 is intended for setting up ferry and bridge crossings in overcoming water barriers. It can be used to construct:

– pontoons of a carrying capacity of 60 and 20 t (Class 60 and 20), and

– ferries of a carrying capacity of 20 to 170 t. The main types of ferries are 40, 60, 80, 110 and 150 t.

The SPB M71 (park) is constructed so that it can be divided into two halves and each half consists of a separate unit (two halfparks) with which a bridge or ferry crossing can be set independently. It is clear from the above why one pontoon company is responsible for one halfpark, precisely for the reason that it could independently deploy a BCP. The SPB M71 basic features are:

– bridge is constructed of floats (4 prefabricated pontoons) which represent the ready-made sections of the bridge or the ferry;
– in structural terms, bridge and ferry floats are identical;
– for ferry landing, unloading and/or loading MAs, slipways are not needed;
– float decks represent roadways of bridges and ferries with 4 lanes;
– for loads up to 20 t and a width of up to 3 m, two lanes can be used.

The capacity of each float, i.e. floating article (FA) is 20 t, and the capacity of the end (bank) float article (EFA) is 10 t.The time required for the assembly of a bridge/ferry is calculated from the moment when the first military vehicle (m/w) with a laden article arrives at the water (this method of calculating time is performed only in the case where articles can be immediately lowered to the water). In case of bad weather conditions, high-speed waterflow, shortage of personnel, enemy fire and the like, the time norm increases by 1.5 to 2 times.

For the transport of FAs and EFAs, motor vehicles FAP 2026 BDS are used. For the transportation or towing, the RPP M68/88 (river pusher propeller, or tug, which represents the structural version of the Soviet tugboat BMK-130M) is used as well as the AB M70 (aluminum boat) with an OBM (outboard motor). In addition, the FAP AVG 2026 motor vehicle is used for carriage with the OBM AB M70 and accessories for navigation.

Table 1 shows the basic tactical and technical data relating to the SPB M71, as well as the possibility to assemble bridges from this set standards and necessary manpower.

Table 1 – List of tactical and technical data for the SPB M71
Таблица 1 – Тактические и технические данные ПМП М71
Табела 1 – Тактичко-технички подаци КПМ М71

No.	Part of set	Quantity	Weight /kg/
1.	FA on m/w	32	/
2.	EFA on m/w	4	/
3.	Pavement surfacing on m/w	2	/
4.	RPP with m/w	12	/
5.	Support equipment, tools and spare parts - set	1	/
6.	FA on m/w	/	17840

No.	Part of set	Quantity	Weight /kg/
7.	EFA on m/w	/	18170
8.	FA	/	7230
9.	EFA	/	7860
10.	RPP M68	/	4350
Possibilities of assembling bridges			
Bridge capacity 60 t (Class 60)			
No.	Length/width of the bridge roadway in m	Number of people for construction (pontoniers+driver)	The time required for the construction at day/night in min
1.	227 / 6.50	68+34	30 / 50
Bridge capacity 20 t (Class 20)			
1.	382 / 3.30	68+34	50 / 80

Figure 1 shows two float articles assembled into a bridge section, in Figure 2 there is a RPP M88 attached to the bridge section with a tug, and Figure 3 shows a class 20 bridge which connects the Great War Island in Belgrade with the bank.

Figure 1 – Float on water
Рис. 1 – Плот на воде
Слика 1 – Пловни чланак на води

Figure 2 – Tug RPP M88
Рис. 2 – Буксирное судно РПП М88
Слика 2 – Реморкер РПП М88

Figure 3 – Pontoon bridge class 20
Рис. 3 – Понтонный мост класс 20
Слика 3 – Понтонски мост класе 20

The concept of organization of engineering works

Organization of engineering works is a purposeful activity focused on synchronysing human and material resources of an engineering unit in time, area and type of work, in order to complete quality engineering tasks, with the most rational use of time, manpower, resources and energy (Hristov,1978).

In many aspects, the organization of engineering works is very similar to the organisation of construction works (similar concepts, principles, methods of work, etc.), and because of this similarity in the realization and development of tasks, the literature in the field of civil engineering is very often used. Despite the similarity of the above organizations, engineering works are different, mainly because they are based on the military rules of use, resources, personnel, military logistics support system and the like.

Organization of engineering works is a remarkable method of „networking" or combining theoretical and practical capabilities of an engineering unit (technical and human), as well as a way of finding the best solution to apply these capabilities in realizing assigned tasks in the most cost-effective way. Commanders of engineering units, as well as their superiors, are a special type of managers. Since there are eight specialties within military engineering, we can only imagine how much knowledge and skills this group of people must have.

In accordance with the principles of the organization of engineering works, prior to any engagement of one engineering unit or its part, there is preparation of engineering works consisting of the following elements:

– Study of the task with supporting data and information:

- exploring the content, volume, difficulty level and conditions,
- the study of the Technical Solution, and
- development of a plan of reconnaissance and preparation of units for the execution of the task.

– Situation Assessment:
  - enemies (closeness, activity),
  - one's own power (availability of manpower and MAs),
  - characteristics of the water barriers (speed, width, depth of the water flow, coverage of the coastal area in greenery, the slope and height of the banks, access roads and the composition of the bottom),
  - speed of the water flow, because of the drift of vessels, and, consequently, their reduced capacity, and
  - time (increase in the norms because of the enemy, the meteorological conditions, human factor).
– Reconnaissance of works area - depending on the type of work being performed;
– Arranging the camp and/or the site;
  - done according to the following principles: grouping, environ mental quality, technological priorities and succession, gravity, communication and security.
– Organization of material preparation - depending on the type of work being performed;
– Organization of transport;
  - external and
  - internal.
– Operational order (OPORD) depends on the work being performed, but, in principle, it should have the following elements:
  - task for each subordinate unit according to the project documentation (manufacture, repair, maintenance of the road section, and the like),
  - sites for the reserves of pontoon material,
  - the method of traffic regulation in the work area,
  - production facilities, plants (for ferries, platforms, access roads, ramps, etc.),
  - safety measures,
  - measures of combat security, and
  - deadlines for individual phases and tasks in general.

Establishment of a BCP with a capacity of 20 t from the SPB M-71 with the organization of engineering works

Irrespective of the type of water obstacle crossing, prior to the BCP establishment, the pontoon unit commander is handed the OPORD, with the appendix “F" - OPORD Engineering, prepared by the engineering officer in the brigade command and/or unit of the same rank, where the Plan of engineering operations is given in detail, with the engineering plan of actions and the specific task of establishing the BCP. The Plan also specifies MAs and the personnel. The explanation of the Plan of engineering operations is provided in the Guidelines for operational planning and command operations in the SAF - Annexes page I-59 (Generalštab Vojske Srbije, 2013).

Upon receipt and understanding of the task, the commander issues a preparation order to subordinate commanders, and with the command members he organises reconnaissance. In pontoon battalions, there is a specialty, reconnaissance and diving, which forms the core of the reconnaissance patrol (from a group to a platoon) whose task is to collect data about the characteristics of the water obstacle in the allocated crossing point area. The patrol can walk or use an m/w depending on the distance of the crossing point region. In practice, since reconnaissance-diving squads (RECO) have not been developed, i.e. in no pontoon battalion the RECO organization and establishment structure has such personnel but only RECO equipment, the commander forms a reconnaissance patrol from the existing personnel.

In practice, there is usually no time for this activity; instead, information is obtained from the superior command and/or government institutions dealing with these issues (such as the Directorate of Waterways). Then the commander develops a technical solution for the bridge construction and organizes the work for the entire BCP. To solve this task, the commander may engage some other persons from his unit (deputies, experienced non-commissioned officers or professional soldiers).

The norms for the assembly of the bridge class 20 are listed in Table 1, page 221, the Combat Rules for pontoon and amphibious units (Generalštab JNA, 1974), and refer to a pontoon company and a battalion. According to this rule, a pontoon company can assemble a bridge class 20 with a maximum length of:

- 193.25 m at water speed ≤ 1,5 m/s and,
- 173 m at water speed > 1.5 m/s.

The basic problem here is the fact that there is currently no recent literature, or current standards for the assembly and the establishment of BCPs, as well as that the current norm relates to the organizational-formation structure and the capabilities of a pontoon company from the

time of the then-JNA, which represents the difference in the terms of structure and capabilities of the SAF pontoon companies. It is true that the SPB M71has not changed much (for example, under the existing rules, float carriers or RPP and CA M70 are m/w FAP 2220 BDS and AVG, and now the m/w are FAP 2026 BDS and AVG, with the difference in the number of RPP and RPP OBM departments in the pontoon companies and the like), but there is a change in the structure in terms of manpower of pontoon units. Literature relating to the organization of engineering works dates from the end of the 70s of the last century, and there is not one kind of recent literature that deals with this issue. It is important to emphasize the fact that a road plotoon is also engaged in deploying BCPs, primarily for building access roads to the bridge and slipways for ramps; however, the standards in the current literature refer to engineering machines that have been out of use for a long time.

Organization of engineering works is a very important element when performing any kind of engineering work, as a good knowledge of these issues can result in maximum optimization in terms of stress of any kind of resources (both material and technical, and human), affecting not only the work duration time, but also the cost of the works. It is important to emphasize that this would reduce the possibility of injury to personnel and frequent failures of equipment. In practice, most often engineering officers rely on experience and many actions are performed based on the experience of decades of practice in dealing with pontoons.

In order to overcome the above mentioned problems and to meet the existing norms, it is necessary to: change the material structure of the SAF pontoon units through a system of lessons learned; start work on the literature relating to the organization of engineering works, where, in addition to experience-based knowledge, it is necessary to implement knowledge from other „related" areas – economics, civil engineering, mechanical engineering, hydrology and meteorology.

The following part of the paper gives an example of a task, i.e. project documentation consisting of: the data from the engineering reconnaissance (Table 2), calculation for the required pontoon material, the specification of the required MA and the people (Tables 3 and 4) and a part of the organization of engineering works in deploying a BCP, i.e. a concrete product of all calculations is illustrated through a parallel dynamic plan (Table 5).

APPROVAL:
COMMANDER
Brigadier General
N.N.

Numeral designation according to
the records of 03 / 20XX

TASK

1. Execute the march of the 1st pontoon company, and the 1st squad/ road construction platoon/ 111th pontoon battalion from the village of Neradovac into the village of Rataje and establish a BCP, by assembling a bridge, class 20, with a length of approximately 150 m in accordance with the technical solution given with the task.

2.Organize a reconnaissance patrol at a squad level and send it to collect information on the characteristics of the water obstacle.

3. Construct a bridge class 20, no later than 12:00 o'clock on: XX.03.20XX. The crossing of the technical workload across the bridge is to be finished no later than 12:30 on: XX.03.20XX.

4. Establish a BCP with all the elements no later than 16:00 o'clock on: XX.03.20XX. and submit a written report by courier.

5. Directly secure the BCP during the works executed with one's own forces and resources, on the commander's orders. In terms of combat security of a wider BCP, rely on combat security measures.

6. Regulate the movement across the bridge with one's own forces.

7. At the crossing point, there have not been any preparations.

DATA

from the engineering reconnaissance across the river *Južna Morava*
at village *Rataje*

Reconnaissance start: 06.00 XX.03.20XX. year
Reconnaissance end: 08.00 XX.03.20XX. year

Table 2 – Data from the engineering reconnaissance
Таблица 2 – Данные инженерной разведки
Табела 2 – Подаци са инжињеријског извиђања

The required data	Reconnaissance results
Width of the water level at various water levels	LWL = 145 m
	MWL = 135 m
	HWL = 125 m
Water speed at various water levels	LWL = 1.3 m/s
	MWL = 1.2 m/s
	HWL = 0.7 m/s
The depth of water at various water levels	LWL = 4.5 m
	MWL = 2.8 m
	HWL = 1.8 m
Composition of bottom and banks	clay + sand; shore is gently sloping
Access roads to the site with information on the type of road and objects on the road: – on this bank, they are well kept and coated with asphalt; – on the other bank, it is necessary to repair a road section 300 m long	
Point for unloading material, possibility of approach and possibility of camouflage	unloading point - 150 m from the bank; approach possibility - 1 ramp downstream from the axis of the bridge - the possibility to throw 2 FAs in one go and 1 ramp upstream from the axis of the bridge - the possibility to throw 5 FAs in one go
Existence of local materials and floating assets	no
Change of water level	poor, no large shifts in changes in water level
Existence of facilities on the river	no
Data on forests in the BCP region	Bank covered with trees
Convenient location for assembling ferry – bridge parts	downstream 1 ramp-throwing 2 FAs upstream 1 ramp-throwing 5 FAs
Number of workshops in the BCP region	no
Possibility to use the RPP and OBM	good
Water level ≥ 0.4 m	left bank = 3.2 m
	right bank = 1.2 m
Note: The data relating to the water level - high, medium and low (HWL, MWL and LWL) are taken from relevant civilian structures and/or based on experience; since it takes long to acquire this information, and since there is no time for that, especially in combat conditions, the current values are taken. Data relating to the water level are experiential or taken from the field when raising a bridge.	

CALCULATION OF A PONTOON BRIDGE CLASS 20

a) Calculation of the length of the bridge

Calculation of the required length of FAs is carried out based on the formula:

$$B = \frac{\check{S} - 2 * M}{6.75} = \frac{145 - 23{,}5}{6.75} = 18$$

adopt 18 FA lengths

where:

B – number of the required FA lengths

Š – width of the river in meters (m)

M – is a length of EFAs and FAs, that is, the bank sections on both sides of the river i.e.. 2*(6.75 +5) = 23.5 m

b) length of the pontoon bridge made of FAs => 18*6.75 = 121.5 m

c) width of the river, the depths bigger than 0.4 m (for assembling floats, the water depth must be bigger than 0.4 m)

$$\check{S}_1 = \check{S} - (a+b) = 145 - (3.2 + 1.8) = 140 \text{ m}$$

where:

Š – width of the river in meters (m)

Š1 – required width of the river in meters

a – data obtained from the reconnaissance of this bank

b – data obtained from the reconnaissance of the other bank

d) total length of the bridge made of pontoon material:

$$18*6.75 + 2*M = 121.5 + 23.5 = 145 \text{ m}$$

e) withdrawing EFAs:

- left bank – 0.5 m
- right bank – 0.5 m

g) length of the bridge with the road (the length of the bridge + ramps made of EFAs):

$$145 + 2*2 = 149 \text{ m}$$

h) calculation of the number of complete floating articles:

$$B_1 = 2 + \frac{B_2 * (k+1)}{2 * k} = 2 + \frac{18 * 6}{10} = 12.8$$

adopt 13 complete FAs

where:

B1 - the required number of complete FAs

B2 - adopted length of the number of required FAs

Kovačević, N., Organization of engineering works in deploying a bridge crossing point made of class 20 pontoon material,pp.1060-1079

k – coefficient of the influence of water flow, for the water flow speed of 1 to 1.5 m/s, is 5. (Pifat, 1980)

The calculation shows that there is a difference between the number of the required lengths and the number of complete articles (the values obtained in the formulas ,,a" and ”h"), because *for the bridge class 20, every third FA is complete, and the two previous ones are disassembled to halves* (as it can be seen in Figure 3). The total length of the bridge is 149 m, which is longer than the width of the river (145 m), and thus we conclude that the calculation is correct and applicable in practice, i.e. manageable.

Table 3 – List of needed assets
Таблица 3 – Перечень необходимых средств
Табела 3 – Попис потребних средстава

No.	Name of MA	Unit	Amount
From the 1st pontoon company			
1.	FA with m/w FAP 2026 BDS	piece	13
2.	EFA with m/w FAP 2026 BDS	piece	2
3.	RPP with m/w FAP 2026 AVG	piece	4
4.	AB M70	piece	3
5.	OBM Johanson 40	piece	3
Reserve			
6.	FA with m/w FAP 2026 BDS	piece	3
7.	RPP with m/w FAP 2026 AVG	piece	2
8.	AB M70	piece	2
9.	OBM Johanson 40	piece	2
From a road-construction platoon			
1.	Dozer TG 220	piece	1
2.	ULT 160C	piece	1
3.	Tipper 6.5 t	piece	1
4.	Rig	piece	1

Table 4 – List of required manpower
Таблица 4 – Перечень необходимых специалистов
Табела 4 – Списак потребног људства

No.	Name of duties	Personnel category	Number of persons
From the 1st pontoon company			
1.	Company commander	officer	1
2.	Platoon commander	officer	2
3.	Squad commander	non-commissioned officer	4
4.	Attendant SPB M71	professional soldier	30
5.	Driver attendant SPB M71		19
6.	Attendant RPP		8
7.	Attendant OBM		6
Total: 3 officers, 4 non-commissioned officers and 63 professional soldiers			
Reserve			
6.	Attendant SPB M71	professional soldier	6
7.	Driver attendant SPB M71		5
8.	Attendant RPP		4
9.	Attendant OBM		4
Total: 19 professional soldiers			
From a road-construction platoon			
1.	Squad commander	non-commissioned officer	1
2.	Attendant ULT 160C	professional soldier	1
3.	Tipper driver		1
4.	Rig driver		1
5.	Attendant TG 220		1
Total: 1 non-commissioned officer and 4 professional soldiers			
Total: 3 officers, 5 non-commissioned officers and 86 professional soldiers			

TIME CALCULATION

a) Road preparation:
   – company march: village of Neradovac - village of Rataje = 12 km => 0.50 h;
   – assembling a 40 t carrying capacity ferry and transporting the engineering machinery to the other bank (TG-220; ULT 160C; –Tipper 6.5) => 1.00 h;
   – repair of the section of the exit road, a distance of 300 m => 2.00 h;
   – total required time: 3.50 h = 3h 30 min.

b) Assembling the bridge:
   – company march: village of Neradovac - village of Rataje = 12 km =>0.50 h;
   – assembling a bridge class 20 t
     - lowering the floating articles in two waves at h = 0.12>0.24 h;
     - lowering the RPP in water in one wave after 0.12 h => 0.12 h;
     - assembling articles (bridge sections) => 0.50 h;
     - linking bridge sections into the bridge axis => 0.50 h;
     - technical inspection of the bridge and test load crossing => 0.50 h;
     - Total time required for the bridge assembly: 2.36 h = 2 h 21 min
c) Total time required**:** 5.36 = h 5 h 21 min.
d) The total required time for the BCP deployment with parallel activities (adequate organization of engineering works): 3.50 = h 3 h 30 min - This difference occurs because the preparation of the access roads and ramps should begin prior to the bridge installation; namely, after the arrival at the crossing point, the assembly of a class 40 ferry should start immediately and the engineering machinery should be transported to the other bank where the exit section of the road is prepared, while on this bank there are parallel ongoing works on lowering SPB M71 parts into water and their assembly.

