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PROJECT MANAGEMENT OF THE SYSTEM FOR REGIONAL PARTNERSHIP OF THE ORGANIZATION OF THE AUTOMOBILE TRANSPORT IN THE DEVELOPMENT OF THE SYSTEM OF TECHNICAL PREPARATION OF THE VEHICLE PARKS

BY

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Abstract: There had been developed a system model for project management for the development strategy for automobile transport organizations (ATO) following the stages of its life cycle on the basis of assumption which is the base of the business model of the regional partnership of ATO in the development of system for technical preparation (STP), about the increase in the efficiency of the common (centralized) performance of some functions and /or works on technical preparation of vehicles on the manufacturing and technical base (MTB) of some ATO or mutual order for these services from other suppliers (outsourcing).

Keywords: organization of the automobile transport; regional partnership; system model; life circle; strategy.

1. Introduction

The analysis of the vehicle park structure, used for passenger transportation in Ukraine showed that the above parks are characterized by prevailing the small carriers, big number of car makes, their models and vehicle

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modifications, which are operated by one enterprise simultaneously; relatively long operation period of the vehicle. This, together with such factors as uncertainty of conditions, in particular as for the state of road infrastructure, vehicle operation, stipulates for the complexity in vehicle maintenance in the level, required by the competition and the requirements of the state (municipal) regulations on the corresponding markets.

One of the approaches to the creation of the efficient STP of the vehicle parks with the ATO is the regional partnership.

2. Review of the Latest Issues

The interest to the issues of the formation and the development of the interorganisational alliances is biing traced in the scientific researches beginning with 1970-1980 of the XX century. In their paper, published in 1978, Dj. Pfeffer and G. Salancik came to the conclusion, that the understanding of the market in the developed economies as the "open" arena, unlike in traditional, is changed with the organizational, regulatory and bruch systems, connected between each other by pretty complex relations (Pfeffer & Salancik, 1978). The authors emphasize that the organizations may adapt to the requirements of the environment (the adherers of the environmental school in strategic management also keep to this point of view) and may try to change the latter in a way it answers their peculiarities (school of authority in strategic management, theory of dependence on external resources) etc.

The notions of "team strategy", "common enterprise", "strategic alliance", "business network" were introduced, as is noted by Minzberg *et al.*, (2001), in the development of work (Pfeffer & Salancik, 1978) within the development of the school of authority. In accordance with the conceptual principles of the latter, along with spreading the interorganisational cooperation, the formation of the strategy gradually transforms into the common process with the participation of some partners. The possibility in the creation of team strategy implies, that during the negotiations each separate organization must consider the complexity of the organizational relations in the business network. The latter, within the frameworks of the models of the organizational development of the authority school, is considered as the network of different types of cooperation with other units of the network by the persons, including the suppliers, competitors and customers (Haransson & Snekota, 1989). Summarizing the research principles of the authority school, G. Minzberg notes that it proceeds from the fact that apart from the corporate strategies and strategies of business units, the organizations must develop strategies n the level of the personnel, which consider the complex system of the mutual dependences. These dependences are the integral part of the cooperative society, which results in the fact that each organization appears to be integrated in the system of the so called shared unit, the nature of which does not allow the isolated actions. The cooperation spirit dominates in this situation, the organizations gradually reject the orientation on the competitive antagonism. The attention shall be paid to the issues of institutionalization of the alike activities (Minzberg *et al*., 2001).

The conception of the business networks became one of the decisive in the formation of the theory and practice of strategic alliances as the variants of the corporative agreements, usually made between the suppliers and consumers or partners, and the latter remained competitive in other spheres. The notions of "common enterprise" as the strategic alliance, in which partners take equal positions in the new business and the notion of "corporate agreement" as the situation with the unequal positions are being differentiated. The comparative analysis of the variety of strategic alliances is presented by Pekar & Allio (1994). The objective of the paper is to form the system model of the project management of the regional partnership of ATO in the development of the system for technical preparation of the vehicle parks.

3. Main Part

The presented assumptions as for the formulation of the strategic alliances must be considered in conditions of the development of the theory of project management of partnership of ATO in the development of СТП of the vehicle parks and organizational, technical and economic systems. This partnership at the same time, proceeding from mutual execution and a possible mutual ordering services for technical preparation of vehicles parks by the ATO partners requires the analysis of the strategic base of the outsourcing. Outsourcing is considered to be one of the preconditions for the formation of the strategic alliances. Outsourcing as an alternative to the execution of certain activities by the own forces was researched in the theory of the operation costs. This theory , as one of the theories of the organizational development proceeds from the fact that during the creation of the business organization it is necessary to consider the uncertainty of the environment composed of different (by the stage of risk and uncertainty) supplies and/or consumers.

Since any organization, following this theory, strives to build an organization of higher level to be able to control over the behavior of those supplies and/or consumers through the corresponding mechanisms.

When the own operational costs of the organization (costs for transactions) are higher then those on the open market, it is appropriate to apply to the latter, having made an outsourcing agreement.