Note: Standards for lowering SPB M71 parts, as well as for their assembly, are taken from the book Pontoon Bridge M71, pp. 23-24 (Generalštab JNA, 1976).

ORGANIZATION OF WORKS

The 1st pontoon company:
Company command:
– monitors and controls the work of subordinates and deals with any issues on the spot;
– improves documentation necessary for the functioning of the BCP;
– determines the personnel for the BCP (in terms of determining the number of persons needed for specific BCP organs).

The 1st pontoon platoon:
– regulates the exit section of the road in a length of 300 m
– lowers 4 RPPs (1 for the downstream river guard, and 3 for linking the bridge sections into the axis);
– assembles a part of the bridge out of 10 FAs and 1 EFA - the downstream part;

– with the available manpower, establishes a part of the CCS - the bridge crew, maintenance of the ramp on the right bank, traffic regulation station on the right bank;
– establishes a post for observing the water level.

The 2nd pontoon platoon:
– lowers 3 AB M70 with 3 OBM;
– assembles a part of the bridge out of 3 FAs and 1 EFA - the upstream part;
– with the available manpower, establishes a part of the CCS - the maintenance of the ramp on the left bank, the station to regulate traffic on the left bank, downstream and upstream river guard, rescue station, emergency squad;

Table 5 – Parallel dynamic plan
Таблица 5 – График параллельной динамики
Табела 5 – Паралелни динамички план

No.	Activity	Duration in h					
		1	2	3	4	5	6
1.	Company march						
2.	Assembling a ferry and transporting machinery						
3.	Preparation of access roads						
4.	Assembling bridge sections						
5.	Linking the bridge sections into the axis						
6.	Load testing and technical inspection						

Table 5 provides an overview of the budget for the establishment of a CBP through a parallel dynamic plan, where it can be seen how much a quality organization of engineering works affects the duration of works and the consumption of resources. The dashed line shows the duration of the process when activities are not performed concurrently, and the solid line shows the process duration when the activities run simultaneously.

Optimizing the organization of engineering works for this task could be achieved primarily by applying or introducing into operational use contemporary engineering earthmoving machines.

Conclusion

In accordance with the current concept of warfare and the concept of air-ground operations which has become a „cliché” of combat operations, especially in the US Armed Forces and NATO member countries, it is easy to notice that the speed of maneuvering has become one of the decisive

factors for successful execution of any military operation. Whether it is a question of offensive combat operations, which are the main type of operations in the US Armed Forces and NATO member countries, or defensive combat actions, it is evident that, in addition to modern techniques and good planning, speed and ability to perform a maneuver are a prerequisite for retaining initiatives during action, and for achieving the goal. Therefore, today all modern armies of the world have a large number of various means for overcoming water obstacles (Milojević, 2010, p.129).

A big problem in the allocation of tasks and the estimation of time for their implementation is the fact that there are no contemporary norms and adequate literature that could serve as an orientation to determine the time required for the organization of works of preparation, establishment and maintenance of BCPs. It is necessary in the future, based on the current (real) conditions of the units and means, to carry out standardization of works in the establishment of BCPs, i.e. to elaborate a comprehensive and detailed organization of engineering works during the realization of these tasks; in other words, to start dealing with prevention, not just the consequences, because BCPs can also be used in peacetime for Domain 3 tasks in the SAF mission.

Tactically and technically speaking, crossing over water obstacles is an exclusive activity of specialized engineering units - pontoon units. The order to establish some kind of crossing over water obstacles of certain objects can only and exclusively be issued by operating level unit commanders (Kitanović, 2000).

In all armed forces of the world, pontoon bridges are the backbone of overcoming water obstacles. The armed forces of the Russian Federation are the leaders in this area. The data which proves this fact is that the Russian troops have had a pontoon rail bridge in their operational use since 2005.

This article is an attempt to take a comprehensive look at all the specific characteristics in the establishment of BCPs for a bridge class 20 made of CPB M71 and its components, i.e. to point out the importance of timely and quality organization of engineering works in this task. Also, the article seeks to point out the possibility of the CPB M71 (its parts - RPP, OBM, BA M70) multiuse which was (unfortunately) confirmed during the catastrophic floods in Serbia in May 2014, and during the NATO aggression on the Federal Republic of Yugoslavia in 1999. Consequently, the SAF must urgently start the modernization of the existing CPB M71, or acquire new types of sets of pontoon bridges from abroad.

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ОРГАНИЗАЦИЯ ИНЖЕНЕРНЫХ РАБОТ ПРИ УСТРОЙСТВЕ ПОНТОННОГО МОСТА КЛАССА 20 НА МЕСТЕ ПЕРЕХОДА

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ОБЛАСТЬ: инженерные войска
ВИД СТАТЬИ: практический опыт
ЯЗЫК СТАТЬИ: английский

Резюме:

При использовании понтонов для устройства мостов или прочих видов перехода через водные преграды (паромы, десантные переправы) чрезвычайно важно разработать такие этапы работ как: организация подготовительных работ, организация производства работ, а также распределение подразделений и материалов для сооружения и содержания места переправы. Производством данного вида работ занимаются специальные подразделения инженерных войск Вооруженных сил Республики Сербия – понтонно-мостового батальона, являющегося частью Речной флотилии (объединение - бригада). Описанная в данной статье организация инженерных работ представляет собой

целесообразную разработку всех процессов, задействованных в области переправы через водные преграды, в том числе распределение нагрузки на понтеров при устройстве понтонномостовых переправ, грузоподъемностью 20 тонн. Одной из насущных проблем, с которой сталкиваются военные инженеры при оформлении основной документации по устройству ПМП, является отсутствие современной литературы (существующая литература относится к 70-80-ым годам прошлого века), таким образом, разработчики вынуждены опираться исключительно на практический опыт как в оформлении проектной документации, так и в самом процессе производства работ.

Ключевые слова: инженерные войска, инженерные работы, переправа через реку, понтоны.

ОРГАНИЗАЦИЈА ИНЖИЊЕРИЈСКИХ РАДОВА ПРИ УСПОСТАВЉАЊУ МОСНОГ МЕСТА ПРЕЛАСКА ОД ПОНТОНСКОГ МАТЕРИЈАЛА КЛАСЕ 20

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ОБЛАСТ: инжињерија
ВРСТА ЧЛАНКА: искуства из праксе
ЈЕЗИК ЧЛАНКА: енглески

Сажетак:

Приликом употребе понтонског материјала за успостављање мосног и/или неке друге врсте преласка преко водене препреке (скелског, десантног), врло је важна организација извођења радова приликом припреме, у току успостављања, али и при дезангажовању јединица и понтонског материјала за успоставу и одржавање места преласка. За извођење ових радова у Војсци Србије постоје специјализоване (наменске) јединице. То су јединице једне од специјалности у оквиру рода инжињерије, понтонирске специјалности, које егзистирају у оквиру понтонирских батаљона, односно у оквиру Речне флотиле (јединица ранга бригаде). Организација инжињеријских радова која је описана у чланку представља, у ствари, изналажење најцелисходнијег решења у погледу употребе покретних ствари, али и напрезања људства, при успостављању мосног места преласка од понтонског материјала, носивости 20 т. Недостатак савремене литературе само је један у низу проблема са којима се срусрећу старешине приликом израде основних докумената за успостављање

ММП-а (постојећа литература је из 70-их и 80-их година прошлог века), те се при раду са овим средствима и при изради пројектне документације углавном ослањају на практична искуства.

Кључне речи: инжињеријске јединице, инжињеријски радови, прелаз преко река, понтонски материјал.

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ПРИКАЗИ

ОБЗОРЫ

REVIEWS

ТРИНАЕСТИ МЕЂУНАРОДНИ СИМПОЗИЈУМ „ПРЕВЕНЦИЈА САОБРАЋАЈНИХ НЕЗГОДА НА ПУТЕВИМА 2016”

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ОБЛАСТ: саобраћај
ВРСТА ЧЛАНКА: приказ
ЈЕЗИК ЧЛАНКА: српски

Сажетак:

На симпозијуму који се сматра најугледнијим стручним скупом из ове области у Републици Србији, припадници Министарства одбране и Војске Србије узели су запажено учешће са шест стручних радова из области безбедности војних учесника у саобраћају на путевима. Министарство одбране и Војска Србије улажу знатне напоре на повећању нивоа безбедности војних учесника у саобраћају, што утиче и на ниво безбедности саобраћаја у Републици Србији.

Кључне речи: безбедност војних учесника у саобраћају, обука возача, активна безбедност возила, стратегија безбедности саобраћаја, затворени системи, вредновање безбедности саобраћаја, саобраћајне незгоде, путеви.

У организацији Факултета техничких наука Универзитета у Новом Саду, Саобраћајног факултета Универзитета у Београду, Факултета за грађевину, саобраћајно инжењерство и архитектуру Универзитета у Марибору, Високе техничке школе у Нишу, Интернационалног центра за безбедност саобраћаја, Криминалистичко-полицијске академије из Земуна и Удружења за безбедност саобраћаја Србије, 13. и 14. октобра 2016. године одржан је XIII међународни симпозијум „Превенција саобраћајних незгода на путевима 2016” у Новом Саду.

На симпозијуму који се сматра најугледнијим стручним скупом из ове области у Републици Србији, презентовано је 45 радова од 80 аутора и коаутора, од којих 30 страних стручњака.

Традиционално и на овом симпозијуму припадници Министарства одбране и Војске Србије узели су запажено учешће са шест стручних радова из области безбедности војних учесника у саобраћају на путевима, око 13% од свих презентованих радова.

Уводну реч одржао је председник програмског одбора проф. др Крсто Липовац са Саобраћајног факултета Универзитета у Београду. У име Министарства одбране и Војске Србије стручни скуп поздравио је начелник Одељења за саобраћај и транспорт Управе за логистику (J-4) Генералштаба ВС пуковник др Жељко Ранковић, и истакао да Министарство одбране и Војска Србије улажу знатне напоре на повећању нивоа безбедности војних учесника у саобраћају, што утиче и на ниво безбедности саобраћаја у Републици Србији. Такође, изразио је велико задовољство што припадници Министарства одбране и Војске Србије традиционално учествују на симпозијуму.

Основне тематске целине (сесије) овог симпозијума биле су:

1. Организација и спровођење безбедности саобраћаја.
2. Безбеднији учесници у саобраћају.
3. Безбеднији путеви и кретање.
4. Безбеднија возила.
5. Активности након незгоде.

У сесији 1. презентован је рад на тему „Possible use of ISO standards liability in drivers training" (Могућност примене ИСО стандарда у обуци возача), аутора пуковника др Жељка Ранковића, потпуковника мр Александра Гошића и мајора мр Игора Милановића.

У раду је представљен приказ стандарда ISO 39000 „Road Safety Management" (Управљање безбедношћу саобраћаја) и могућност његове примене у обуци возача. Истакнут је значај обуке возача, али и значај мера које се предузимају након завршетка обуке возача ради њеног унапређења. Приказано је и спроведено истраживање у аутошколама о утицају броја саобраћајних незгода и прекршаја након завршене обуке на начин обуке возача. Применом статистичког алата доказан је велики утицај информација о понашању возача након обуке на могућност унапређења процеса обуке (Ranković et al, 2016, pp.25-34).

У сесији 2. презентована су два рада на тему „Стратегија безбедности саобраћаја у затвореним системима", аутора потпуковника мр Александра Гошића, пуковника др Жељка Ранковића и мајора Александра Дробњаковића и „Вредновање безбедности саобраћаја у затвореним системима", аутора пуковника др Жељка

Drobnjaković, A., Trinaesti međunarodni simpozijum „Prevencija saobraćajnih nezgoda na putevima 2016", pp.1080-1085

Ранковића, потпуковника мр Александра Гошића и мајора Александра Дробњаковића.

У раду под називом „Стратегија безбедности саобраћаја у затвореним системима" приказана је методологија израде стратегије у затвореним системима, са посебним освртом на Стратегију безбедности војних учесника у саобраћају. Наглашене су специфичности које одређују начин и структуру стратегије као највишег регулативног акта. Представљен је и приказ два истраживања у којима су применом SWOT анализе дефинисане мере за повећање безбедности саобраћаја и визија и циљеви у оквиру стратегије. На крају је изложен кратак приказ Стратегије безбедности војних учесника у саобраћају. Поред приказа стања, указано је на потребу дефинисања мисије, визије и циљева, као и подручја деловања који одговарају специфичностима затворених система (Gošić et al, 2016, pp.91-100).

У раду под називом „Вредновање безбедности саобраћаја у затвореним системима" приказана је методологија и дат предлог модела вредновања безбедности саобраћаја у затвореним системима, са посебним освртом на безбедност војних учесника у саобраћају. Такође, представљен је преглед усвојених индикатора безбедности саобраћаја у европским земљама и начин њиховог праћења. Применом статистичког алата доказана је веома јака корелација између појединих индикатора и показатеља последица саобраћајних незгода, на основу чега је и доказана могућност примене одабраних индикатора у затвореним системима. Наглашене су специфичности које утичу на вредновање безбедности саобраћаја, а посебно на избор показатеља који на оптималан начин презентују стање и омогућавају дефинисање мера и активности на унапређењу стања (Ranković et al, 2016, pp.111-118).

У сесији 4. презентована су два рада на тему „Систем транспорта опасног терета у Војсци Србије са освртом на обуку учесника", аутора потпуковника Драгише Зинаје, потпуковника Слободана Цаковића и мајора Александра Дробњаковића и „Ефекти примене безбедне и еко-вожње у обуци возача у Војсци Србије", аутора потпуковника Слободана Цаковића, потпуковника Драгише Зинаје и мајора Александра Дробњаковића.

У раду под називом „Систем транспорта опасног терета у Војсци Србије са освртом на обуку учесника" приказан је систем транспорта опасног терета у Војсци Србије и његове специфичности које се огледају у намени, врсти и количини опасног терета који се транспортује. Посебно је истакнут значај обуке и оспособљавања свих субјеката који су укључени у транспорт опасног терета. Дат је преглед развијених курсева прилагођених потребама Војске Србије,

циљева обуке и групе лица за коју је намењена (Zinaja et al, 2016, pp.211-220).

У раду под називом „Ефекти примене безбедне и еко-вожње у обуци возача у Војсци Србије" приказан је систем обучавања возача у Војсци Србије, са посебним освртом на реализацију обуке у примени безбедне и еко-вожње. Приказан је нови облик додатног оспособљавања возача војних возила у којем су дефинисани показатељи вредновања промена понашања возача, начин праћења и упоређивање резултата, као и постигнути ефекти са становишта унапређења безбедности војних учесника у саобраћају на путевима и повећању енергетске ефикасности возног парка у Војсци Србије. У закључку рада наведени су позитивни ефекти по свим посматраним показатељима, њихов утицај на безбедност војних учесника у саобраћају и предложена масовнија примена у Војсци Србије, по фазама (Caković et al, 2016, pp.221-229).

У сесији 5. презентован је рад на тему „Савремени системи активне безбедности возила и њихова заступљеност на возилима за превоз менаџмента Министарства одбране и Војске Србије", аутора капетана сц Славка Пантића.

У раду су разматрани системи активне безбедности возила који се уграђују у возила новије производње, а затим је извршена анализа њихове заступљености на возилима која се користе за превоз менаџмента Министарства одбране и Војске Србије. Представљен је преглед заступљености система на одабраној групи моторних возила у Војсци Србије. У закључку је наглашен значај сагледавања стварних потреба употребе наведених система приликом набавке моторних возила (Pantić, 2016, pp.375-382).

На крају стручног скупа Програмски одбор усвојио је предлог закључака са симпозијума, истичући запажено учешће припадника Министарства одбране и Војске Србије на скупу.

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ТРИНАДЦАТЫЙ МЕЖДУНАРОДНЫЙ СИМПОЗИУМ «ПРЕДУПРЕЖДЕНИЕ ДОРОЖНО-ТРАНСПОРТНЫХ ПРОИСШЕСТВИЙ 2016»

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ОБЛАСТЬ: транспорт
ВИД СТАТЬИ: обзор
ЯЗЫК СТАТЬИ: сербский

Резюме:

Представители Министерства обороны и Вооруженных сил Республики Сербия приняли активное участие в работе симпозиума, который считается самой значительной профессиональной конференцией в области транспорта и путей сообщения в Республике Сербия, представив вниманию аудитории шесть профессиональных статей в области безопасности военных участников дорожного движения. В работах была подчеркнута роль Министерства обороны и Вооруженных сил РС, которые принимают все возможные меры для повышения уровня безопасности военных участников дорожного движения, оказывая тем самым благоприятное влияние и на уровень безопасности дорожного движения в Республике Сербия в целом.

Ключевые слова: безопасность военных участников дорожного движения, обучение водителей, активная безопасность транспортного средства, стратегия безопасности дорожного движения, закрытые системы, анализ и оценка безопасности дорожного движения, дорожно-транспортные происшествия, дороги.

THIRTEENTH INTERNATIONAL SYMPOSIUM "PREVENTION OF TRAFFIC ACCIDENTS ON THE ROAD 2016"

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FIELD: Traffic
ARTICLE TYPE: Review
ARTICLE LANGUAGE: Serbian

Summary:

At the symposium, which is considered the most prestigious professional gathering in this area in the Republic of Serbia, members of the Ministry of Defense and the Army of Serbia took a noteworthy part with six expert papers on the security of military participants in road traffic. The Ministry of Defense and the Serbian Armed Forces are making significant efforts to increase the level of security of military participants in traffic, which has an impact on the level of traffic safety in the Republic of Serbia.

Key words: safety of military participants in traffic, driver training, active vehicle safety, traffic safety strategy, closed systems, evaluation of traffic safety, traffic accidents, roads.

Датум пријема чланка / Дата получения работы / Paper received on: 24.11.2016.
Датум достављања исправки рукописа / Дата получения исправленной версии работы / Manuscript corrections submitted on: 26.12.2016.
Датум коначног прихватања чланка за објављивање / Дата окончательного согласования работы / Paper accepted for publishing on: 28.12.2016.