In the context of formation of goals of the organizational development in conditions of outsourcing introduction, the regulations of the theory of dependence on external resources are of interest. In accordance with this theory, which proceeds from the fact that the organization strives for the controlling over the external (in relation to it) environment for the achievement of the own profit. Since the organization cannot create the necessary recourses within the "own limits" economically efficiently, looking for variants, which allow it to influence the external environment. This means the development of the organization through transformation (business merger, cooperation) and other interorganizational agreements.

For example, historically, having in mind the improvement of the results of their activities, the organizations of different branches strived to acquire control over the technological stages proceeding the main production or are the following on its way. That is, they actually took the way of creation of the vertically integrated corporative structures, which may be considered following the results of the strategic choice of the enterprise in conditions of limited recourses.

The last ten decades testify to the opposite tendency – the organizations expect to increase their competitiveness, concentrating on their activities, considered as the principal ones.

Under these circumstances there is the transition from the vertical to so called virtual integration. To make this transition successful the manager has to master the approaches to managing the assets and processes, which they cannot control directly, but have to follow the their efficiency of functioning (Vorkut, 2002).

Today the "soft" international formations as the net organizational forms are becoming more widely used.

They are created on the bases of the agreement relations, on the base of the mutual exchange of recourses. The organization, participating in such an agreement, is specialized on the key profile types of works, where it has the competitive advantages, the other – non profile – it transfers to other organizations on contractual bases, that is to the other members of the network, which may perform them more efficiently. The notoon of non-profile activity is associated with the conception of the "central (key) competence of the organization" introduced in 1990 by K.K. Ptahalad and G. Hamel as the means of combining the recourses and abilities of the organization for the achievement of the real result (Prahalad & Hamel, 1990).

Under the considered conditions the advantage in the using resourses is achieved due to the fact that the organisation does not have to hold (produce) all the necessary resourses for the main manufacturing, but can use the assets of other organisations, which may be located in different places of the chain. The conception of management of the sypply chain may be a classical example in this case.

Proceeding from the assumption, laid in the base of the business model of the regional ATO partnership in the development of STP about the improvement of the efficiency of common (centralized) performance of some separate functions, and/or works on technical preparation of vehicles on MTB of some ATO or mutual ordering of the execution of these services by other organisations (on the base of the outsoursing), the system model of the project management of the ATO strategic development as the stages of its life circle, had been developed with the consideration of the approaches, suggested by Bilichenko, (2012), may be improved taking into account the system principles of individualization and integration.

On the stage of the goal setting, the goal level G_{2j}^{1} may be written as follows:

$$G_{2j}^{1} = G_{2j}^{1}\,(G_{2j\,\text{інд}}^{1}, G_{2j\,\text{інт}}^{1})\,, \tag{1}$$

where $G_{2j\,\text{інд}}^{1}$ – subset of local goals of individualization as for the project of the formation of the strategy life circle to the STP ATO on the *j*-th time interval; $G_{2j\,\text{інт}}^{1}$ – subset of local goals of the integration as for the project stage.

The formation of the life circle of the strategy to the STP ATO on the *j*-th time interval.

Correspondingly, the target level G_{2j}^{2} may be presented as:

$$G_{2j}^{2} = G_{2j}^{2}\,(G_{2j\,\text{інд}}^{2}, G_{2j\,\text{інт}}^{2})\,, \tag{2}$$

where: $G_{2j\,\text{інд}}^{2}$ is the subset of local goals of individualization as for the project of the stage of the development of strategic portfolio of the life circle of the strategy to the STP ATO on the *j*-th time interval; $G_{2j\,\text{інт}}^{2}$ – subset of local goals of the integration as for the project stage of the development of portfolio of the life circle of the strategy to the STP ATO on the j-th time interval.

The target level G_{2j}^{3} may be written as:

$$G_{2j}^{3} = G_{2j}^{3}\,(G_{2j\,\text{інд}}^{3}, G_{2j\,\text{інт}}^{3})\,, \tag{3}$$

where: $G_{2j\,\text{інд}}^{3}$ is the subset of local goals of individualization as for the project of the planning and realization of the strategic portfolio of the life circle of the strategy to the STP ATO on the *j*-th time interval; $G_{2j\,\text{інт}}^{3}$ – subset of local goals of the integration as for the project stage of the development of portfolio of the life circle of the strategy to the STP ATO on the *j*-th time interval.

The target level G_{2j}^{4} may be written as:

$$G_{2j}^{4} = G_{2j}^{4}\,(G_{2j\,\text{інд}}^{4}, G_{2j\,\text{інт}}^{4})\,, \tag{4}$$

where: $G^{4}_{2j\,\text{інд}}$ is the subset of local goals of individualization as for the project of the stage of operation an devaluation of the strategic portfolio of the life circle of the strategy to the STP ATO on the *j*-th time interval; $G^{4}_{2j\,\text{інт}}$ – subset of local goals of the integration as for the project stage of the operation and evaluation of the strategic portfolio of the life circle of the strategy strategy to the СТП АТО on the *j*-th time interval.