Одржан Осми међународни сајам наоружања и војне опреме „Партнер 2017”

Од 27. до 30. јуна 2017. године у Београду је одржан Осми међународни сајам наоружања и војне опреме „Партнер 2017”. Сајам се традиционално одржава сваке друге године, а ове године су излагачи имали на располагању хале 1 и 4 Београдског сајма, као и отворени простор испред хале 1.

Традиционални покровитељ сајма је Министарство одбране Републике Србије, у суорганизацији са јавним предузећем „Југоимпорт СДПР” и извршној организацији Београдског сајма. Осми по реду „Партнер 2017” окупио је укупно 128 излагача, од којих је највише било из Србије, њих 91, док су међу земљама учесницама биле и Француска, Аустрија, Финска, Немачка, Велика Британија, Италија, САД, Кина, Индија и друге. Од земаља из региона своје представнике на сајму имале су Бугарска, Црна Гора, Босна и Херцеговина, Хрватска и Словенија.

Национални произвођач „Јумко АД” представио је најновије елементе производног програма. Фото: Милош Јевтић

Основни циљ сајма јесте представљање наоружања и војне опреме националних произвођача и произвођача из иностранства, остваривање односа пословне и научне сарадње, размена искустава између стручњака из области, односно стварање позитивног амбијента за покретање иницијатива за сарадњу и разумевање. Такође, сајам „Партнер" увек је и прилика за званичне иностране делегације да уговоре директно снабдевање оружаних снага, као и да учествују у стручном пратећем програму које организује Министарство одбране Р. Србије.. У оквиру овогодишњег пратећег програма реализован је дводневни скуп Групације произвођача НВО под називом основном темом „Утицај индустрије 4.0 на развој одбрамбене технолошке и индустријске базе Републике Србије".

У оквиру Осмог сајма наоружања и војне опреме представили су се Министарство одбране Републике Србије са расположивим научним, техничким и ремонтним капацитетима, национални произвођачи НВО, попут ЈП „Југоимпорт СДПР", „Телеоптик – жироскопи д.о.о", „Јумко АД", „Миле Драгић", „ППТ – Наменска АД", „Застава оружје", „Први партизан Ужице" и други. Од иностраних произвођача и ове године представили су се „Aimpoint AB", са врхунским рефлексним нишанима који су данас у употреби у великом броју војних и полицијских јединица за специјалне намене, затим италијански произвођач „Benelli Armi Spa", изложивши три модела борбених сачмарица, финска компанија „Sako Ltd", промовисавши два квалитетна система пушака за прецизно гађање са системом мануелног репетирања, аустријска компанија „Ritter & Stark", са својом пушком „SLX" у калибру .308 Winchester, „Walter Arms", промовисавши неколико система полуаутоматских пиштоља, „Surefire LLC", са својим поузданим тактичким лампама, „AD2V Industries GmbH" из Аустрије, представивши изузетно модеран систем за осматрање у ноћним условима и други.

Национална одбрамбена индустрија

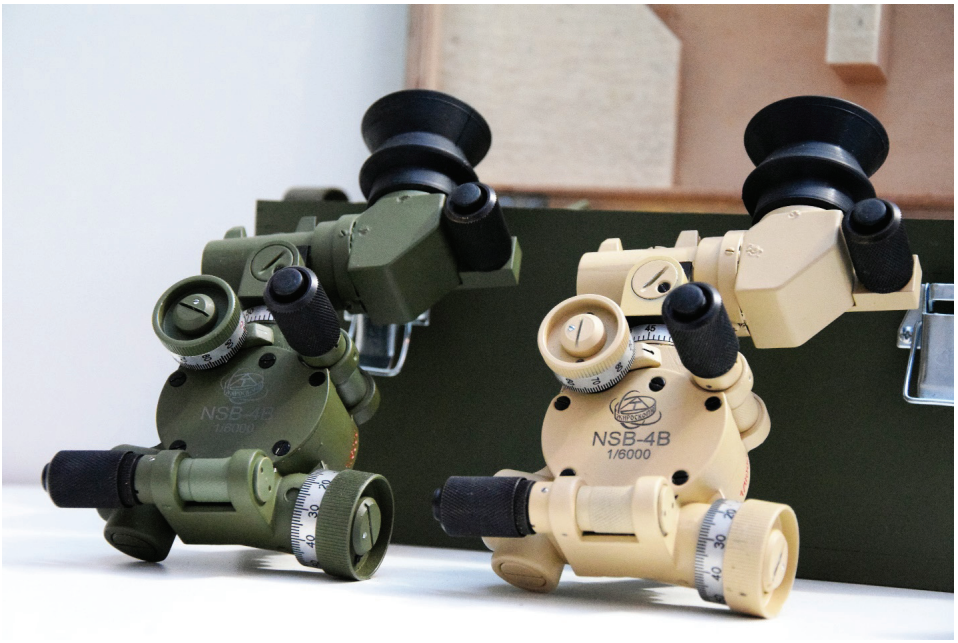
Јавно предузеће „Југоимпорт СДПР", са седиштем у Београду, представило је више система различитих намена, од којих су многи виђени и на недавно организованом приказу у Центру за опитовање наоружања и војне опреме „Никинци".

Посетиоци су имали прилику да се упознају са ракетним системом веома атрактивног изгледа „АЛАС", намењеном за гађање покретних и непокретних непријатељевих циљева на земљи и води. Систем се састоји од лансера са шест ракетних контејнера и командног возила, а омогућава гађање циљева ван визуелног контакта, према координатама добијеним од артиљеријских осматрача, односно других извиђачких система. Сам лансер ракета карактерише изузетна аутоматизација функција. Пажњу посетилаца привукао је и модернизовани вишецевни ракетни систем „Огањ", који је намењен за општу ватрену подршку јединица бригадног нивоа. Вишецевни ракетни систем монтира се на камион националног произвођача типа „ФАП 2026", који је опремљен и оклопном кабином за посаду. Модернизација овог система такође подразумева и уградњу система за упра-

вљање ватром, инерционо-навигационог система и GPS, радио-уређаја „Талес”, модула „УПАРС” за аутоматско добијање елемената гађања и др. Изузетно интересовање показано је и за модуларни вишецевни ракетни систем „Шумадија” који, за сада, користи две врсте ракета: „Јерина-1”, домета 285 километара, односно „Јерина-2”, домета до 70 km. У оквиру овогодишњег сајма предузеће је представило и аутоматски топ-хаубицу „Александар”, калибра 155 mm, са брзином паљбе од 6 граната у минути. Представљена је и самоходна хаубица „НОРА Б-52”, калибра 155 mm, затим модернизована борбено-оклопна возила 4×4 М-11,,М-15,,М-16, са даљински управљаним борбеним станицама – ДУБС. Посетиоци су такође имали прилику да се упознају и са карактеристикама вишенаменског борбено-оклопног возила 4×4 „Милош”, односно вишенаменским оклопним возилом точкашем 8×8 „Лазар 3”, који је представљен у конфигурацији са аутоматским топом 2-А 42 руске производње и калибра 30 mm, намењеним за уништавање непријатељеве заклоњене и незаклоњене живе силе, лакооклопљених техничких средстава, односно лакоутврђених објеката на даљинама до 3000 метара. Наведена возила су на задужењу и при јединицама Жандармерије Републике Србије. Изузетно интересантан био је и први беспилотни хеликоптер „Стршљен”.

Ракетни систем „АЛАС”, произвођача „Југоимпорт СДПР”. Фото: Милош Јевтић

Компанија „Телеоптик – жироскопи” представила је више елемената производног програма. Понос компаније су свакако нове нишанске справе са јединственим конструкцијским решењима типа НСБ-3, односно НСБ-4Б.



Нишанске справе НСБ-3(лево) и НСБ-4Б, произвођача „Телеоптик – жироскопи”. Фото: Милош Јевтић

Справе су намењене управљању минобацачима 60 и 82 mm (НСБ-3), односно 120 mm (НСБ-4Б), у правцу циља у дневним и ноћним условима. Реч је о изузетно робустним справама чији су делови третирани наночестицама ради увећања радног века и отпорности на екстремне климатско-теренске услове. Оба модела одликују се врстом поделе 1/6000. Такође, компанија је представила и више модела пригушивача пуцња, који су у потпуности третирани наночестицама, затим пригушиваче за полуаутоматски пиштољ ЦЗ-99, односно серију „999”, калибра 9 mm, као и модел за пиштоље калибра .22 ЛР, али и јуришне пушке калибра 7,62×39 mm, односно 5,56 mm. Занимљиво је било приметити и пригушиваче пуцња намењене за митраљез „Застава М-84”, калибра 7,62×54 мм Р, као и пригушиваче за пушке за прецизно гађање, попут модела за системе „Застава М-93”, у калибру 12,7×108 mm, „Застава М-76”, у калибру 7,92×57 mm, нови систем пушке са мануелним репетирањем „Застава М-07”, у калибру 7,62×51 mm и др. Међу осталим производима компаније треба издвојити систем за управљање ватром који је саставни део опреме система произвођача „Југоимпорт СДПР”, што је случај и са вођеном главом за ракетни

систем „АЛАС”. У питању су две врсте главе „АЛАС дневни” и „АЛАС ноћни”. Компанија је представила и више модела рефлексних и оптичких нишана који су у употреби при јединицама Војске Србије.

На штанду произвођача „Миле Драгић” посетиоци су се могли упознати са више конфигурација тактичких униформи, опреме и балистичких производа. Веома запажени били су и нови модели балистичких шлемова, као и балистичких прслука.

Ручни бацач граната М-11, калибра 40 mm, произвођача „ППТ – Наменска”.
Фото: Милош Јевтић

Стручњаци из Трстеника представили су ручне бацаче граната М-11, односно М-13, оба у калибру 40 мм, у конфигурацији са телескопским и преклапајућим кундаком, јуришним рукохватом и рефлексним нишаном типа “Norconia R205-30”, немачке производње. Добоши поменутих модела су капацитета 6 граната.

Изузетно атрактиван био је и штанд произвођача „Застава оружје” из Крагујевца. Произвођач је представио различите системе, од којих је свакако најатрактивнији био модернизовани програм аутоматских пушака и пушака за прецизно гађање. Посетиоци су се могли упознати са ТТ карактеристикама нове модуларне аутоматске пушке 6,5×39 mm/7,62×39 mm, са системом позајмице барутних гасова као принципом рада, односно директном позајмицом са дугим трзањем клипа као врстом позајмице и брављењем преко ротирајућег затварача. Захваљујући монтираним „Pica-

tinny" шинама по принципу 12-6, систем омогућава прихват додатне тактичке опреме и опто-електронских уређаја. Поред поменуте, произвођач је представио и аутоматске пушке М-05 Н1, у калибру 7,62×51 mm НАТО, затим М-05 Е1, у калибру 7,62×39 mm, као и М-05 Е2 и модел Е3, у истом калибру. Од пушака за прецизно гађање на штанду су биле представљене М-12 „Црно копље" и М-93 „Црна стрела", у разорном калибру 12,7 mm,, односно М-07 АС у калибру 7,62×51 НАТО, све са системом мануелног репетирања, затим полуаутоматске М-91 Н, у калибру 7,62×51 mm НАТО, М-91 у калибру 7,62×54 mm Р. Занимљиво је било приметити да су неки од поменутих система били представљени у конфигурацији са оптичким нишанима „Valiant". Од полуаутоматских пиштоља у калибру 9 mm произвођач је представио серије ЦЗ-999, односно Е3-9.

Иностранн излагачи

Сајам наоружања и војне опреме „Партнер" је и ове године, традиционално, окупио реномиране произвођаче из иностранства. Посетиоци су се могли упознати са делом производног програма познате компаније „Aimpoint AB", која је у оквиру свог штанда представила неколико модела „red dot" нишана и увеличавача, међу којима су свакако најпознатије серије „Comp M3", односно „Comp M4", као и компактније „Micro T-1" и „Micro T-2".

Производи компаније „Aimpoint AB". Фото: Милош Јевтић

Италијанкса компанија „Benelli Armi Spa" представила је три модела борбених сачмарица, међу којима је веома позната и серија M-4, која је, у различитим моделима, у употреби и у елитним јединицама српске полиције и војске.

Финска компанија „Sako Ltd" представила је два изузетно атрактивна система „репетирки" (енг. bolt action). У питању су серије „Sako TRG M-10", односно „Tikka T3x TAC A1". Серија M-10 је, према речима представника компаније, конструисана примарно према потребама полицијских јединица за специјалне намене: „Овим системом нудимо елитном стрелцу да у различитим сценаријима употреби исту пушку уз минималне измене у конструкцији. Тако, примера ради, у ситуацијама у којима се мета ангажује на мањим даљинама, што је у полицијским акцијама и најчешће случај, наша пушка у калибру .308 Winchester са цеви дужине 16 или 20 инча и пригушивачем пуцња била би одличан избор. Насупрот томе, када је потребна већа пробојност, односно ангажовање мете на већим даљинама, оружје се лако модификује једноставним мењањем цеви, затварачког склопа и оквира". Поред .308 Winchester, купцима се нуди и поменута серија у калибрима .300 Winchester Magnum, односно .338 Lapua Magnum. Серија „Tikka T3x TAC A1" рађена је по узору на „Tikka T3", а нуди се у калибру .308 Winchester, уз капацитет оквира од 10 метака.

Дигиталне наочаре за осматрање у ноћним условима „Luxiter-1".
Фото: Милош Јевтић

На овогодишњем сајму представила се и аустријска компанија „Ritter & Stark”, са пушком са системом мануелног репетирања SLX-308, у калибру .308 Winchester, а велику пажњу посетилаца привукли су и производи аустријске компаније „AD2V Industries GmbH”, посебно „Luxiter-1” – дигиталне наочаре за осматрање у ноћним условима. Систем обезбеђује јединствене аналогне и дигиталне приступе (енг. interface), који омогућавају, поред осталог, и видео-снимање , увођење и обраду информација из спољашњих извора и томе слично. Захваљујући ниском профилу наочаре се могу носити и у ситуацији када оперативац носи шлем или кацигу са монтираним визиром. Према речима представника компаније, систем се може користити и у дневним условима без разлике у квалитету слике, резолуције 795×596, а посебни сензори редукују бљесак приликом паљбе и употребе пиротехничких и експлозивних средстава, без опасности по вид. Батерије обезбеђују аутономију рада од 10 сати, а укупна маса од 440 грама не представља оптерећење ни при дужој употреби.

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Тактичка употреба балистичких штитова

Балистички штитови представљају изузетно важан елемент тактичке опреме који користе посебно обучени оперативци при извођењу наменских активности у специфичним околностима. Израђују се од материјала изузетне тврдоће, а основна намена им је остваривање балистичке заштите одређеног нивоа. У зависности од нивоа заштите, који се данас углавном усклађују са стандардом 0108.01 (пуне ознаке NIJ Std 0108.01) о балистички отпорним заштитним материјалима (енгл. Ballistic Resistant Protective Materials), који је утврдио Национални институт правде САД (енгл. National Institute of Justice-NIJ), септембра 1985. године, балистички штитови спречавају пробијање пројектила различитих калибара испаљених из ватреног оружја. Наравно, балистички штитови служе и за фрагментациону заштиту оперативца, односно заштиту од последица механичког удара неког фрагмента или чврстог предмета.

Производња и захтеви тржишта

Елементи балистичке опреме данас су неизоставан део конфигурације опреме оперативаца. Захваљујући развоју наменске индустрије и технике уопште, омогућена је масовна производња ове врсте опреме, уз обарање трошкова производње, што је утицало и на обарање тржишне цене, па су данас балистички производи део стандардне опреме војних и полицијских формација. Унапређивањем технологије производње, као и

увећавањем искуства из употребе на терену, реномирани произвођачи усмеравали су капацитете у различитим правцима. Модерно тржиште поставља високе стандарде, међу којима корисници највише обраћају пажњу на укупну масу балистичког штита, као и на ниво балистичке заштите који се гарантује. Историјски посматрано, може се приметити тенденција умањивања укупне масе штитова, што је омогућено првенствено употребом савремених материјала у изради. Умањивањем укупне масе увећана је конфорност оперативца, али и број ситуација у којима се одређени модел штита (пре свега ручни балистички штит) може тактички оправдано употребити. Мања маса штита итекако побољшава маневрисање, увећавајући и борбену ефикасност индивидуалног корисника, борбене групе или тима.

Врсте

Модерни балистички штитови могу се систематизовати према критеријуму величине и, наравно, нивоу балистичке заштите. У полицијским и војним формацијама користе се индивидуални, ручни балистички штитови који су прилагођени носиоцу. Најчешће обезбеђују ниво заштите III или IIIA, према неком од усвојених стандарда (нпр. NIJ Std 0101.04, NIJ Std 0108.01 и другим). Поред ручних, у употреби су и средњи, односно велики балистички штитови који су, услед веће масе, неприкладни за ручно ношење, те се постављају на постоља са точкићима и гурањем померају. Основна предност ручних штитова је прихватљивија маса која омогућава брже маневрисање и ефикасније извођење ширег спектра дефанзивних и офанзивних тактичких радњи. Основни недостатак, са друге стране, односи се на мању заштитну површину, али се она превазилази употребом већег штита, који димензијама и масом ограничава и врсте ситуација у којима се оправдано може употребити.

Треба поменути и модуларне конструкције у које се умећу балистичке плоче, а које се, по потреби, могу фиксирати у различитим положајима, у складу са потребама конкретне интервенције. Имајући у виду значајну заштитну површину, ове конструкције се, поред балистичких визира, опремају и мањим „пушкарницама", које омогућавају оперативцима да ангажују мете, остајући потпуно заклоњени иза балистичких плоча. Модуларне конструкције се такође померају помоћу точкића.

Обука

Балистички штитови су конструкцијски прилично једноставни. При упознавању оперативца са конкретним моделом највећа пажња обраћа се на балистички визир, уколико је штит испоручен у таквој конфигурацији, затим на светлосне лампе на предњој страни и ергономску ручку на задњој. Рад лампи се, по правилу, контролише померањем положаја прекидача или притискањем тастера, који су најчешће постављени на ергономској ручки и лако су доступни.