Correspondingly, it is necessary to specify the algorithm for the construction of the model of the goal achievement stage in the part of ensuring the activity of STP of the vehicle.

The above algorithm shall determine:

1) the subsets of the individualization function, $F^{n}_{2j\,\text{інд}}$, and the subset of the function of management integration, $F^{n}_{2j\,\text{інт}}$, which are necessary to realize in the project of the *n*-th stage of the life circle of the ATO strategy as for the STP of the vehicle on the *j*-th time interval for the achievement of the subsets:

$$G^{n}_{2j\,\text{інд}} \to F^{n}_{2j\,\text{інд}} \left\{ f^{n}_{2j\,\text{інд}} : f^{n}_{2j\,\text{інд}} \in F^{n}_{2j\,\text{інд}},\, n=1,2,...,N;\, i=1,2,...,I;\, j=1,2,...,J \right\}, \quad (5)$$

$$G^{n}_{2j\,\text{інт}} \to F^{n}_{2j\,\text{інт}} \left\{ f^{n}_{2j\,\text{інт}} : f^{n}_{2j\,\text{інт}} \in F^{n}_{2j\,\text{інт}},\, n=1,2,...,N;\, i=1,2,...,I;\, j=1,2,...,J \right\}, \quad (6)$$

2) subsets of the tasks for management individualization, $O^{n}_{2j\,\text{інд}}$, and the subset of the tasks of management integration, $O^{n}_{2j\,\text{інт}}$, which are necessary to solve in the project of the *n*-th stage of the life circle of the ATO strategy as for the STP of the vehicle on the *j*-th time interval for the realisation of the subsets $F^{n}_{2j\,\text{інд}}$ and $F^{n}_{2j\,\text{інт}}$ correspondingly:

$$F^{n}_{2j\,\text{інд}} \to O^{n}_{2j\,\text{інд}} \left\{ o^{n}_{2j\,\text{інд}} : o^{n}_{2j\,\text{інд}} \in O^{n}_{2j\,\text{інд}},\, n=1,2,...,N;\, i=1,2,...,I;\, j=1,2,...,J \right\}, \quad (7)$$

$$F^{n}_{2j\,\text{інт}} \to O^{n}_{2j\,\text{інт}} \left\{ o^{n}_{2j\,\text{інт}} : o^{n}_{2j\,\text{інт}} \in O^{n}_{2j\,\text{інт}},\, n=1,2,...,N;\, i=1,2,...,I;\, j=1,2,...,J \right\}, \quad (8)$$

3) subsets of methods and models for the solution of the tasks of management individualisation, $M^{n}_{2j\,\text{інд}}$, and subsets of methods and models for the solution of the tasks of the integration of management, $M^{n}_{2j\,\text{інт}}$, which are necessary to use in the project of the *n*-th stage of the life circle of the ATO strategy as for the STP of the vehicle on the *j*-th time interval for the subsets $O^{n}_{2j\,\text{інд}}$ and $\mathrm{O}^{\mathrm{n}}_{2\mathrm{j}\,\text{інт}}$ correspondingly:

$$O^{n}_{2j\,\text{інд}} \to M^{\,n}_{2j\,\text{інд}}\left\{m^{n}_{2j\,\text{інд}}: m^{n}_{2j\,\text{інд}} \in M^{\,n}_{2j\,\text{інд}},\, n=1,2,...,N;\; i=1,2,...,I;\; j=1,2,...,J\right\}, (9)$$

$$O^{n}_{2j\,\text{інт}} \to M^{\,n}_{2j\,\text{інт}}\left\{m^{\text{n}}_{2j\,\text{інт}}: m^{n}_{2j\,\text{інт}} \in M^{\,n}_{2j\,\text{інт}},\, n=1,2,...,N;\; i=1,2,...,I;\; j=1,2,...,J\right\}, (10)$$

4) subsets of algorithms of methods and models for the solution of the tasks of management individualization, $A^{n}_{2j\,\text{інд}}$, and and subsets of methods and models for the solution of the tasks of the integration of management, $A^{n}_{2j\,\text{інт}}$, which are necessary to use in the project of the *n*-th stage of the life circle of the ATO strategy as for the STP of the vehicle on the *j*-th time interval for the subsets $M^{\,n}_{2j\,\text{інд}}$ and $M^{\,n}_{2j\,\text{інт}}$ correspondingly:

$$M^{\,n}_{2j\,\text{інд}} \to A^{n}_{2j\,\text{інд}}\left\{a^{n}_{2j\,\text{інд}}: a^{n}_{2j\,\text{інд}} \in A^{n}_{2j\,\text{інд}},\, n=1,2,...,N;\; i=1,2,...,I;\; j=1,2,...,J\right\}, \quad (11)$$

$$M^{\,n}_{2j\,\text{інт}} \to A^{n}_{2j\,\text{інт}}\left\{a^{n}_{2j\,\text{інт}}: a^{n}_{2j\,\text{інт}} \in A^{n}_{2j\,\text{інт}},\, n=1,2,...,N;\; i=1,2,...,I;\; j=1,2,...,J\right\}, \quad (12)$$