Основни сегмент обуке у вези са балистичким штитовима јесте изучавање и увежбавање тактичке кретње у пару, групи или тиму при употреби балистичког штита или више њих, са тежиштем на тактици при извође-

њу упада у објекте затвореног типа, претраге и чишћења просторија, али и при извођењу дефанзивних радњи. Једна од претпоставки ваљане кретње јесте и увежбавање техника ношења штита. Услед специфичног облика и знатне масе штит се приликом ношења мора држати што ближе центру равнотеже тела, ради умањивања стреса на активиране скелетне мишиће. Техника ношења зависи и од конфигурације штита, односно од тога да ли је опремљен визиром или не. У случају да балистички штит нема визир тада штитоноша, по правилу, штит држи тако да горња ивица буде отприлике у нивоу усана или браде. Овом приликом штитоноша, поред балистичког шлема, мора носити и балистички визир, а пожељно је да се у овом случају визир и штит додирују.

Пример употребе балистичких штитова ради заштите антитерористичке групе у нападу. Фото: Милош Јевтић

Штит се, по правилу, носи помоћном шаком, док доминантном шаком оперативац носи оружје, најчешће пиштољ или изразито компактни аутомат, односно оружје за личну заштиту (енгл. Personal Defense Weapon-PDW). При обучавању оперативаца пажња се, такође, усмерава и на увежбавање и правилно усвајање техника ношења оружја при ношењу штита, ради што мањег излагања шаке или руке.

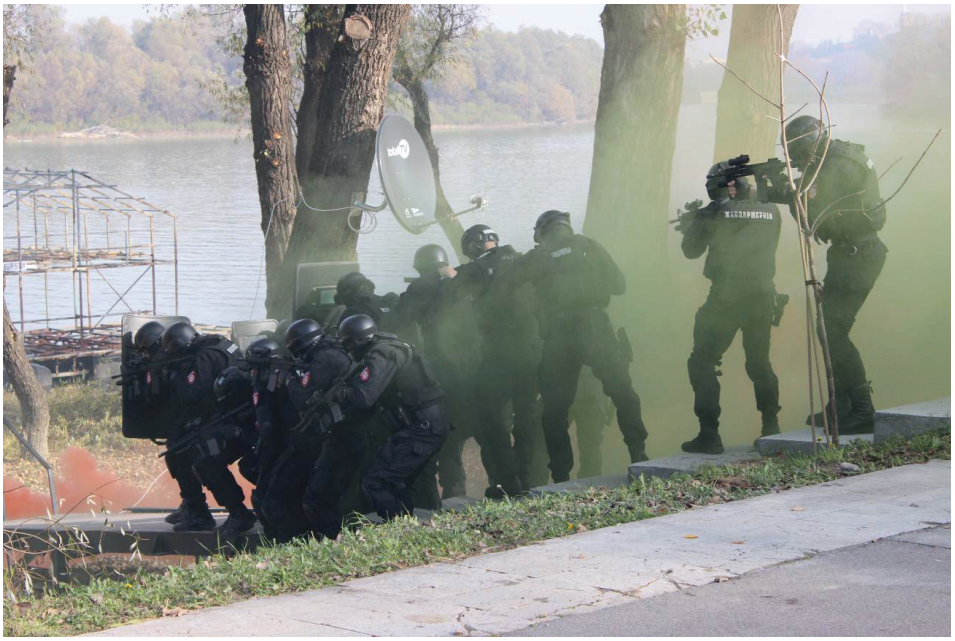
Штитоноша, по правилу, одређује параметре кретње групе или тима: правац и брзину. Правац кретње прилагођава се врсти окружења, а брзина би требало да буде „контролисана журба", тј. у нивоу брзог ходања. Поред тога, задатак је штитоноше да својој групи или тиму

саопштава информације у вези са конфигурацијом окружења, као и о уоченим претњама. С обзиром на то да се штитоноша, по правилу, први суочава са претњом, нужно је да буде веома искусан и обучен оперативац који не сме заборавити да је примарни задатак штитоноше да штити своју групу или тим, а не да ангажује мету. Међутим, уколико су остварени услови за употребу ватреног оружја као средства принуде и штитоноша, наравно, може ангажовати мету. Радња ангажовања мете зависи од технике којом оперативац носи оружје при ношењу штита, као и од конфигурације самог штита (уколико је, примера ради, штит опремљен балистичким визиром оперативац може нишанити постављањем оружја испред визира). Оперативци, такође, увежбавају и радње инстинктивног нишањења. Монтирањем ласерског обележивача циља на оружје штитоноша знатно сигурније и једноставније може ангажовати мету и очекивати прецизнији погодак. Фокусирањем на светлосну тачку на мети штитоноша може употребити ватрено оружје уз минимално „отварање" шаке и руке. У ситуацијама када се претња фокусира на штитоношу и покушава да избије или отме балистички штит, штитоноша мора умети да сачува штит и применом физичке снаге као средства принуде. У таквим ситуацијама могу се применити тзв. „схиелд упперцут" ударачке технике.

Тактичка употреба

Имајући у виду примарну намену балистичког штита јасно је да се тактички оправдана употреба првенствено односи на ситуације у којима се оправдано претпоставља да је осумњичени (или више лица) наоружан ватреним оружјем.

Употреба балистичког штита прилагођава се утврђеним и претпостављеним околностима конкретне ситуације, са тежиштем на врсти окружења у којем се изводи интервенција, особине претњи и друге чињенице, односно оправдане претпоставке. Понекад и ситан детаљ, као што су, на пример, степенице испред улазних врата, умногоме могу утицати на тактику групе или тима. У случају упада у затворени, односно барикадирани објекат, један од оперативаца опрема се и „овном" за пробијање. При извођењу упада веома је важно да се оперативци групе или тима не одвајају, те да константно штитоношу на неки начин обавештавају о свом блиском присуству, како би он могао остати фокусиран на сопствени видокруг. Специфичност дејстава ове врсте захтева и значајну динамичност при поступању, па је важно да штитоноша диктира оптималан темпо кретње коју, као што је наглашено, треба примарно прилагођавати особинама непосредног окружења. Када су у питању просторије у објектима, изузетна пажња посвећује се правилном „отварању углова" и другим сегментима тактике поступања.



Пример прилагођавања тактике поступања карактеристикама непосредног окружења. Фото: Милош Јевтић

Нема сумње да су балистички штитови изузетно користан, практичан елемент заштитне тактичке опреме, те трошење наменских средстава на набавку модерних штитова поузданих произвођача представља рационалан расход. Ипак, ови штитови остварују своју сврху само уколико их користе добро обучени оперативци.

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Пуном брзином напред – Русија наставља програм изградње ратних бродова[1]

Ратна морнарица Руске Федерације налазила се 2010. године у озбиљним новчаним проблемима. Новоизграђени бродови нису могли да замене ни постојеће. Тек након 20 година руска црноморска флота добила је по једну нову подморницу и фрегату. Међутим, када је у у питању оперативна употреба, америчка ратна морнарица примећује да је ниво активности руских подморница највиши још од хладног рата.

Наиме, ради се о промени политике и убризгавању значајне финансијске инјекције. Процењује се да су послови на изградњи бродова знатно боље финансирани и да је сума од 2 милијарде долара којом је финансиран развој ратних бродова у 2010. години, 2016. године нарастао на 6 милијарди долара. Питање је колико ће Русија моћи да издржи овај темпо с обзиром на стање у економији, али за сада и даље подржава развој великог броја програма.

Носачи авиона

Једини руски носач авиона, Project 1143.3, Admiral Kuznetsov, 2017. године упућен је на генерални ремонт, што значи да ће руска ратна морнарица остати без јединог носача и то на неодређени период.

Руски носач авиона Project 1143.3 Admiral Kuznetsov је, након операција у Сирији, упућен на генерални ремонт

[1] Jane's Navy International September 2016

На дуже стазе Русији је потребан велики носач авиона на нуклеарни погон, али је такав подухват тренутно под знаком питања с обзиром на постојеће ресурсе и разне изјаве у штампи.

Површинска флота

Руски војни планери предлажу изградњу великих и сложених разарача. У јавности су се током јуна 2017. године појавиле вести о планирању изградње нове класе разарача носивости од чак 15.000 тона са нуклеарним погоном класе Lider који би заменили разараче класе Udaloy I (Project 1155 Fregat), Udaloy II (Project 1155.1 Fregat II) и Sovremennyy (Project 956 Sarych), као и о новом класичном носачу авиона, такође на нуклеарни погон, али с обзиром на финансијску ситуацију питање је да ли ће то бити могуће.

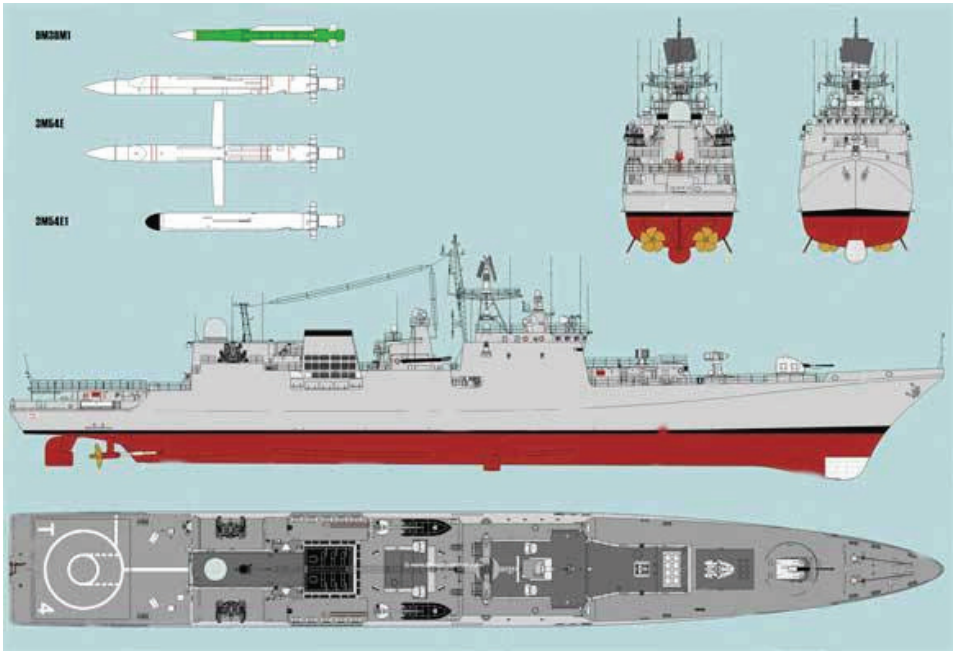
Руски разарач класе Udaloy II

Очекује се да ће основу руске флоте чинити фрегате класе Project 22350 Admiral Gorshkov и то двадесет бродова. Радови су почели 2005. године и убрзавају се с обзиром на уложена финансијска средства. Радови на бродовима два, три и четири започети су 2009, 2012. и 2013. године, али су испитивања првог брода те класе потрајала дуже него што је било планирано. Поред тога, сукоби у Украјини утицали су на престанак сарадње

у вези с испоруком делова система поморских гасних турбина. Тренутно Русија ради на изградњи сопствених капацитета, али то неће бити завршено пре 2019. године. Прва фрегата из поменуте класе завршена је, а увођење у оперативну употребу очекује се током 2017. године. Други брод из серије поринут је, док су радови на трупу трећег брода скоро завршени. Међутим, питање погона за те бродове још увек није решено.

Фрегата класе Project 22350 Admiral Gorshkov

Током 2010. године одлучено је да се гради нова варијанта фрегате класе Project 1135 Krivak. Радови су убрзо започети на фрегатама класе Project 11356 Admiral Grigorovich, али су опет, због рата у Украјини, стопирани због недостатка делова погонских система. Ипак, два су брода испоручена током 2016. године, а очекује се крај радова и на трећем броду.



Фрегата класе Project 11356 Admiral Grigorovich

Замена фрегата класе Grisha фрегатама Project 20380 Steregushchiy започета је на пет бродова у периоду од 2010. до 2014. године. Међутим, криза у Украјини је утицала и на овај програм, тако да су радови на преосталим бродовима из те класе прекинути. Прва два брода испоручена су 2016. године, а завршетак радова на трећем био је планиран до краја 2016. године.

Фрегата Project 20380 Steregushchiy

Трансфер немачких дизел-мотора компаније MTU био је стопиран, а у мају 2016. године омогућена је инсталација дизел-мотора DDA 12000 руске компаније Kolomna. Поново је започета изградња бродова класе 20380. Два брода су поринута почетком 2015. године, а следећа два брода средином 2015. и почетком 2016. године.

Изградња бродова модификоване класе 21631 Buyan-M са вертикалним лансерима противбродских ракета започета је 2010. године и трајала је до 2015. године. Поринуто је девет бродова, а први пут су испробани у октобру 2015. године, када су са њих испаљене крстареће ракете типа Kalibr на циљеве у Сирији.

Мањи ратни бродови

Дошло је до интересантног развоја у сектору мањих ратних бродова. Како се испоставило да ће набавка бродова класе 20380 ради замене застарелих корвета и фрегата бити скупа, 2010. године појавили су се планови о набавци већег броја мањих, јефтинијих бродова који би попунили ову празнину. Радови на изградњи патролних бродова класе 22160 Bykov започети су током 2014. године. Три кобилице поринуте су у периоду од 2014. до 2016. године, а очекује се да ће морнарица добити најмање шест бродова ове класе у периоду од 2017. до 2020. године. Сматра се да ће и ови бродови бити опремљени крстарећим ракетама типа Kalibr.

Патролни брод класе 22160 Bykov

Овај тренд се наставља и током 2015. године са новим патролним бродовима класе 22800 Karakurt наоружаним крстарећим ракета од којих ће један број бити израђен на Криму. Очекује се да ће се ова класа састојати од 18 бродова.

Други програми

Најављена је изградња посебног тешко наоружаног брода намењеног за операције близу северног пола, као и још два патролна брода класе 23350 намењена за операције на Арктику.

Такође, активно се ради на појачавању флоте помоћних бродова од којих највећи део датира из совјетских времена.

Начињени су велики помаци у амфибијској области, где морнарица прелази са десантних бродова пројектованих за искрцавање опреме на обалу на велике амфибијске бродове који са веће даљине могу искрцавати трупе и опрему путем десантних бродова и хеликоптера. Ови планови су тренутно застали с обзиром на кризу у Украјини и поништавање уговора за испоруку два француска амфибијска брода класе Mistral, али само тренутно, јер се већ ради на пројектовању сличних великих амфибијских бродова.

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Нове и старе (модернизоване) руске подморнице[2]

Русија ће поринути две напредне нуклеарне подморнице током 2017. године. Заменик команданта руске морнарице вицеадмирал Виктор Бурсук изјавио је да ће две нове нуклеарне подморнице бити поринуте, и то једна класе Improved Project 955-A, а друга класе Yasen-M.

Ради се о најмодернијим руским подморницама, нуклеарној балистичкој подморници класе Improved Project 955-A Borei II („Северни ветар”) и нуклеарној нападној подморници класе Project 855 Yasen-M. Подморница класе Project 955A Borei-II је, у ствари, модернизована верзија класе Project 955 Borei, која ће заменити стратешке нуклеарне подморнице из совјетског времена, класе Project 941 Typhoon и класе Project 667 BDRM Delta IV.

[2] The Diplomat 27th December 2016

Vučković, D., SAVREMENO NAORUŽANJE I VOJNA OPREMA / MODERN WEAPONS AND MILITARY EQUIPMENT, pp. 1098-1117

Руска балистичка подморница класе Project 955/955A

Радови на подморници класе Project 955A Borei II, под називом Knyaz Vladimir, започети су 20. јула 2012. године у бродоградилишту Sevmash у граду Severodvinsk, а очекује се да ће бити завршени до 2018. године, када се очекује њено увођење у оперативну употребу. Русија планира флоту од осам стратешких подморница класе Borei, од којих ће три бити класе Borei и пет класе Improved Borei II (модернизоване верзије). Модернизована верзија класе Borei II биће опремљена са четири додатна контејнера за лансирање балистичких ракета типа Bulava (RSM-56), имаће мањи труп, а биће опремљена новим акустичким уређајима и још тиша у односу на основни модел. Обе верзије биће опремљене новим ракетама типа Bulava. Класа Borei имаће капацитет од 16 интерконтиненталних ракета, док ће модернизована класа Borei II носити до 20 ракета овог типа.

Модернизована варијанта класе Borei имаће могућност лансирања 96 до 200 хиперсоничних нуклеарних бојевих глава са могућношћу независног маневрисања снаге од по 100–150 килотона.

Данас руска морнарица има три подморнице класе Borei: Alexander Nevsky, Vladimir Monomakh (у руској пацифичкој флоти) и Yuri Dolgoruky која је распоређена у руској северној флоти.

Руска морнарица има тренутно само једну нападну нуклеарну подморницу класе Yasen – K-329 Severodvinsk. То је подморница носивости од 13.800 тона, дужине 119 метара са врло високим нивоом аутоматизације. Нажалост, подморница ове класе је изузетно скупа, чак и два пута скупља од стратешке подморнице класе Borei, па је Русија увела само једну под-

морницу ове класе у оперативну употребу у односу на планираних осам. Претпоставља се да ће још три до четири подморнице ове класе бити завршене до краја 2020. године. Међутим, поставља се питање да ли ће руска поморска индустрија бити у могућности да заврши више од две подморнице класе Yasen због финансијских проблема. Прва подморница ове класе подвргнута је поморским тестовима још 2011. године, али се не зна да ли је у оперативној употреби или не, иако је наводно завршила своју прву мисију током августа 2016. године.

Нови подморнички торпедо са топлотним навођењем

Обе класе подморница биће опремљене новим торпедом, под називом Futlyar, који је тренутно у фази испитивања. Он представља модернизовану верзију самонаводећег торпеда 533 милиметара Fizik-1 којим су од недавно наоружане руске подморнице. Торпедо Fizik-1 има дужину од 7,2 метара, масу од 2.200 килограма и бојеву главу од 300. Мотор торпеда користи специјално гориво уместо стандардне мешавине кисеоника и воде. Торпедо Fizik-1 има два и по пута већи домет од застарелог торпеда USET-80 који се налази у наоружању руске морнарице још од осамдесетих година и којем истиче рок употребе.

Торпедо Futlyar биће опремљен новим системом вођења са продуженим дометом. Очекује се да ће торпедо имати домет 50 км, брзину од преко 50 чворова и дубину употребе до 400 м. То су параметри које поседују и друга руска торпеда, као што су торпеда Fizik-1, али ће овај торпедо бити опремљен системом за топлотно навођење и биће могуће наводити га из подморнице.