5) subsets of software and hardware means for the realization of the algorithms of methods and models for the solution of the tasks of management individualization, $P^{n}_{2j\,\text{інд}}$, subsets of software and hardware means for the realization of the algorithms of methods and models for the solution of the tasks of management integration, $P^{n}_{2j\,\text{інт}}$, which are necessary to use in the project of the *n*-th stage of the life circle of the ATO strategy as for the STP of the vehicle on the *j*-th time interval for the subsets $A^{n}_{2j\,\text{інд}}$ and $A^{n}_{2j\,\text{інт}}$ correspondingly:

$$A^{n}_{2j\,\text{інд}} \to P^{n}_{2j\,\text{інд}}\left\{p^{n}_{2j\,\text{інд}}: p^{n}_{2j\,\text{інд}} \in P^{n}_{2j\,\text{інд}},\, n=1,2,...,N;\; i=1,2,...,I;\; j=1,2,...,J\right\}, \quad (13)$$

$$A^{n}_{2j\,\text{інт}} \to P^{n}_{2j\,\text{інт}}\left\{p^{n}_{2j\,\text{інт}}: p^{n}_{2j\,\text{інт}} \in \mathrm{P}^{n}_{2j\,\text{інт}},\, n=1,2,...,N;\; i=1,2,...,I;\; j=1,2,...,J\right\}, \quad (14)$$

6) subsets of the results of the solution of the task of management individualisation, $R^{n}_{2j\,\text{інд}}$, and subsets of the results of the solution of the task of management integration, $R^{n}_{2j\,\text{інт}}$, which are necessary to use in the project of the *n*-th stage of the life circle of the ATO strategy as for the STP of the vehicle on the *j*-th time interval for the subsets $P^{n}_{2j\,\text{інд}}$ and $P^{n}_{2j\,\text{інт}}$ correspondingly:

$$P^{n}_{2j\,\text{інд}} \to R^{n}_{2j\,\text{інд}}\left\{r^{\text{n}}_{2j\,\text{інд}}: r^{n}_{2j\,\text{інд}} \in R^{n}_{2j\,\text{інд}},\, n=1,2,...,N;\; i=1,2,...,I;\; j=1,2,...,J\right\}, \quad (15)$$

$$P^{n}_{2j\,\text{інт}} \to R^{n}_{2j\,\text{інт}}\left\{r^{n}_{2j\,\text{інт}}: r^{n}_{2j\,\text{інт}} \in R^{n}_{2j\,\text{інт}},\, n=1,2,...,N;\; i=1,2,...,I;\; j=1,2,...,J\right\}, \quad (16)$$

Project management of regional partnership of ATO in STP vehicle parks may be described by the model, presented below (Fig. 1), following the system model of project management of strategies for the stages of their life circles of the development as projects.

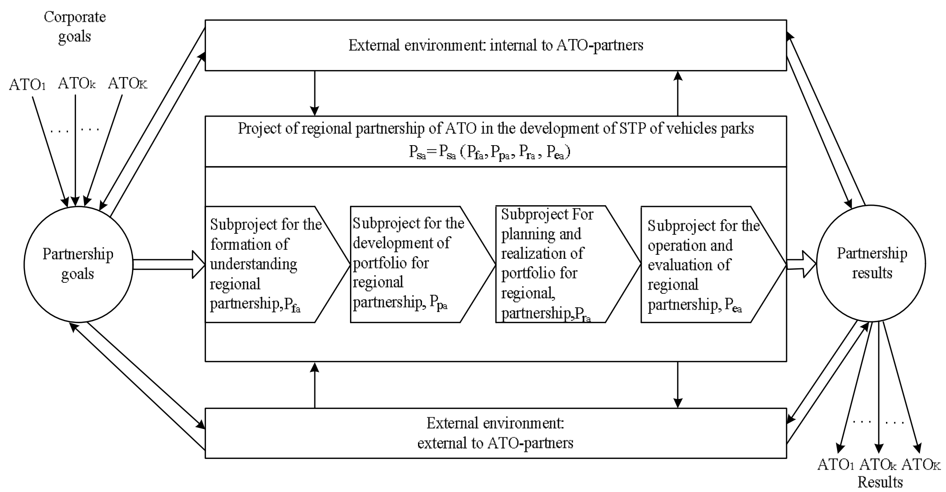

Fig. 1 – System model of the project management of the regional partnership of ATO on the development of STP of the vehicle parks.

The considered system model, which is of the descriptive character, may serve as a base, in particular in the part of goal setting and goal achievement, in conditions of creation and development of corporate systems for project management of the strategy for the ATO development as for the stages of its life circle, systems for projects management of regional partnership in the development of STP vehicle parks of ATO, which realize the corresponding business model of partnership etc.

4. Conclusions

On the base of the system model of project management in ATO strategies, as for the phases of the life circle of the latter as strategies, as well as using the theory of strategic management and organizational development, in particular in the part of goal formation of the organization, there had been suggested the system model, which describes the conditions for project management for the system of regional partnership of ATO in the development of STP vehicle parks, taking into account the principles of individualization and integration.

The base of this partnership system, as the innovational business model, is the assumption about the improvement of efficiency of mutual (centralized) performance of some functions, and/or works on technical preparation of vehicles on MTB of some ATO or mutual ordering these services with the other enterprises (on the base of outsourcing in relation to ATO-partners.

REFERENCES

Bilichenko V., *Goal Setting and Goal Attainment in the Models of Life Cycle of the Development Strategies of Automobile Transport Manufacturing Systems*. Bul. Inst. Politehnic, Iaşi, **LVIII (LXII)**, *4*, 77-83 (2012).

Haransson F.I., Snekota I., *No business is an Island: The Network Concept of Business Strategy*. Scandinavian J. of Manag., **3**, *5*, 187-200 (1989).

Minzberg G., Alstrond B., Lempel Dj., *Strategic Schools* (translated from Engl.). Under the edition of You. N. Kapturevskyi. SPb.: Piter, 2001, 211-336.

Pekar P.Jr., Allio R., *Maring Alliances Work: Guideline for Success*. Long-Range Planning, **4**, *27*, 54-65 (1994).

Pfeffer J., Salancik G.R., *The External Control of Organizations: A Resource Dependence Perspective*. Harper & Row, New York , 1978, 116-300.

Prahalad C.K., Hamel G., *The Core Competence of the Corporation*. Harvard Business Review, 1990, 79-91.

Vorkut T.A., *Designing of Systems of Transport Servicing in Sypplying Chains*. NTU, 2002, 8-248.

MANAGEMENTUL DE PROIECT AL SISTEMULUI PENTRU PARTENERIATUL REGIONAL AL ORGANIZĂRII TRANSPORTULUI AUTO ÎN DEZVOLTAREA UNUI SISTEM DE PREGĂRIRE TEHNICĂ A PARCURILOR AUTO

(Rezumat)

A fost dezvoltat un model de sistem pentru managementul proiectului, pentru strategia de dezvoltare pentru organizații tip transportator auto, urmărind fazele ciclului de viață, având la bază un model de afacere tip parteneriat regional al intreprinderilor de transport auto, pentru dezvoltarea unui sistem tehnic de întreținere în scopul creşterii eficienței unor funcții sau lucrări de întreținere a vehiculelor în baze tehnice comune de producție sau de comenzi comune către alți furnizori.

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EXPERIMENTAL DETERMINATION OF THE YIELD STRESS FOR ALUMINUM, Al_99.5

BY

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Abstract: The paper presents the determination of the yield stress for aluminum, Al_99.5, at standard ambient temperature, by means of upsetting of cilyndrical specimens. In order to determine the force-displacement dependency, it has been ascertained the allowable degree of deformation by compression testing, using a hydraulic press equipped with a data acquisition system, so that the determination of the resistance to deformation could be made within the cold deformability limits of this material. The outcomes achieved can be used in the process of cold volumic deformation of Al_99.5 taking into account the experimental conditions based on which they have been obtained.

Keywords: multiaxial forging; degree of deformation; yield stress; resistance to deformation.

1. Introduction

Manufacturing a part with the best possible mechanical properties by using multiaxial forging techniques, depends heavily on the mode of deformation and on the rigorous compliance with the value imposed to the degree of deformation (Semiatin *et* al., 1988; Comăneci *et al.*, 2006).

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The degree of deformation is a parameter which serves, in general, to define the magnitude of the deformation and hence it is used, in most cases, in the mathematical relationships that determine the deformation forces. Also, the degree of deformation provides information on the maximum deformation permitted in a single operation, and therefore it helps to establish the stages of the technological process of treatment (Bejinariu, 2008; Popa, 2013).

Resistance to deformation means the resistance opposed by the materials which undergo plastic processing through pressure. The more easily a metallic material will deform, the lesser its resistance to deformation will be. For having a smaller resistance to deformation one must create appropriate conditions, so that at the crystalline network level of the metallic material undergoing a deformation could be achieved a slight movement of the dislocations, regardless of their density and of the locks existing between dislocations (Azushima & Aoki, 2002).

Theoretical calculation of force and pressure of the multiaxial forging, and also the simulation of material flow in the process require good knowledge of the dependency relationship existing between the resistance to deformation and the degree of deformation, which represents the yield stress (Zaharia, 2001).

To determine the cold yield stress of Al_99.5 one has used the method of upsetting of cylindrical specimens, where high deformations can be achieved under uniaxial stress.

2. Experimental Conditions

Material. Aluminium with the purity of 99.5%, having the chemical composition, obtain at University POLITEHNICA of Bucharest Laboratory Spectral and Chemical Analysis and Biocompatibility from the Faculty of Material Science and Engineering, set out in Table 1.