Увођењем новог торпеда Futlyar биће замењене верзије Fizik-1 и Fizik-2, иако су те две верзије тек недавно уведене (јун 2016. године) у наоружање руске морнарице.

Модернизација руских подморница

Поред рада на подморницама пете генерације, Русија ће извршити модернизацију десет вишенаменских подморница до 2020. године. Два руска бродоградилишта, Zvyozdochka на северозападу и Zvezda на далеком истоку Русије, радиће модернизацију десет нуклеарних подморница класе Project 971 Akula и Project 949A Oscar II у следећих неколико година.

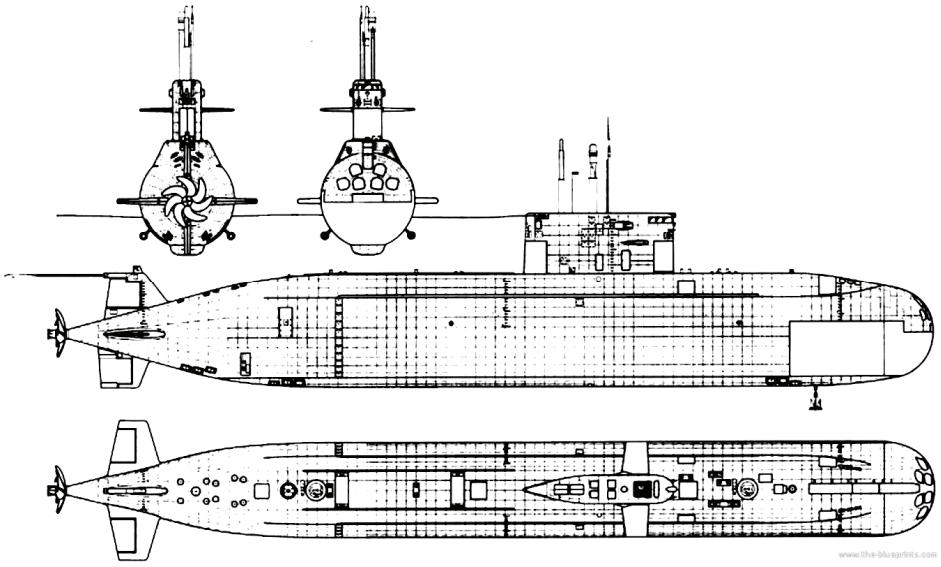
Две подморнице класе Oscar II активне су у руској северној флоти, а пет подморница те класе налазе се у руској пацифичкој флоти. Са друге стране, пет подморница класе Akula распоређене су у руској пацифичкој флоти, а шест у руској северној флоти. Претпоставља се да између 40 и 70 процената руских подморница у обе флоте није оперативно. Очекује се да ће модернизација ових подморница (наоружање и витални системи) продужити њихов животни век за још 15 до 20 година.

Поред подморница ове две класе, руски адмирал Vladimir Chirkov изјавио је, током априла 2016. године, да ће и подморнице класе Project 945 Sierra I бити укључене у пројекат модернизације. Првобитни план предвиђа модер-

низацију две подморнице ове класе до краја 2017. године, иако он не изгледа и остварљив.

Чини се да су проблеми финансијске природе утицали на овакву одлуку руске морнарице. Наиме, велика кашњења и огромни (непредвиђени) трошкови изградње нове пете класе нападних подморнице класе Project 885 Yasen представљају разлог овакве одлуке. Подморнице класе Yasen требало је да замене све нападне подморнице класе Akula, Sierra и Oscar до 2020. године, али су поменути трошкови то спречили. У временском интервалу којим је била предвиђена изградња осам подморница класе Yasen само је једна завршена, док су све остале у различитим фазама изградње.

Када су у питању конвенционалне подморнице, очекивало се да ће се прећи на производњу нове подморнице класе Project 677 Lada са погоном независним од ваздуха, које би замениле флоту од око 20 подморница класе Project 877/636 M Kilo и класе Improved Kilo. Међутим, започета је производња на само три подморнице те класе, а одлучено је да се поновно започне производња класе 636 M. Првобитни план да се израде три подморнице за црноморску флоту повећан је на шест. Испоруке су вршене по плану, тако да је прва подморница Novorossiysk уврштена у флоту током 2015. године. Испорука остатка од пет подморница очекује се до краја 2017. године.



Подморница класе Project 677 Lada

Почетком 2016. године појавили су се извештаји о плану изградње серије од шест подморница за пацифичку флоту које су требале да замене осам старијих дизел-електричних подморница. Уколико се настави овим

темпом (укључујући испоруке подморница Алжиру и Вијетнаму) преосталих пет подморница биће испоручено до краја 2017. године.

Са друге стране, будућа руска подморничка флота садржаће и нову подморницу са погоном независним од ваздуха под називом Kalina. Очекује се да ће првих 10 подморница овог типа бити испоручено до 2030. године.

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Raptor и Ligthning нису више сами: остатак света развија петту генерацију ловаца[3]

Иако су САД за сада једина држава која има ловце бомбардере пете генерације (Lockheed Martin F-22 Raptor и F-35 Ligthning II Joint Strike Fighter) у оперативној употреби, њихови савезници, али и противници, из све снаге се труде да смање предност развојем програма развоја летелица пете генерације.

Иако F-22 није никада добио извозну дозволу америчке владе, F-35 ће бити доминантна платформа у западним и савезничким арсеналима током следећих деценија. Међутим, и друге земље се труде да развију пету генерацију платформи у следећих десет до петнаест година.

Када се помињу програми развоја пете генерације ловаца важно је тачно дефинисати шта то значи, односно проверити да ли је то само маркетиншки трик, на пример компаније Lockheed Martin ради демонстрирања супериорности својих летелица, нарочито у односу на руске авионе. Ова градација употребљава се за дефинисање нове генерације ловаца који су „невидљиви", а што се постиже преко конфигурације унутрашњег складиштења наоружања, употребом композитних материјала и дизајна авиона, суперкрстареће брзине и обједињених сензора.

По овим критеријумима обично се прихвата да, осим два америчка авиона, F-22 и F-35, постоји укупно седам платформи пете генерације које се налазе у поступку развоја широм света. Једна од њих је Sukhoi T-50 Perspektivinnyi Aviatsonnyi Kompleks Frontovoi Aviatsyi (PAK-FA), затим Индија са Русијом ради на развоју ловца пете генерације, Fifth Generation Fighter Aircraft (FGFA)/Prospective Multirol Fighter Aircraft (FGFA) и Advanced Medium Combat Aircraft (AMCA), јапанска компанија Mitsubishi Heavy Industries развија F-3, бивши X-2 Advanced Technology Demonstrator-Experimental (ATD-X), Јужна Кореја развија ловац Korean Fighter Experimental (KFX), кинеска компанија Chengdu Aircraft Corporation (CAC) ради на развоју ловца J-20, док кинеска компанија Shenyiang Aircraft Corporation (SAC) развија FC/J-31 и, на крају, Турска развија авион Turkish Figther Experimental (TFX).

[3] IHS Jane's International Defence Review October 2016

Sukhoi T-50

Како ове платформе представљају сам технолошки врх аеронаутичке индустрије није чудно што су техничке спецификације строго чуване. Упркос томе, појавили су се одређени детаљи у пакету са сликама које су случајно или намерно објављене. На основу тога могуће је извршити процену потенцијалних могућности ових авиона.

Руски програм PAK-FA је, несумњиво, највише напредовао. Радови на програму започети су 1998. године након совјетских и руских покушаја за развојем пете генерације кроз платформе MiG 1.42 и Sukhoi S-37/47Berkut.

У јануару 2010. године извршен је први пробни лет ловца PAK-FA. PAK-FA. Споља личи на авион пете генерације који је „невидљив" са свих страна, осим са задње. Са предње стране вентилаторске лопатице скривене су усисницима ваздуха у облику слова S, што ограничава одбијање радарских таласа, док је остатак конструкције авиона рађен под угловима, што уз унутрашње складиштење наоружања такође утиче на слабију радарску видљивост. Иако се води као платформа пете генерације, аналитичари сумњају у пуне борбене могућности ловца PAK-FA.

Многи системи инсталирани на авиону пресликани су са ловца Su-30, укључујући радар Irbis, као и моторе компаније NPO Saturn 117S. Радар Irbis налази се у категорији пасивног електронског скенирања (PESA) и не може бити модернизован на ниво система активног електронског скенирања (AESA). У току је развој радара са електронским скенирањем N036 Byel-

ка намењеном ловцу PAK-FA. Иначе, AESA радари имају мању радарску видљивост, отпорнији су на ометање и много су поузданији.

PAK-FA дефинитивно није „невидљив" са своје задње стране. Тродимензионалне округле млазнице на прототипу јесу врло ефикасне и обезбеђују супераневарабилност авиону, али не маскирају радарски одраз, а вероватно је да ће будуће серијске машине имати исту конфигурацију. Иако је јасно зашто је оваква конфигурација употребљена на ловцу F-35 којем највећа опасност од непријатељске ПВО прети са фронталне стране, то не важи и за авионе чија је улога постизање ваздушне супериорности, као што је улога ловца PAK-FA.

Као и друге летелице пете генерације, PAK-FA задржава своје „невидљиве" особине употребом унутрашњег спремника наоружања и топа Gsh-301 9A1-4071K 30 mm. PAK-FA носи најновије ракете ваздух-ваздух и ваздух-земља у четири интерна спремишта (два у средњем делу и два на крајевима ваздушних усисника). Такође, опремљен је и са шест спољних подвесних тачака за мисије у којима „невидљивост" нема значајну улогу.

Иако је могуће анализирати степен „невидљивости" на основу самог дизајна летелице, многе ствари зависе и од интерне структуре авиона. Тренутно се композитни делови, неопходни за „невидљивост" авиона, делови трупа, крила и други подсистеми израђују само ручно. То није проблем када је у питању израда прототипа, али ће представљати велики проблем када буде покренута серијска производња авиона.

До данас нису објављене информације о особинама радарски абсорбујућих материјала авиона PAK-FA, иако су се појавили извештаји који наводе да је радарски одраз авиона само четрнаести део одраза ловца Su-27 Flanker (то би значило да је одраз прототипа PAK-FA мањи од пола квадратна метра ако се рачуна да је одраз Su-27 20 квадратних метара, али је то опет много више од америчког ловца F-22 за који је објављен податак о видљивости на нивоу 0.0001 квадратног метра.

Поред свог „невидљивог" дизајна, авион PAK-FA биће опремљен најновијом сензорском технологијом у облику радарског система AESA Sh121 компаније NIIP. Иако је овај систем несумњиво способан, он је ипак на нивоу најбољих решења која користе авиони четврте генерације. Према руским медијима, ова конфигурација омогућава ловцу PAK-FA могућност детекције, локације и праћења до 60 циљева истовремено на даљинама до 400 км. Ловац може ангажовати 16 циљева истовремено.

По питању обједињавања сензора, ловац PAK-FA може извршити сједињавање радарских података са другим сензорима на авиону, али и са спољним сензорима, што омогућује прецизну слику бојног поља која се приказује пилоту преко најновијих кабинских инструмената.

Летелица PAK-FA је први пут приказан на аеро-митингу MAKS током 2011. године. Прве процене су говориле да ће авион ући у оперативну употребу руског ратног ваздухопловства до 2015. године, па је тај рок померен на крај 2016. године, затим на 2017. годину, али се тренутно рокови више не помињу.

Иако је планирана набавка 200 авиона, у марту 2015. године објављено је да ће бити набављено само 12 примерака до 2020. године. Поставља се питање зашто је наведен тако мали број авиона, а поводом тога појавиле су се информације у медијима које наводе да је изузетно тешко израдити делове авиона по постојећим пројекту, нарочито када су у питању мотори. Иако су постојећи модели PAK-FA опремљени моторима AL-41F1 за које се наводи да троше много горива, а не производе довољан потисак, план је да они буду замењени много ефикаснијим и јачим моторима Izdeliye 30, који су још увек у развојној фази, а која би, по неким предвиђањима, трајала чак до 2027. године. Упркос свих постојећих проблема, очекује се да ће PAK-FA бити у оперативној употреби до 2050. године, а можда и након тога.

Упоредо, бар теоретски, тече и пројекат индијског „невидљивог" ловца FGFA/PMF. Док ће PAK-FA бити једносед, Индија има потребе за двоседом варијантом. Током 2010. године индијска влада је објавила да ће потрошити 32 милијарде долара на пројектовање, развој и производњу 200 до 250 летелица, иако је тај број у накнадним изјавама сведен на 140.

Индијска варијанта PAK-FA, FGFA/PMF представља половину индијских потреба за авионима пете генерације, док ће другу половину сачињавати ловци ADA AMCA. Ради се о авиону који би требало да замени флоту индијских ловаца типа SEPECAT Jaguar и Dassault Mirage 2000. То ће бити вишенаменска летелица намењена мисијама ваздушне супремације, блиске ваздушне одбране, мисијама дубинског продора и специјалним мисијама, а улазак у оперативну употребу очекује се након 2020 године.

Ловац AMCA је у развојној фази још од 2007. године, али још није одмакао од концептуалне фазе. Ради се о ловцу једноседу, опремљеног са два мотора, трапезоидним крилима и двоструким вертикалним стабилизаторима. Очекује се да ће AMCA испуњавати већину одредби које дефинишу „невидљиви" авион, осим конвенционалних издувника, слично као код руског PAK-FA.

Претпоставља се да ће ловац AMCA покретати два турбовентилаторска мотора GTRE GTX 35 VS Kaveri NG, а биће опремљен AESA радаром, али без назнака о ком моделу се ради. Вероватно је да ће тип радара бити исти или сличан оном који буде постављен на авион PAK-FA, а очекује се да ће и питање уређаја за инфрацрвено трагање и праћење бити решено на сличан начин.

AMCA ће бити наоружан са три ракете ваздух-ваздух за пресретање циљева ван визуелног домета и четири ракете ваздух-ваздух кратког домета у мисијама ваздушне супериорности, док ће за мисије ваздух-земља бити наоружан прецизним планирајућим авио-бомбама које ће се налазити у унутрашњем спремишту. Авион ће бити опремљен са 10 подвесних тачака за мисије у којима „невидљивост" нема неку улогу.

Предвиђена маса ловца AMCA биће 18.000 кг при полетању, максмална брзина 1,8 маха, максимална висина до 16.000 м и радијус дејства до 1.500 км. Очекује се да ће прототип имати свој пробни лет током 2017. године, а

претпоставља се да ће индијско ратно ваздухопловство и морнарица наручити преко 250 авиона.

Будући индијски ловац AMCA

С обзиром на то да су САД ускратиле дозволу за набавку ловца F-22 Raptor, којим је Јапан планирао да замени авион Mitsubushi F-2, држава је одлучила да покрене свој домаћи програм Mitsubishi ATD-X/X2 „Shinshin". Ради се о технолошком демонстратору, а не о прототипу оперативне платформе. Први подаци су се појавили 2005. године, иако је програм званично започео тек две године касније.

Први модел у пуној величини приказан је 2008. године и ту се могло приметити да је ATD-X/X2 сличних габаритета као шведски Gripen. По изгледу макете могло би се закључити да је тежиште на „невидљивости" и маневрабилности, али није могуће закључити да ли ће бити употребљени радарски апсорбујући материјали, „паметна" оплата авиона, пасивни сензори и инфрацрвени трагач. Нема података о авионским инструментима, али се претпоставља да ће сигурно бити инсталиран радар типа AESA.

У току је рад на мотору XF5-1 компаније IHI Corporation, чија снага би била 44,5–89 килоњутна.

Јапански ловац Mitsubishi ATD-X/X2 „Shinshin“

Први технолошки демонстратор појавио се 8. маја 2014. године, а први лет требало је да буде у јануару 2015. године. Лет је ипак одложен због проблема са софтвером који контролише аутоматско покретање мотора, тако да се авион ATD-X/X2 винуо у небо тек у априлу 2016. године.
Технолошки демонстратор ATD-X/X2 треба да обезбеди технолошку базу на основу које би Јапан дошао до ловаца пете генерације, а могао би представљати основу и за „шесту генерацију" платформи. Накнадно ће бити донета одлука о томе да ли ће се цео пројекат развијати у домаћој режији или ће се ићи на заједнички развој на међународном нивоу.
На основу доступних информација претпоставља се да ће максимална полетна маса авиона бити око 13.000 кг, максимална висина око 20.000 м, максимална брзина у нивоу маха 2,25 (1,82 у режиму суперкрстарења) и радијус дејства око 2.200 км (са два подвесна резервоара).

Јужна Кореја такође развија ловац пете генерације под ознаком KFX, што је пројекат компаније Korea Aerospace Industries, а предвиђен је као замена за јужнокорејске ловце F-16 Fighting Falcon.

Индонезија се прикључила пројекту на основу којег ће бити развијена платформа IFX. Формални споразум о почетку истраживања и развоја потписале су обе земље у августу 2012. године. Јужнокорејска компанија води пројекат у сарадњи са америчком компанијом Lockheed Martin (уложено 8 милијарди долара), док Индонезија учествује са једном милијардом долара и опцијом набавке до 50 ловаца.

Јужна Кореја такође развија ловац пете генерације под ознаком KFX

Иако је првобитно планирано постизање оперативне способности авиона KFX/IFX за 2023. годину, буџетска ограничења и технички проблеми навели су компанију KAI ка превођењу програма развоја ловца пете генерације у развој ловца „генерације 4.5", што значи одустајање од великог, једноседог, вишенаменског авиона са два мотора, радаром типа AESA и унутрашњим спремником наоружања на једномоторни авион са употребом система и авионских инструмената који су већ развијени за авион FA-50, а који, у суштини, представља замену тренажног авиона T-50 Golden Eagle.

У јулу 2014. поново долази до преокрета. Министарство одбране променило је своју одлуку и одлучило да ће се наставити рад на првобитном дизајну авиона KFX.

Постојећи подаци указују на то да ће KFX/IFX имати полетну масу од 24.000 кг, док други подаци нису доступни, а очекује се да ће Република Јужна Кореја наручити око 150 ових летелица.

Кина, такође, ради на развоју авиона пете генерације. То су две платформе – J-20 и FC/J-31 од којих су обе имале своје прве пробне летове.