Tabel 1

The Chemical Composition of the Material Used for the Calculation of the Yield Stress

Element	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ni	Ti
Percentage	0.143	0.213	0.021	0.004	0.050	0.003	0.021	0.008	0.006

Element	Pb	Sn	B	Ca	Co	V	Na	P	Al
Percentage	0.005	0.011	0.000	0.003	0.002	0.011	0.004	0.000	99.495

Specimen. There have been used cylindrical test specimens with a diameter of 10 mm and a height of 15 mm, thus with a dimensional factor of $h_0/d_0 = 1.5$.

Preparation of test specimens. To determine the yield stress, the preparation of test specimens included turning and grinding operations.

Equipment and machinery. For deformation it has been used the hydraulic press Hydramold 750 kN, Made in Romania.

In order to determine the upsetting force it has been used a dynamic data acquisition system consisting of fully equipped master unit, force transducer of 1,000 kN and long stroke displacement transducer of 0...100 mm.

The master unit is a Traveller System 1, model MUT-1, type 1016-S (Fig. 1), with the following main elements:

a) 8 channels strain gauge amplifier, type SG-2 with 1 kHz bandwidth;

b) 4 channels Opto-Isolated Digital Input, with the possibility of clock and external trigger;

c) 8 channels direct analog input of high signal;

d) power from battery chargers of 12 (24) V_{cc} or from the power supply included 220 Vca/12 (24) V_{cc};

e) sampling frequency max. 100,000 Hz;

f) software package Model EST-1 Basic for Windows;

g) PC connectivity via USB interface;

h) full set of pair connectors and interconnection cables.

Fig. 1 – System Traveller 1, model MUT-1 type 1016-S.

The device allows both calibration of the transducers used and acquisition of data delivered from them through the E.S.A.M. software (Electronic Signal Acquisition Module), version 3.0, at a rate of up to 100,000 acquisitions per second.

3. Experimental Results

Before the test itself for determining the dependency between force and displacement, it has been ascertained the allowable plastic deformation of Al_99.5, using compression test on the same device (Fig. 2), so that the determination of the resistance to deformation should be made within the cold deformability limits of this material.

The experimental results are presented in Table 2, wherefrom it is inferred that Al_99.5% retains its integrity up to a degree of deformity of ε_{adm} = = 80% which represents the allowable degree of plastic deformation.

Fig. 2 – General view of the instalation for the determination of the yield stress: 1 – press; 2 – hydraulic unit; 3 – load cell; 4 – displacement transducer; 5 – notebook; 6 –Traveller System 1.

Table 2

Plastic Deformation Allowable Degree of Aluminium with the Purity of 99.5 %

No.	Dimensions, [mm]				Degree of deformation, ε, [%]	Cracks occurance
	Initial		Final			
	h_0	d_0	h_1	d_1		
1.			15.00	10	0	No
2.			13.50	10.54	10	No
3.			12.00	11.18	20	No
4.			10.50	11.95	30	No
5.	15	10	9.00	12.90	40	No
6.			7.50	14.14	50	No
7.			6.00	15.81	60	No
8.			4.50	18.25	70	No
9.			3.00	22.36	80	No
10.			1.50	31.62	90	Yes

Processing of the experimental results is shown in Table 3, wherein: h is the current height of the specimen, determined as the difference between the original (initial) height of the specimen and the stroke of operation (movement); ε – conventional degree of deformation, calculated as follows:

$$\varepsilon = \frac{h_0 - h}{h_0} \cdot 100, [\%];$$

φ – actual degree of deformation, calculated with the formula:

$$\phi = \left(\ln \frac{h_0}{h}\right) \cdot 100,\ [\%];$$

F – force of deformation, acquired in the process; d – current diameter of the specimen, calculated with the formula:

$$d = d_0 \sqrt{\frac{h_0}{h}}\ ,\ [\text{mm}];$$

S – front surface of the specimen; m = 1+ $\mu d/3h$ – coefficient of friction, where μ is 0.17 for Aluminium (Popa, 2013); σ = F/mS – material's resistance to deformation, [daN/mm^2].

Table 3
Experimental Values of the Force and Tension to the Compression Testing of the Cylindrical Specimens Made of Aluminum with the Purity of 99.5%

No.	h mm	ε %	φ %	F kN	d mm	S mm^2	m	σ daN/mm^2	σ MPa
1	15.00	0.00	0.00	0.00	10.00	79	1.04	0.00	0.00
2	14.92	0.53	0.53	0.51	10.03	79	1.04	0.62	6.22
3	14.47	3.53	3.60	17.83	10.18	81	1.04	21.06	210.61
4	14.32	4.53	4.64	22.19	10.23	82	1.04	25.92	259.23
5	13.71	8.60	8.99	26.29	10.46	86	1.04	29.33	293.28
6	13.41	10.60	11.20	26.29	10.58	88	1.04	28.65	286.46
7	13.03	13.13	14.08	27.25	10.73	90	1.05	28.80	287.96
8	12.72	15.20	16.49	29.11	10.86	93	1.05	29.98	299.81
9	11.89	20.73	23.24	31.04	11.23	99	1.05	29.74	297.36
10	10.83	27.80	32.57	33.86	11.77	109	1.06	29.32	293.22
11	10.38	30.80	36.82	34.76	12.02	113	1.07	28.74	287.41
12	9.92	33.87	41.35	36.68	12.30	119	1.07	28.86	288.60
13	9.55	36.33	45.15	37.58	12.53	123	1.07	28.36	283.56
14	9.16	38.93	49.32	38.54	12.80	129	1.08	27.77	277.68
15	9.09	39.40	50.09	39.50	12.85	130	1.08	28.22	282.19
16	8.86	40.93	52.65	41.11	13.01	133	1.08	28.54	285.43
17	8.56	42.93	56.10	41.36	13.24	138	1.09	27.63	276.31
18	8.33	44.47	58.82	44.18	13.42	141	1.09	28.63	286.26
19	8.10	46.00	61.62	45.08	13.61	145	1.10	28.30	283.01
20	7.80	48.00	65.39	47.01	13.87	151	1.10	28.28	282.77
21	7.58	49.47	68.25	47.90	14.07	155	1.11	27.89	278.87
22	7.27	51.53	72.43	49.83	14.36	162	1.11	27.65	276.55
23	6.82	54.53	78.82	52.65	14.83	173	1.12	27.14	271.36
24	6.59	56.07	82.25	54.51	15.09	179	1.13	26.99	269.91
25	6.28	58.13	87.07	57.33	15.45	188	1.14	26.82	268.21
26	6.06	59.60	90.63	59.19	15.73	194	1.15	26.54	265.43
27	5.83	61.13	94.50	61.11	16.04	202	1.16	26.16	261.63
28	5.61	62.60	98.35	65.79	16.35	210	1.17	26.89	268.88

Table 3 (*Continuation*)

No.	*h* mm	*ε* %	*φ* %	*F* kN	*d* mm	*S* mm^2	*m*	*σ* daN/mm^2	*σ* MPa
29	5.07	66.20	108.47	74.26	17.20	232	1.19	26.81	268.06
30	4.54	69.73	119.51	86.44	18.18	259	1.23	27.15	271.52
31	4.31	71.27	124.71	94.91	18.66	273	1.25	27.88	278.84
32	3.56	76.27	143.83	124.09	20.53	331	1.33	28.26	282.64
33	3.26	78.27	152.63	139.09	21.45	361	1.37	28.04	280.36
34	3.03	79.80	159.95	155.06	22.25	389	1.42	28.16	281.63
35	2.80	81.33	167.84	180.45	23.15	421	1.47	29.21	292.08

Based on the results in Table 2 it has been determined the yield stress of aluminium with the purity of 99.5%, as shown in Fig. 3.

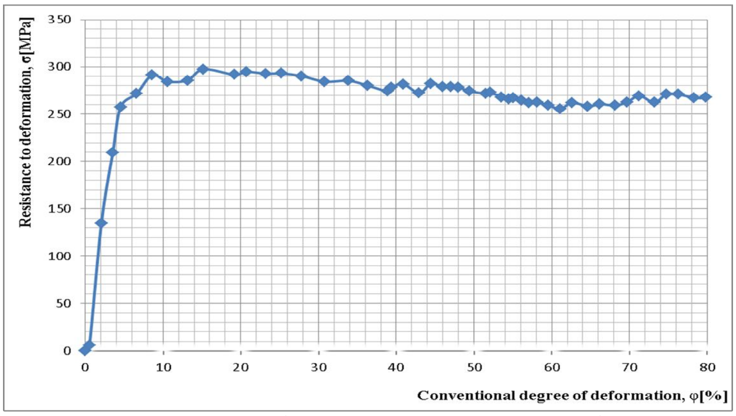

Fig. 3 – Yield stress of aluminium with the purity of 99.5 %.

Fig. 4 represents a simplified yield stress of aluminum with the purity of 99.5%, consisting of 7 items and being used for simulation programs.

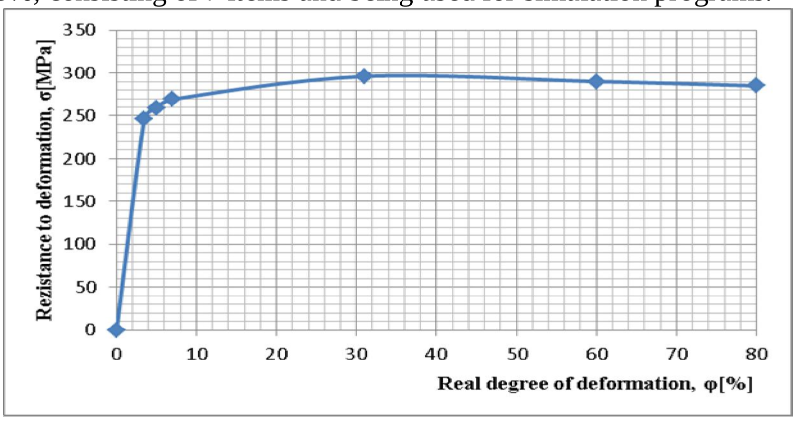

Fig. 4 – Simplified Yield stress of aluminum with the purity of 99.5%.