J-20 је прва кинеска платформа пете генерације која је приказана јавности још у децембру 2010. године, иако се спекулише да је њен први пробни лет обављен неколико месеци раније.

Претпоставља се да постоји шест прототипова у фази испитивања, који се међусобно мало разликују, а постоје и незванични извештаји да је израђен мањи број авиона који је већ испоручен кинеском ратном ваздухопловству.

Кинески ловац J-20

Основни дизајн ловца J-20 подразумева двомоторни једносед са додатним крилцима ради постизања веће маневарабилности. Карактеристике „невидљивости" састоје се у посебно обликованим стабилизаторима, унутрашњем спремишту наоружања и посебно обликованим вратима сајног трапа. Авион покреће руски мотор из серије AL-31FM, а очекује се да ће серијски примерци бити погоњени моторима WS15 Emei за које се каже да ће бити опремљени системом за векторисања потиска. Очекује се да ће погонска група покретати ловац до брзине 2100 км/ч. Подаци који се односе на структуру, авионске инструменте и систем ловца J-20 нису познати.

Иако је пројектован као оперативна платформа, ловац J-20 делимично је развијен ради истраживања нових технологија. Већина делова авиона је домаће производње, осим мотора. Мотор је руског порекла и сви досадашњи покушаји Кине да произведе рентабилан, снажан и поуздан мотор још увек нису уродили плодом.

По наводима из кинеских извора ловац J-20 је уведен у оперативну употребу већ у априлу 2017. године. Нови подаци говоре да ће ловац бити коришћен као пресретач у мисијама ваздух-ваздух великог домета са задатком пресретања непријатељских авиона-цистерни и шпијунских летећих платформи, али и са задатком да напада непријатељеве системе ваздушне одбране, бродовље и копнена комуникациона постројења. Нове слике авиона ипак говоре о одређеним недостацима. Наиме, као и код руског невидљивог ловца, висок је коефицијент невидљивости на предњој страни, али не и са бокова и задње стране авиона, што ће сигурно утицати и на мисије авиона.

Нови подаци говоре да ће J-20 пресретати циљеве на даљинама до 200 км, користећи ракету ваздух-ваздух PL-15. Конкурент му је FC/J-31, Shen Fei. Иако се причало о „још једном авиону пете генерације", тек су се 2012. године појавиле прве слике овог ловца. Оне су приказале једносед FC/J-31, много мањи у односу на J-20, што је навело на помисао да се ради о авиону који је на доњој граници летелица пете генерације. Ради се о авиону са ниско постављеним трапезоидним крилима, спољa окренутим вертикалним стабилизаторима и унутрашњим спремиштем наоружања. Оваква конструкција указује на одређен степен „невидљивости".

Кинески ловац једносед FC/J-31

FC/J-31 је опремљен, као и J-20, са два руска турбовентилаторска мотора, Klimov RF-93, а очекује се да ће авиони из серијске производње бити опремљени моторима кинеске производње.

Подаци за овај авион су штури, али се претпоставља да поседује „вишенаменске способности", интеграцију екстерних података, могућност размене података, могућност напада на циљеве ван визуелног домета, могућност прецизног гађања циљева у свим временским условима, низак радарски одраз, низак инфрацрвени одраз, као и одличне могућности у противелектронској борби.

Авионски системи описани су као „систем отворене архитектуре који је компатибилан са напредним радарским, електронским оптичким сензорским системима, интегрисаним комуникационим и навигационим системима и системима за електронско ометање". Авион има четири интерна носача за ракете, шест екстерних подвесних носача за напредне ракете ваздух-ваздух и ваздух-земља.

Нема информација о датуму увођења у наоружање ловца FC/J-31, али је авион први пут приказан на изложби ваздухопловног наоружања Zhuhai airshow током новембра 2016. године на којем је примећен електрооптички нишански систем сличан оном на америчком ловцу F-35, а претпоставља се да је ловац тада био опремљен радарским системом KLJ-7A AESA који је развила кинеска компанија Nanjing Research Institute of Electronics Technology.

FC/J-31 има максималну масу при полетању од 22.226 кг са максималним тежином наоружања од 2.268 кг. Максимална брзина је 1,8 маха, док је радијус лета око 1.000 км са унутрашњим резервоарима и око 1.600 км са подвесним резервоарима.

На крају, Турска развија свој авион пете генерације TF-X који би требало да уђе у наоружање 2023. године.

Турска компанија TAI удружила се са компанијом Saab у концептуалној фази пројекта.

Иако још увек није обелодањен дизајн авиона, очекује се да ће TF-X бити сличног облика као други ловци пете генерације који су сада у развоју са трапезоидним крилом, двоструким вертикалним стабилизаторима.

Иако се много прича о ловцима пете генерације, очекује се да ће многи ловци четврте генерације, као и они класификовани као ловци генерације 4.5 остати у оперативној употреби следећих неколико деценија. Ови авиони, као што су Typhoon, Gripen, Rafale, F/A-18 Super Hornet, и F-15 Advanced Eagle, биће наоружани ракетама ваздух-ваздух за борбу ван визуелног домета типа MBDA Meteor.

Ови авиони су, или ће ускоро бити, опремљени радарима типа AESA и напредним пасивним трагачима, што ће утицати на умањење предности ловаца пете генерације. Употреба пасивних трагача је нарочито занимљива, јер произвођачи оваквих уређаја наглашавају могућност детекције и праћења летелица пете генерације. Приликом сусрета америчких и француских авиона на војним вежбама, француски ловци типа Rafale успели су да детектују и прате америчке ловце F-22 на даљинама које су им омогућиле лансирање ракета ваздух-ваздух. Ради се о уређајима који су опремљени напредним оптоелектронским уређајима и инфрацрвеним трагачима. То

им омогућује детектовање циљева са малим радарским одразом на даљинама од чак неколико десетина километара (нишански систем OLS-35 руског ловца Su-35 детектује термални одраз авиона на даљини од око седамдесет километара), са којих могу лансирати и навести ракете ваздух-ваздух. У овом случају потпуно је небитан радарски одраз авиона, јер је авион детектован на основу своје термалне слике формиране од издувних гасова, али и захваљујући аеродинамичком грејању структуре авиона. На несрећу, томе највише доприноси управо „невидљива" оплата авиона која није потпуно глатка, па долази до већег трења на одређеним брзинама. Да иронија буде већа, што ће мотори авиона пете генерације бити моћнији више ће загревати структуру, што ће повећавати могућност детекције пасивним трагачима којима су опремљене летелице четврте генерације. Иначе, технологија пасивних трагача постоји још од краја седамдесетих година, а први су је употребили Американци у свом ловцу F-14 Tomcat, а затим и Совјети у свом ловцу MiG-29, као и у серијама ловца Su-27. Наравно, данашњи пасивни трагачи су много осетљивији у односу на прве употребљене примерке, а могло би се десити да предност ловаца пете генерације у знатној мери буде поништена.

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ПОЗИВ И УПУТСТВО АУТОРИМА
ПРИГЛАШЕНИЕ И ИНСТРУКЦИИ ДЛЯ АВТОРОВ РАБОТ
CALL FOR PAPERS AND INSTRUCTIONS FOR AUTHORS

ПОЗИВ И УПУТСТВО АУТОРИМА О НАЧИНУ ПРИПРЕМЕ ЧЛАНКА

Упутство ауторима о начину припреме чланка за објављивање у *Војнотехничком гласнику* урађено је на основу Акта о уређивању научних часописа, Министарства за науку и технолошки развој Републике Србије, евиденциони број 110-00-17/2009-01, од 09. 07. 2009. године. Примена овог Акта првенствено служи унапређењу квалитета домаћих часописа и њиховог потпунијег укључивања у међународни систем размене научних информација. Засновано је на међународним стандардима ISO 4, ISO 8, ISO 18, ISO 215, ISO 214, ISO 18, ISO 690, ISO 690-2, ISO 999 и ISO 5122, односно одговарајућим домаћим стандардима.

Војнотехнички гласник / Vojnotehnički glasnik / Military Technical Courier (втг.мо.упр.срб, www.vtg.mod.gov.rs, ISSN 0042-8469 – штампано издање, e-ISSN 2217-4753 – online, UDC 623+355/359) јесте мултидисциплинарни научни часопис Министарства одбране Републике Србије, који објављује научне и стручне чланке, као и техничке информације о савременим системима наоружања и савременим војним технологијама. Часопис прати јединствену интервидовску техничку подршку Војске на принципу логистичке системске подршке, области основних, примењених и развојних истраживања, као и производњу и употребу средстава наоружања и војне опреме, те остала теоријска и практична достигнућа која доприносе усавршавању свих припадника српске, регионалне и међународне академске заједнице, а посебно припадника Министарства одбране и Војске Србије.

Министарство просвете, науке и технолошког развоја Републике Србије, сагласно одлуци из члана 27. став 1. тачка 4), а по прибављеном мишљењу из члана 25. став 1. тачка 5) Закона о научноистраживачкој делатности („Службени гласник РС”, бр. 110/05, 50/06-испр. и 18/10), утврдило је категоризацију Војнотехничког гласника, за 2016. годину:

за област технолошки развој:

– на листи часописа за материјале и хемијске технологије:

категорија водећи научни часопис националног значаја **(М51)**,

– на листи часописа за електронику, телекомуникације и информационе технологије:

категорија научни часопис националног значаја **(М52)**,

– на листи часописа за машинство:

категорија научни часопис националног значаја **(М52)**,

за област основна истраживања:

– на листи часописа за математику, рачунарске науке и механику:

категорија научни часопис националног значаја **(М52)**.

Усвојене листе домаћих часописа за 2016. годину могу се видети на сајту Војнотехничког гласника, страница Категоризација часописа (Министарство просвете, науке и технолошког развоја Републике Србије још увек није објавило званичну категоризацију научних часописа за 2017. годину).

Детаљније информације могу се пронаћи и на сајту Министарства просвете, науке и технолошког развоја Републике Србије.

Подаци о категоризацији могу се пратити и на сајту КОБСОН-а (Конзорцијум библиотека Србије за обједињену набавку).

Категоризација часописа извршена је према Правилнику о поступку и начину вредновања и квантитативном исказивању научноистраживачких резултата истраживача, који је прописао Национални савет за научни и технолошки развој (Службени гласник РС, број 38/2008).

У складу са овим правилником и табелом о врсти и квантификацији индивидуалних научноистраживачких резултата (у саставу Правилника), објављени рад у Војнотехничком гласнику вреднује се са 2 бода (категорија М51) и 1,5 бод (категорија М52).

Часопис се прати у контексту Српског цитатног индекса – СЦиндекс (база података домаћих научних часописа) и Руског индекса научног цитирања (РИНЦ). Подвргнут је сталном вредновању (мониторингу) у зависности од утицајности (импакта) у самим базама и, посредно, у међународним (Clarivate Analytics) цитатним индексима. Детаљи о индексирању могу се видети на сајту Војнотехничког гласника, страница Индексирање часописа.

Војнотехнички гласник омогућава и примењује Creative Commons (CC BY) одредбе о ауторским правима. Детаљи о ауторским правима могу се видети на сајту часописа, страница **Ауторска права и политика самоархивирања**.

Радови се предају путем онлајн система за електронско уређивање ASEESTANT, који је развио Центар за евалуацију у образовању и науци (ЦЕОН).

Приступ и регистрација за сервис врше се на сајту www.vtg.mod.gov.rs, преко странице ASEESTANT или СЦИНДЕКС, односно директно на линку aseestant.ceon.rs/index.php/vtg.

Детаљно упутство о регистрацији и пријави за сервис налази се на сајту www.vtg.mod.gov.rs, страница Упутство за е-Ур: Електронско уређивање – ASEESTANT.

Потребно је да се сви аутори који подносе рукопис за објављивање у Војнотехничком гласнику региструју у регистар ORCID (Open Researcher and Contributor ID), према упутству на страници сајта Регистрација за добијање ORCID идентификационе шифре.

Војнотехнички гласник објављује чланке на српском, енглеском, руском, немачком или француском језику (arial, српска ћирилица или српска латиница, величина слова 11 pt, проред Single).

Поступак припреме, писања и уређивања чланка треба да буде у сагласности са **Изјавом о етичком поступању** (http://www.vtg.mod.gov.rs/izjava-o-etickom-postupanju.html).

Чланак треба да садржи сажетак са кључним речима, увод, разраду, закључак, литературу и резиме са кључним речима на енглеском језику (без нумерације наслова и поднаслова). Обим чланка треба да буде око једног ауторског табака (16 страница формата А4 са проредом Single), а највише 24 странице.

Чланак треба да буде написан на обрасцу за писање чланка, који се у електронској форми може преузети са сајта на страници Образац за писање чланка.

Наслов

Наслов треба да одражава тему чланка. У интересу је часописа и аутора да се користе речи прикладне за индексирање и претраживање. Ако таквих речи нема у наслову, пожељно је да се придода и поднаслов. Наслов треба да буде преведен и на енглески језик.

Ови наслови исписују се испред сажетка на одговарајућем језику.

Текући наслов

Текући наслов се исписује са стране сваке странице чланка ради лакше идентификације, посебно копија чланака у електронском облику. Садржи презиме и иницијал имена аутора (ако аутора има више, преостали се означавају са „et al.“ или „и др.“), наслове рада и часописа и колацију (година, волумен, свеска, почетна и завршна страница). Наслови часописа и чланка могу се дати у скраћеном облику.

Име аутора

Наводи се пуно име и презиме (свих) аутора. Веома је пожељно да се наведу и средња слова аутора. Имена и презимена домаћих аутора увек се исписују у оригиналном облику (са српским дијакритичким знаковима), независно од језика на којем је написан рад.

Назив установе аутора (афилијација)

Наводи се пун (званични) назив и седиште установе у којој је аутор запослен, а евентуално и назив установе у којој је аутор обавио истраживање. У сложеним организацијама наводи се укупна хијерархија (нпр. Универзитет одбране у Београду, Војна академија, Катедра природно-математичких наука). Бар једна организација у хијерархији мора бити правно лице. Ако аутора има више, а неки потичу из исте установе, мора се, посебним ознакама или на други начин, назначити из које од наведених установа потиче сваки од наведених аутора. Афилијација се исписује непосредно након имена аутора. Функција и звање аутора се не наводе.

Контакт подаци

Адреса или е-адреса свих аутора даје се на првој страници чланка.

Категорија (тип) чланка

Категоризација чланака обавеза је уредништва и од посебне је важности. Категорију чланка могу предлагати рецензенти и чланови уредништва, односно уредници рубрика, али одговорност за категоризацију сноси искључиво главни уредник.

Чланци у часописима се разврставају у следеће категорије:

Научни чланци:

1. оригиналан научни рад (рад у којем се износе претходно необјављивани резултати сопствених истраживања научним методом);

2. прегледни рад (рад који садржи оригиналан, детаљан и критички приказ истраживачког проблема или подручја у којем је аутор остварио одређени допринос, видљив на основу аутоцитата);

3. кратко или претходно саопштење (оригинални научни рад пуног формата, али мањег обима или прелиминарног карактера);

4. научна критика, односно полемика (расправа на одређену научну тему, заснована искључиво на научној аргументацији) и осврти.

Изузетно, у неким областима, научни рад у часопису може имати облик монографске студије, као и критичког издања научне грађе (историјско-архивске, лексикографске, библиографске, прегледа података и сл.) – дотад непознате или недовољно приступачне за научна истраживања.

Радови класификовани као научни морају имати бар две позитивне рецензије.

Ако се у часопису објављују и прилози ваннаучног карактера, научни чланци треба да буду груписани и јасно издвојени у првом делу свеске.

Стручни чланци:

1. стручни рад (прилог у којем се нуде искуства корисна за унапређење професионалне праксе, али која нису нужно заснована на научном методу);

2. информативни прилог (уводник, коментар и сл.);

3. приказ (књиге, рачунарског програма, случаја, научног догађаја, и сл.).

Језик рада

Језик рада може бити српски, енглески или други језик који се користи у међународној комуникацији у одређеној научној области (руски, немачки или француски).

Текст мора бити језички и стилски дотеран, систематизован, без скраћеница (осим стандардних). Све физичке величине морају бити изражене у Међународном систему мерних јединица – SI. Редослед образаца (формула) означава се редним бројевима, са десне стране у округлим заградама.

Сажетак (апстракт) и резиме

Сажетак (апстракт) јесте кратак информативан приказ садржаја чланка који читаоцу омогућава да брзо и тачно оцени његову релевантност. У интересу је уредништава и аутора да сажетак садржи термине који се често користе за индексирање и претрагу чланака. Саставни делови сажетка су циљ истраживања, методи, резултати и закључак. Сажетак треба да има од 100 до 250 речи и треба да се налази између заглавља (наслов, имена аутора и др.) и кључних речи, након којих следи текст чланка. Ако је рад написан на српском (руском, немачком или француском) језику пожељно је да се, поред сажетка на српском (руском, немачком или француском), даје и сажетак у проширеном облику на енглеском језику – као тзв. резиме (summary). Овакав резиме треба да буде на крају чланка, након одељка Литература. Важно је да резиме буде у структурираном облику, а његова дужина може бити до 1/10 дужине чланка (опширнији је од сажетка са почетка чланка). Почетак овог резимеа може бити преведени сажетак (са почетка чланка), а затим треба да следе преведени главни наслови, поднаслови и основе закључка чланка (литература се не преводи). Потребно је да се у структурираном резимеу преведе и део текста испод наслова и поднаслова, водећи рачуна да он буде пропорционалан њиховој величини, а да одражава суштину. Након резимеа на енглеском језику (проширеног сажетка) додаје се његов превод на српском, да би редакција извршила проверу и лектуру.

Кључне речи

Кључне речи су термини или фразе које адекватно представљају садржај чланка за потребе индексирања и претраживања. Треба их додељивати ослањајући се на неки међународни извор (попис, речник или тезаурус) који је најшире прихваћен или унутар дате научне области. За нпр. науку уопште, то је листа кључних речи Web of Science. Број кључних речи не може бити већи од 10, а у интересу је уредништва и аутора да учесталост њихове употребе буде што већа. Кључне речи дају се на језику на којем је написан чланак (сажетак) и на енглеском језику. У чланку се пишу непосредно након сажетка, односно након резимеа.

Систем ASEESTANT у ту сврху користи специјалну алатку KWASS: аутоматско екстраховање кључних речи из дисциплинарних тезауруса/речника по избору и рутине за њихов одабир, тј. прихватање односно одбацивање од стране аутора и/или уредника.

Датум прихватања чланка

Датум када је уредништво примило чланак, датум када је уредништво коначно прихватило чланак за објављивање, као и датуми када су у међувремену достављене евентуалне исправке рукописа наводе се хронолошким редоследом, на сталном месту, по правилу на крају чланка.

Захвалница

Назив и број пројекта, односно назив програма у оквиру којег је чланак настао, као и назив институције која је финансирала пројекат или програм, наводи се у посебној напомени на сталном месту, по правилу при дну прве стране чланка.

Претходне верзије рада

Ако је чланак у претходној верзији био изложен на скупу у виду усменог саопштења (под истим или сличним насловом), податак о томе треба да буде наведен у посебној напомени, по правилу при дну прве стране чланка. Рад који је већ објављен у неком часопису не може се објавити у Војнотехничком гласнику (прештампати), ни под сличним насловом и измењеном облику.

Табеларни и графички прикази

Пожељно је да наслови свих приказа, а по могућству и текстуални садржај, буду дати двојезично, на језику рада и на енглеском језику.

Табеле се пишу на исти начин као и текст, а означавају се редним бројевима са горње стране. Фотографије и цртежи треба да буду јасни, прегледни и погодни за репродукцију. Цртеже треба радити у програму word или corel. Фотографије и цртеже треба поставити на жељено место у тексту.

За слике и графиконе не сме се користити снимак са екрана рачунара програма за прикупљање података. У самом тексту чланка препоручује се употреба слика и графикона непосредно из програма за анализу података (као што су Excel, Matlab, Origin, SigmaPlot и други).

Навођење (цитирање) у тексту

Начин позивања на изворе у оквиру чланка мора бити једнообразан.

Војнотехнички гласник за референцирање (цитирање и навођење литературе) примењује Харвардски систем референци, односно Харвардски приручник за стил (Harvard Referencing System, Harvard Style Manual). У самом тексту, у обичним заградама, на месту на којем се врши позивање, односно цитирање литературе набројане на крају чланка, обавезно у обичној загради написати презиме цитираног аутора, годину издања публикације из које цитирате и, евентуално, број страница. Нпр. (Petrović, 2012, pp.10–12).

Детаљно упутство о начину цитирања, са примерима, дато је на страници сајта Упутство за Харвардски приручник за стил. Потребно је да се позивање на литературу у тексту уради у складу са поменутим упутством.

Систем ASEESTANT у сврху контроле навођења (цитирања) у тексту користи специјалну алатку CiteMatcher: откривање изостављених цитата у тексту рада и у попису референци.

Напомене (фусноте)

Напомене се дају при дну стране на којој се налази текст на који се односе. Могу садржати мање важне детаље, допунска објашњења, назнаке о коришћеним

изворима (на пример, научној грађи, приручницима), али не могу бити замена за цитирану литературу.

Листа референци (литература)

Цитирана литература обухвата, по правилу, библиографске изворе (чланке, монографије и сл.) и даје се искључиво у засебном одељку чланка, у виду листе референци. Референце се не преводе на језик рада и набрајају се у посебном одељку на крају чланка.

Војнотехнички гласник, као начин исписа литературе, примењује Харвардски систем референци, односно Харвардски приручник за стил (Harvard Referencing System, Harvard Style Manual).

Литература се обавезно пише на латиничном писму и набраја по абецедном редоследу, наводећи најпре презимена аутора, без нумерације.

Детаљно упутство о начину пописа референци, са примерима, дато је на страници сајта Упутство за Харвардски приручник за стил. Потребно је да се попис литературе на крају чланка уради у складу са поменутим упутством.

Нестандардно, непотпуно или недоследно навођење литературе у системима вредновања часописа сматра се довољним разлогом за оспоравање научног статуса часописа.

Систем ASEESTANT у сврху контроле правилног исписа листе референци користи специјалну алатку RefFormatter: контрола обликовања референци у складу са Харвардским приручником за стил.

Пропратно писмо (само за ауторе из Републике Србије и по посебном захтеву уредника)

Поред чланка доставља се пропратно писмо у којем треба истаћи о којој врсти чланка се ради, који су графички прилози (фотографије и цртежи) оригинални, а који позајмљени.

У пропратном писму наводе се и подаци аутора: име, средње слово, презиме, чин, звање, е-маил, адреса послодавца (ВП), кућна адреса, телефон на радном месту и кућни (мобилни) телефон, рачун и назив банке, СО места становања, број личне карте и ЈМБ грађана.

Сви радови подлежу стручној рецензији.

Списак рецензената Војнотехничког гласника може се видети на страници сајта Списак рецензената. Процес рецензирања објашњен је на страници сајта Рецензентски поступак.

Адреса редакције:
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ПРИГЛАШЕНИЕ И ИНСТРУКЦИЯ ДЛЯ АВТОРОВ О ПОРЯДКЕ ПОДГОТОВКИ СТАТЬИ

Инструкция для авторов о порядке подготовки статьи к опубликованию в журнале «Военно-технический вестник» разработана в соответствии с Актом о редактировании научных журналов Министерства науки и технологического развтия Республики Сербия, № 110-00-17/2009-01 от 09.07.2009 г. Применением этого Акта, в первую очередь, обеспечивается совершенствование качества отечественных жуналов и их более полного включения в международную систему обмена научной информацией. Инструкция соответствует международным стандартам ISO 4, ISO 8, ISO 18, ISO 215, ISO 214, ISO 18, ISO 690, ISO 690-2, ISO 999, ISO 5122 и соответствующим отечественным стандартам.

Военно-технический вестник (**Vojnotehnički glasnik / Military Technical Courier**), втг.мо.упр.срб, www.vtg.mod.gov.rs/index-ru.html, ISSN 0042-8469 – печатное издание, e-ISSN 2217-4753 – online, UDK 623+355/359, является мультидисциплинарным научным журналом Министерства обороны Республики Сербия, который публикует научные и профессиональные статьи, а также техническую информацию о современных системах вооружения и современных военных технологиях. Журнал следит за единой межвойсковой технической поддержкой вооруженных сил, основанной на принципах системной логистики, за прикладными и инновационными научными исследованиями, в том числе, в области производства военного оборудования и средств вооружения, и за прочими теоретическими и практическими достижениями, которые способствуют профессиональному совершенствованию представителей сербского, регионального и международного академического сообщества, и особенно служащих Министерства Обороны и Вооруженных сил Республики Сербия.

Министерство образования, науки и технологического развития Республики Сербия, согласно решению по ст. 27 абзац 1, пункт 4 и по полученному толкованию ст. 25 абзац 1 пункт 5 Закона о научно-исследовательской деятельности („Службени гласник РС", № 110/05, утверждило категоризацию Военно-технического вестника за 2016 год:

Категории в области технологического развития:

– Область материалов и химической технологии:

ведущий научный журнал национального значения **(M51)**,

– **Область электроники, телекоммуникаций и информационных технологий:** научный журнал национального значения **(M52),**

– Область механики:

научный журнал национального значения **(M52)**.

Категории в области основных исследований:

– Область математика, компьютерные науки, технические науки:

научный журнал национального значения **(M52)**.

Информацию относительно категоризации за 2016 год можно посмотреть на странице сайта Военно-технического вестника Категоризация вестника (Министерством просвещения, науки и технологического развития Республики Сербия пока не производилось официальное ранжирование научных журналов за 2017 год.).

Более подробную информацию можно прочитать на сайте Министерства образования, науки и технологического развития Республики Сербия.

Информацию о категоризации можно посмотреть и на сайте КОБСОН-а (Консорциум библиотек Республики Сербия по вопросам объединения закупок).

Категоризация вестника проведена согласно Положению о порядке и способе категоризации научно-исследовательских результатов, утвержденному Национальным комитетом по науке и технологиям (Службени гласник РС, № 38/2008).

В соответствии с вышеуказанным Положением и табличкой с показателями классификации и категоризации индивидуальных научно-исследовательских результатов (являющейся неотъемлемой частью Положения), работа, опубликованная в Военно-техническом вестнике, оценивается следующим способом: 2 балла (категория М51) и 1,5 баллов (категория М52).

Журнал соответствует стандартам Сербского цитатного индекса – SCindeks (база данных отечественных научных журналов), а также Российского индекса научного цитирования (РИНЦ). Журнал постоянно оценивается (мониторинг) в зависимости от численного показателя важности научного журнала в самих базах, в т.ч. опосредованно в международных цитатных индексах (Clarivate Analytics).

С информацией об индексировании можно ознакомиться на странице сайта журнала «Индексирование вестника».

«Военно-технический вестник» обеспечивает читателям возможность открытого доступа, в соответствии с положениями об авторских правах, утвержденными Creative Commons (CC BY). С инструкцией об авторских правах можно ознакомиться на странице **Авторские права и политика самоархивирования**, перейдя по ссылке http://www.vtg.mod.gov.rs/index-ru.html.

Работы представляются путем online системой e-Ур: Электронное издательство ASEESTANT, запущенное Центром поддерживающим развитие образования и науки (ЦЕОН).

Права доступа и регистрация в системе оформляются по адресу http://www.vtg.mod.gov.rs/index-ru.html, через страницу «ASEESTANT» или «СЦИНДЕКС» (aseestant.ceon.rs/index.php/vtg).

С инструкцией по регистрации и праву доступа можно ознакомиться по адресу http://www.vtg.mod.gov.rs/index-ru.html, на странице «Инструкция по e-Ур: Электронное издательство ASEESTANT».

Все авторы, предоставляющие свои рукописи на публикацию в редакцию журнала «Военно-технический вестник» должны пройти регистрацию в реестре ORCID (Open Researcher and Contributor ID), в соответствии с инструкцией на странице сайта Регистрация в реестре ORCID для присвоения идентификационного кода.

Военно-технический вестник выпускает статьи на сербском, русском, английском, немецком или французском языках (Arial, шрифт 11 pt, пробел Single).

Процесс подготовки, написания и редактирования статьи должен осуществляться в соответствии с принципами **Этического кодекса** (http://www.vtg.mod.gov.rs/etichyeskiy-kodyeks.html).

Статья должна содержать сюжет с ключевыми словами, введение, разработку, выводы, список использованной литературы и резюме с ключевыми словами на английском языке (без нумерации заголовков и подзаголовков). Объем статьи не должен превышать один авторский лист (16 страниц формата А4 с пробелом Single).

Статья должна быть написана на образце написания статьи, который можно скачать на странице сайта «Правила и образец составления статьи».

Заголовок

Заголовок должен отражать тему статьи. Интересы журнала и автора состоят в использовании слов, удобных для индексации и поиска. Если такие слова не содержаны в заголовке, то желательно добавить и подзаголовок. Заголовок должен быть переведен на английский язык. Эти заголовки пишутся перед сюжетами на соответствующем языке.

Текущий заголовок

Текущий заголовок пишется в титуле каждой страницы статьи с целью упрощения идентификации, в первой очереди копий статьей в электронном виде. Содержит в себе фамилию и инициал имени автора (в случае если авторов несколько, остальные обозначаются с «et al.» или «и др.»), заголовки работы и журнала (год, объем, тетрадь, начальная и заключительная страница). Заголовки журнала и статьи могут приводиться в сокращенном виде.

ФИО автора

Приводятся полная фамилия и полное имя (всех) авторов. Очень желательно, чтобы были приведены и средние буквы авторов. Фамилия и имя отечественных авторов всегда пишутся в оригинальном виде (с сербскими диакритическими знаками), независимо от языка, на котором работа написана.

Наименование учреждения автора (аффилиация)

Приводится полное (официальное) наименование и местонахождение уждния, в котором работает автор, а также наименование учреждения, в котором автор пвел исследование. В случае сложных организаций приводится общая иерархия (напр. Университет обороны в г. Белграде, Военная академия, Кафедра военных элтронных систем). По крайней мере, одна из этих организаций в иерархии должна иметь статус юридического лица. В случае если авторов несколько, и если нектоые работают в одном учреждении, нужно отдельными обозначениями или кким-нибудь другим способом указать в каком из приведенных учреждений работает каждый из приведенных авторов. Аффилиация пишется непосредственно после ФИО автора. Должность и квалификация по образованию не указываются.

Контактные данные

Почтовый адрес и/или электронный адрес авторов указываются на первой страницы статьи.

Категория (тип) статьи

Категоризация статьей является обязанностью редакции и имеет особое значение. Категорию статьи могут предлагать рецензенты и члены редакции, т.е. редакторы рубрик, но ответственность за категоризацию несет исключительно главный редактор. Статьи в журналах распределяются по следующим категориям:

Научные статьи:

1. оригинальная научная работа (работа, в которой приводятся раньше неопубликованные результаты собственных исследований научным методом);

2. наглядная работа (работа, содержащая оригинальный, детальный и критический обзор исследовательской проблемы или области, в который автор внес определенный вклад, видимый на основе автоцитат);

3. краткая или предварительная информация (оригинальная научная работа полного формата, но меньшего объема или имеющая предварительный характер);

4. научная критика, т.е. полемика (дискуссия на определенную научную тему, обоснованная исключительно на научной аргументации) и беглые обзоры.

Однако, в некоторых областях научная работа в журнале может иметь форму монографической студии, а также критического издания научного материала (историко-архивного, лексикографического, библиографического, обзора данных и т.п.) – до тех пор неизвестного или недостаточно доступного для научных исследований. Работы, классифицированные в качестве научных, должны иметь, по меньшей мере, две положительные рецензии.

В случае если в журнале объявляются и приложения, не имеющие научный характер, научные статьи должны быть сгруппированы и четко выделены в первой части тетради.

Профессиональные статьи:

1. профессиональная работа (приложения, в которых предлагаются опыты, полезные для совершенствования профессиональной практики, но которые не должны в обязательном порядке быть обоснованы на научном методе);

2. информативное приложение (передовая статья, комментарий и т.п.);

3. рецензия (книги, компьютерной программы, случая, научного события и т.п.).

Язык работы

Работа может быть написана на сербском, английском или другом языке, используемом в международной коммуникации в определенной научной области (русский, немецкий или французский).

Текст должен быть в лингвистическом и стилистическом смысле упорядочен, систематизирован, без сокращений (за исключением стандартных). Все физические величины должны соответствовать Международной системе единиц измерения – СИ. Очередность формул обозначается порядковыми номерами, с правой стороны в круглых скобках.

Сюжет (абстракт) и резюме

Сюжет (абстракт) является кратким информативным обзором содержания статьи, обеспечивающим читателю быстро и точно оценить его релевантность. В интересах редакции и авторов, чтобы сюжет содержал термины, часто используемые для индексирования и поиска статьей. Составными частями сюжета являются цель исследования, методы и заключение. В сюжете должно быть от 100 до 250 слов, и должен находится между титулами (заголовок, ФИО авторов и др.) и ключевыми словами, за которыми следует текст статьи. Если работа написана на сербском (русском, немецком или французском) языке, желательно, чтобы кроме сюжета на сербском (русском, немецком или французском) был предоставлен и сюжет в расширенном виде на английском языке – в качестве т.н. резюме (summary). Такой резюме должен находиться в конце статьи, после раздела Литература. Важно, чтобы резюме было в структурированном виде, и его длина может составлять до 1/10 длины статьи (оно более обширно, чем сюжет из начала статьи). Началом данного резюме может быть переведенный сюжет (из начала статьи), а затем должны следовать переведенные главные заголовки, подзаголовки и основы заключения статьи (литература не переводится). В структурированном резюме нужно перевести часть текста под заголовком и заголовком, принимая во внимание, чтобы она была пропорциональна их размеру и в то же время отражала суть.

Ключевые слова

Ключевыми словами являются термины или фразы, адекватно представляющие содержание статьи, необходимое для индексирования и поиска. Их надо присуждать, опираясь при этом на какой-то международный источник (регистр, словарь, тезаурус), наиболее приемлемый внутри данной научной области. Число ключевых слов не может превышать 10, а в интересах редакции и авторов, чтобы их частота была как можно больше. Ключевые слова даются на языке, на котором написана статья (сюжет), и на английском языке. В статье они пишутся непосредственно после сюжета, т.е. после резюме.

Программа ASSESTANT предоставляет возможность использования сервиса KWASS: автоматическое фиксирование ключевых слов из источников/словарей по выбору, т.е., которые автор/редактор воспринимает или нет.

Дата получения статьи

Дата, когда редакция получила статью, дата, когда редакция окончательно приняла статью для опубликования, а также даты, когда за истекший период были предоставлены эвентуальные исправления рукописи, приводятся в хронологическом порядке, на постоянном месте, как правило, в конце статьи.

Выражение благодарности

Наименование и номер проекта, т.е. название программы, в которой статья возникла, как и наименование учреждения, которое финансировало проект или программу, приводятся в отдельном примечании на постоянном месте, как правило, внизу первой страницы статьи.

Предыдущие версии работы

В случае если статья в предыдущей версии была изложена в устном обращении (под одинаковым или похожим названием), сведение об этом должно быть указано в отдельном примечании, как правило, внизу первой страницы статьи. Работа, которая уже опубликована в некотором из журналов, не может быть опубликована в Военно-техническом вестника (перепечатана), ни под похожим названием, ни измененном виде.

Табличное и графическое представление

Желательно, чтобы названия всех представлений (по возможности и текстуальное содержание) были представлены на двух языках (на языке работы и на английском). Таблицы пишутся таким же способом как и текст и обозначаются порядковыми номерами с верхней стороны. Фотографии и рисунки должны быть понятны, наглядны и удобные для репродукции. Рисунки надо делать в программах Word или corel. Фотографии и рисунки надо поставить на желаемое место в тексте.

Для создания изображений и графиков использование функции снимка с экрана (скриншота) не допускается. В самом тексте статьи рекомендуется применение изображений и графиков, обработанных такими программами, как: Excel, Matlab, Origin, SigmaPlot и пр.

Ссылки (цитирование) в тексте

Оформление ссылок на источники в рамках статьи должно быть однообразным.

Военно-технический вестник для оформления ссылок, цитат и списка использованной литературы пользуется гарвардской системой (Harvard Referencing

System, Harvard Style Manual). В тексте в скобках приводится фамилия цитируемого автора (или фамилия первого автора, если авторов несколько), год издания и по необходимости номер страницы. Например: (Петрович, 2010., пп. 10-20). Рекомендации о способе цитирования размещены на странице сайта «Инструкция по использованию Гарвардского стиля». При оформлении ссылок, цитат и списка использованной литературы необходимо придерживаться установленных норм.

Программа ASEESTANT предоставляет при цитировании возможность использования сервиса CiteMatcher: фиксирование пропущенных цитат в работе и списке литературы.

Примечания (сноски)

Примечания указываются внизу страницы, на которой находится текст, к которым они относятся. Могут содержать менее важные детали, дополнительные объяснения, указания об использованных источниках (напр. научном материале, справочниках), но не могут быть заменой для цитированной литературы.

Лист референций (литература)

Цитированной литературой охвачены, как правило, библиографические источники (статьи, монографии и т.п.) и она представляется исключительно в отдельном разделе статьи, в виде листа референций. Референции не переводятся на язык работы.

Военно-технический вестник для оформления списка использованной литературы применяет гарвардскую систему (Harvard Style Manual). В списке литературы источники даются в алфавитном порядке авторов или редакторов. Рекомендации о способе цитирования размещены на странице сайта «Инструкция по использованию Гарвардского стиля». При оформлении списка использованной литературы необходимо придерживаться установленных норм.

Программа ASEESTANT при оформлении списка литературы предоставляет возможность использования сервиса RefFormatter: контроль оформления списка литературы в соответствии со стандартами Гарвардского стиля.

Нестандартное, неполное и непоследовательное приведение литературы в системах оценки журнала считается достаточной причиной для оспаривания научного статуса журнала.

Все работы подлежат спец. рецензированию.

Список рецензентов Военно-технического вестника можно посмотреть на странице сайта Список рецензентов. Процесс рецензирования описан на странице сайта Правила рецензирования.

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CALL FOR PAPERS AND ARTICLE FORMATTING INSTRUCTIONS

The instructions to authors about the article preparation for publication in the *Military Technical Courier* are based on the Act on scientific journal editing of the Ministry of Science and Technological Development of the Republic of Serbia, No 110-00-17/2009-01 of 9th July 2009. This Act aims at improving the quality of national journals and raising the level of their compliance with the international system of scientific information exchange. It is based on international standards ISO 4, ISO 8, ISO 18, ISO 215, ISO 214, ISO 18, ISO 690, ISO 690-2, ISO 999 and ISO 5122 and their national equivalents.

The Military Technical Courier / Vojnotehnički glasnik (www.vtg.mod.gov.rs/index-e.html, втг.мо.упр.срб, ISSN 0042-8469 – print issue, e-ISSN 2217-4753 – online, UDC 623+355/359) is a multidisciplinary scientific journal of the Ministry of Defence of the Republic of Serbia. It publishes scientific and professional papers as well as technical data on modern weapon systems and military technologies. The journal covers inter-service technical support to the Army on the principle of logistic system support; fundamental, applied and development research; production and use of weapons and military equipment as well as other theoretical and practical achievements leading to professional development of all members of Serbian, regional and international academic communities, members of the Ministry of Defence and the Army of Serbia in particular.

Pursuant to the decision given in Article 27, paragraph 1, point 4, and in accordance with the acquired opinion given in Article 25, paragraph 1, point 5 of the Act on Scientific and Research Activities (Official Gazette of the Republic of Serbia, No 110/05, 50/06-cor and 18/10), the Ministry of Education, Science and Technological Development of the Republic of Serbia classified the Military Technical Courier for the year 2016

in the field technological development:
– on the list of periodicals for materials and chemical technology,
category: leading scientific periodical of national interest **(M51)**,
– on the list of periodicals for electronics, telecommunications and IT,
category: scientific periodical of national interest **(M52)**,
– on the list of periodicals for mechanical engineering,
category: scientific periodical of national interest **(M52)**,
in the field fundamental research:
– on the list of periodicals for mathematics, computer sciences and mechanics,
category: scientific periodical of national interest **(M52)**.

The approved lists of national periodicals for the year 2016 can be viewed on the website of the Military Technical Courier, page Journal categorization (The Ministry of Education, Science and Technological Development of the Republic of Serbia has not yet published the official evaluation of scientific journals for 2017).

More detailed information can be found on the website of the Ministry of Education, Science and Technological Development of the Republic of Serbia.

The information on the categorization can be also found on the website of KOBSON (Consortium of Libraries of Serbia for Unified Acquisition).

The periodical is categorized in compliance with the Regulations on the procedure and method of evaluation and quantitative formulation of scientific and research results of researchers, stipulated by the National Council for Scientific and Technological Development (*Official Gazette of RS*, No 38/2008). More detailed information can be

found on the website of the Ministry of Education, Science and Technological Development.

In accordance with the Regulations and the table about types and quantification of individual scientific and research results (as a part of the Regulations), a paper published in the *Military Technical Courier* scores 2 (two) points (category M51) and 1,5 (one and a half) point (category M52).

The journal is in the Serbian Citation Index – SC index (data base of national scientific journals), in the Russian Science Citation Index (RSCI) and is constantly monitored depending on the impact within the bases themselves and indirectly in the international (e.g. Clarivate Analytics) citation indexes. More detailed information can be viewed on the website of the Military Technical Courier, page Journal indexing.

Military Technical Courier enables open access and applies the Creative Commons Attribution (CC BY) licence provisions on copyright. The copyright details can be found on the **Copyright notice and Self-archiving policy** page of the journal's website.

Manuscripts are submitted online, through the electronic editing system ASEESTANT, developed by the Center for Evaluation in Education and Science – CEON.

The access and the registration are through the Military Technical Courier site http://www.vtg.mod.gov.rs/index-e.html, on the page ASEESTANT or the page SCINDEKS or directly through the link (aseestant.ceon.rs/index.php/vtg).

The detailed instructions about the registration for the service are on the website http://www.vtg.mod.gov.rs/index-e.html, on the page Instructions for e-Ur: Electronic Editing - ASEESTANT.

All authors submitting a manuscript for publishing in the Military Technical Courier should register for an ORCID ID following the instructions on the web page Registration for an ORCID identifier.

The Military Technical Courier publishes articles in Serbian, English, Russian, German or French, using Arial and a font size of 11pt with Single Spacing.

The procedures of article preparation, writing and editing should be in accordance with the **Publication ethics statement** (http://www.vtg.mod.gov.rs/publication-ethics-statement.html).

The article should contain the abstract with keywords, introduction, body, conclusion, references and the summary in English language (without heading and subheading enumeration). The article length should not exceed 24 pages of A4 paper format.

The article should be formatted following the instructions in the Article Form which can be downloaded from website page Article form.

Title

The title should be informative. It is in both Journal's and author's best interest to use terms suitable for indexing and word search. If there are no such terms in the title, the author is strongly advised to add a subtitle. The title should be given in English as well.

The titles precede the abstract and the summary in an appropriate language.

Letterhead title

The letterhead title is given at a top of each page for easier identification of article copies in an electronic form in particular. It contains the author's surname and first name initial (for multiple authors add "et al"), article title, journal title and collation (year, volume, issue, first and last page). The journal and article titles can be given in a shortened form.

Author's name

Full name(s) of author(s) should be used. It is advisable to give the middle initial. Names are given in their original form (with diacritic signs if in Serbian).

Author's affiliation

The full official name and seat of the author's affiliation is given, possibly with the name of the institution where the research was carried out. For organizations with complex structures, give the whole hierarchy (for example, University of Defence in Belgrade, Military Academy, Department for Military Electronic Systems). At least one organization in the hierarchy must be a legal entity. When some of multiple authors have the same affiliation, it must be clearly stated, by special signs or in other way, which department exactly they are affiliated with. The affiliation follows the author's name. The function and title are not given.

Contact details

The postal addresses or the e-mail addresses of the authors are given in the first page.

Type of articles

Classification of articles is a duty of the editorial staff and is of special importance. Referees and the members of the editorial staff, or section editors, can propose a category, but the editor-in-chief has the sole responsibility for their classification.

Journal articles are classified as follows:

Scientific articles:

1. Original scientific paper (giving the previously unpublished results of the author's own research based on scientific methods);

2. Survey paper (giving an original, detailed and critical view of a research problem or an area to which the author has made a contribution visible through his self-citation);

3. Short or preliminary communication (original scientific paper of full format but of a smaller extent or of a preliminary character);

4. Scientific critique or forum (discussion on a particular scientific topic, based exclusively on scientific argumentation) and commentaries.

Exceptionally, in particular areas, a scientific paper in the Journal can be in a form of a monograph or a critical edition of scientific data (historical, archival, lexicographic, bibliographic, data survey, etc.) which were unknown or hardly accessible for scientific research.

Papers classified as scientific must have at least two positive reviews.

If the journal contains non-scientific contributions as well, the section with scientific papers should be clearly denoted in the first part of the Journal.

Professional articles:

1. Professional paper (contribution offering experience useful for improvement of professional practice but not necessarily based on scientific methods);

2. Informative contribution (editorial, commentary, etc.);

3. Review (of a book, software, case study, scientific event, etc.)

Language

The article can be in Serbian, English or other language used in international communication in a particular scientific field (Russian, German or French).

The grammar and style of the article should be of good quality. The systematized text should be without abbreviations (except standard ones). All measurements must be in SI units. The sequence of formulae is denoted in Arabic numerals in parentheses on the right-hand side.

Abstract and summary

An abstract is a concise informative presentation of the article content for fast and accurate evaluation of its relevance. It is both in the Editorial Office's and the author's best interest for an abstract to contain terms often used for indexing and article search. The abstract describes the purpose of the study and the methods, outlines the findings and state the conclusions. A 100- to 250- word abstract should be placed between the title and the keywords with the body text to follow. Besides an abstract in Serbian (Russian, German or French), articles in Serbian (Russian, German or French) are advised to have a summary in English, at the end of the article, after the Reference list. The summary should be structured and long up to 1/10 of the article length (it is more extensive than the abstract). It can start with the translated Serbian (Russian, German or French) abstract from the beginning of the article with translated main headings, subheadings and major conclusions to follow (Reference list is not translated). The structured summary should also contain the proportional informative parts of the text below the headings and subheadings.

Keywords

Keywords are terms or phrases showing adequately the article content for indexing and search purposes. They should be allocated heaving in mind widely accepted international sources (index, dictionary or thesaurus), such as the Web of Science keyword list for science in general. The higher their usage frequency is, the better. Up to 10 keywords immediately follow the abstract and the summary, in respective languages.

For this purpose, the ASEESTANT system uses a special tool KWASS for the automatic extraction of key words from disciplinary thesauruses/dictionaries by choice and the routine for their selection, i.e. acceptance or rejection by author and/or editor.

Article acceptance date

The date of the reception of the article, the dates of submitted corrections in the manuscript (optional) and the date when the Editorial Board accepted the article for publication are all given in a chronological order at the end of the article.

Acknowledgements

The name and the number of the project or programme within which the article was realised is given in a separate note at the bottom of the first page together with the name of the institution which financially supported the project or programme.

Article preliminary version

If an article preliminary version has appeared previously at a meeting in a form of an oral presentation (under the same or similar title), this should be stated in a separate note at the bottom of the first page. An article published previously cannot be published in the *Military Technical Courier* even under a similar title or in a changed form.

Tables and illustrations

All the captions should be in the original language as well as in English, together with the texts in illustrations if possible. Tables are typed in the same style as the text and are denoted by Arabic numerals at the top. Photographs and drawings, placed

appropriately in the text, should be clear, precise and suitable for reproduction. Drawings should be created in Word or Corel.

For figures and graphs, proper data plot is recommended i.e. using a data analysis program such as Excel, Matlab, Origin, SigmaPlot, etc. It is not recommended to use a screen capture of a data acquisition program as a figure or a graph.

Citation in the text

Citation in the text must be uniform. The Military Technical Courier applies the Harvard Referencing System given in the Harvard Style Manual. When citing sources within your paper, i.e. for in-text references of the works listed at the end of the paper, place the year of publication of the work in parentheses and optionally the number of the page(s) after the author's name, e.g. (Petrovic, 2012, pp.10-12). A detailed guide on citing, with examples, can be found on Military Technical Courier website on the page Instructions for Harvard Style Manual. In-text citations should follow its guidelines.

For checking in-text citations, the ASESESTANT system uses a special tool CiteWatcher to find out quotes left out within papers and in reference lists.

Footnotes

Footnotes are given at the bottom of the page with the text they refer to. They can contain less relevant details, additional explanations or used sources (e.g. scientific material, manuals). They cannot replace the cited literature.

Reference list (Literature)

The cited literature encompasses bibliographic sources such as articles and monographs and is given in a separate section in a form of a reference list.

References are not translated to the language of the article.

In compiling the reference list and bibliography, the Military Technical Courier applies the Harvard System – Harvard Style Manual. All bibliography items should be listed alphabetically by author's name, without numeration. A detailed guide for listing references, with examples, can be found on Military Technical Courier website on the page Instructions for Harvard Style Manual. Reference lists at the end of papers should follow its guidelines.

In journal evaluation systems, non-standard, insufficient or inconsequent citation is considered to be a sufficient cause for denying the scientific status to a journal.

All articles are peer reviewed.

The list of referees of the Military Technical Courier can be viewed at website page List of referees. The article review process is described on the Peer Review Process page of the website.

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ОБАВЕШТЕЊА САРАДНИЦИМА И ЧИТАОЦИМА
СООБЩЕНИЯ ДЛЯ АВТОРОВ И ЧИТАТЕЛЕЙ
INFORMATION FOR CONTRIBUTORS AND READERS

Министарство просвете, науке и технолошког развоја Републике Србије објавило категоризацију Војнотехничког гласника за 2015. и 2016. годину

Министарство просвете, науке и технолошког развоја Републике Србије, сагласно одлуци из члана 27. став 1. тачка 4), а по прибављеном мишљењу из члана 25. став 1. тачка 5) Закона о научноистраживачкој делатности („Службени гласник РС" бр. 110/05, 50/06-испр. и 18/10), утврдило је категоризацију Војнотехничког гласника, за 2015. и 2016. годину:

за област технолошки развој:

– на листи часописа за материјале и хемијске технологије: категорија водећи научни часопис националног значаја (М51),
– на листи часописа за електронику, телекомуникације и информационе технологије: категорија научни часопис националног значаја (М52),
– на листи часописа за машинство: категорија научни часопис националног значаја (М52),

за област основна истраживања:

– на листи часописа за математику, рачунарске науке и механику: категорија научни часопис националног значаја (М52).

Усвојене листе домаћих часописа за 2015. и 2016. годину могу се видети на страници Категоризација часописа (http://www.vtg.mod.gov.rs/kategorizacija-casopisa.html).

Детаљније информације могу се пронаћи и на сајту Министарства просвете, науке и технолошког развоја Републике Србије.

Категоризација часописа извршена је према Правилнику о поступку и начину вредновања и квантитативном исказивању научноистраживачких резултата истраживача, који је прописао Национални савет за научни и технолошки развој (Службени гласник РС, број 38/2008).

У складу са овим правилником и табелом о врсти и квантификацији индивидуалних научноистраживачких резултата (у саставу Правилника), објављени рад у Војнотехничком гласнику вреднује се са 2 бода (категорија М51) и 1,5 бод (категорија М52).

Министерство образования, науки и технологического развития Республики Сербия утвердило категоризацию журнала «Военно-технический вестник» за 2015 и 2016 годы

Министерством образования, науки и технологического развития Республики Сербия согласно решению по ст. 27 абзац 1, пункт 4 и по полученному толкованию ст. 25 абзац 1 пункт 5 Закона о научно-исследовательской деятельности («Службени гласник РС» № 110/05, 50/06-испр. и 18/10) утверждена категоризация журнала «Военно-технический вестник» за 2015 и 2016 годы:

Категории в области технологического развития:

– Область материалов и химической технологии: ведущий научный журнал национального значения (М51),
– Область электроники, телекоммуникаций и информационных технологий: научный журнал национального значения (М52),

– Область механики: научный журнал национального значения (М52).

Категории в области основных исследований:

Область математика, компьютерные науки, технические науки: научный журнал национального значения (М52).

С информацией о категоризации за 2015 и 2016 годы можно ознакомиться на странице Категоризация вестника (http://www.vtg.mod.gov.rs/kategorizacia-vestnika.html).

Более подробно с информацией можно ознакомиться на сайте Министерства образования, науки и технологического развития Республики Сербия.

Категоризация журнала проведена в соответствии с Регламентом о порядке и методах категоризации научно-исследовательских результатов, утвержденного Национальным комитетом по науке и технологиям (Службени гласник РС, № 38/2008).

В соответствии с вышеуказанными положениями Регламента и таблицей по классификации и категоризации индивидуальных научно-исследовательских результатов (являющихся неотъемлемой частью Регламента), работа, опубликованная в журнале «Военно-технический вестник», оценивается следующим образом: 2 балла (категория М51) и 1,5 баллов (категория М52).

Ministry of Education, Science and Technological Development of the Republic of Serbia classified the Military Technical Courier for the years 2015 and 2016

Pursuant to the decision given in Article 27, paragraph 1, point 4, and in accordance with the acquired opinion given in Article 25, paragraph 1, point 5 of the Act on Scientific and Research Activities (Official Gazette of the Republic of Serbia, No 110/05, 50/06-cor and 18/10), the Ministry of Education, Science and Technological Development of the Republic of Serbia classified the Military Technical Courier for the years 2015 and 2016

in the field Technological Development:

- on the list of periodicals for materials and chemical technology, category: leading scientific periodical of national interest (M51),
- on the list of periodicals for electronics, telecommunications and IT, category: scientific periodical of national interest (M52),
- on the list of periodicals for mechanical engineering, category: scientific periodical of national interest (M52),

in the field Fundamental Research:

- on the list of periodicals for mathematics, computer sciences and mechanics: category: scientific periodical of national interest (M52).

The approved lists of national periodicals for the years 2015 and 2016 can be viewed on the web page Journal categorization (http://www.vtg.mod.gov.rs/journal-categorisation-1.html).

More detailed information can be found on the website of the Ministry of Education, Science and Technological Development of the Republic of Serbia. The periodical is categorized in compliance with the Regulations on the procedure and method of evaluation and quantitative formulation of scientific and research results of researchers, stipulated by the National Council for Scientific and Technological Development (Official Gazette of RS, No 38/2008).

In accordance with the Regulations and the table about types and quantification of individual scientific and research results (as a part of the Regulations), a paper published in the Military Technical Courier scores 2 (two) points (category M51) and 1.5 (one and a half) point (category M52).

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