4. Conclusions

Studying the yield stress one can note that, at the beginning of the deformation, ε = 0…3.53%, the deformation resistance rate increases due to a strong hardening of the material, after which the curve flattens, and towards the end of the deformation, the deformation resistance rate decreases slightly.

The outcomes achieved can be used in the process of cold volumic deformation of Al_99.5 taking into account the experimental conditions based on which they have been obtained.

The simplified yield stress can be used in deformation simulation programs of Al_99.5.

REFERENCES

Azushima A., Aoki K., *Properties of Ultrafine-grained Steel by Repeated Shear Deformation of Side Extrusion Process.* Materials Sci. a. Engng., **A 377**, *1-2*, 45–49 (2002).

Bejinariu C., *Indirect Cold Extrusion of Steels*. Revised and Added Second Edition, Tehnopress Publ., Iaşi, 2008.

Comăneci R., Chelariu R., Zaharia L., *Obtaining Nanostructured Materials by Severe Plastic Deformation*, 2006.

Popa I., *Advanced Multifunctional Materials with Ultrafine/Nanometric Grain Size Obtained through the Application of Severe Plastic Deformation.* Braşov, 2013.

Semiatin S.L. *et al*., *Metals Handbook*. Ninth Edition, **14**, *Forming and Forging*, ASM Internat., Metals Park, Ohio (1988).

Zaharia L., *The Theory of Plastic Deformation.* „Gh. Asachi" Publ. (2001).

DETERMINAREA EXPERIMENTALĂ A CURBEI DE CURGERE A ALUMINIULUI, Al_99.5

(Rezumat)

Se prezintă determinarea curbei de curgere, la temperatura standard a mediului ambiant a aluminiului, Al_99.5, prin metoda refulării epruvetelor cilindrice. În vederea determinării dependenței forță–deplasare, s-a determinat gradul admisibil de deformare utilizând încercarea prin compresiune folosind o presă hidraulică echipată cu un sistem de achiziție de date, pentru ca determinarea rezistenței la deformare să se facă în limitele deformabilității la rece a acestui material. Rezultatele obținute pot fi utilizate în procesele de deformare volumică la rece a Al_99.5 ținându-se seama de condițiile experimentale în care au fost obținute.

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WORK ACCIDENTS WITH OCULAR AFFECTIONS

BY

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Abstract: This paper presents Romanians law specifications about eyes protection, personal protective equipments and some eyes damages caused by ignorance of protective equipment.

Keywords: legislation; eyes personal protective equipments; eyes trauma.

1. Introduction

According to the Romanian and European legislation, the employer has the responsibility to assess the risks at the work place and provide free personal protective equipment necessary to protect workers. Directives 89/391/EEC on measures to promote the safety and health of workers, 89/686/EEC on personal protective equipment, 89/656/EEC concerning the minimum safety and health requirements for the use by workers of personal protective equipment, set by European Commission, the European standard EN 166:2001 on eyes protection, Law 319/2006 on safety and health, HG 1048/2006 concerning the minimum safety and health requirements for the use by workers of personal protective equipment at work and HG 1028/2006 concerning the minimum safety and health on the use of display screen equipments, the essential requirements governing the use and security of personal protective equipment and conditions for bringing on the market.

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All personal protective equipment must meet the following conditions:

a) to be appropriate for the risks involved, without leading itself to an increased risk;

b) to correspond to existing conditions at work;

c) to take into account the ergonomic requirements and the worker's health status;

d) to fit the wearer correctly after any necessary adjustments.

For the protection of the eyes and face, workers must use the following personal protective equipment:

a) glasses with arms;

b) eyewear mask against X-radiations, laser radiation, ultraviolet radiation, infrared radiation;

c) face shields (visors);

d) masks and helmets for arc welding (hand masks, headband masks or masks that can be mounted on helmets).

The lenses used to produce glasses must have good optical clarity, because a user can use the product without fatigue or reduced quality of vision and have a high level of protection from mechanical impact on the lens.

Wearing personal protective equipment or wearing them incorrectly can lead to accidents at work. After evaluating workstations hazard to workers, the employer should signal danger areas and train the employees on the recommended personal protective equipment, when and how to use.

To avoid accidents, workers must comply with work instructions and procedures established in accordance with occupational safety and wear full and fair protective and work equipment received.

2. Eye Trauma

Ocular trauma is an important risk for a large number of industrial or household activities. Their incidence in the literature ranges from 3 to 65 per 100,000 populations per year, depending on the country where the study was conducted and the severity of lesions studied.

Over 80% of affected patients are young men with an average age of 30 years. In the United States, the proportion of eye trauma related to work (of all eye injuries) decreased from 28% in 1989 to 12% in 2005. This decrease is attributed on one hand on the availability of adequate eye protection laws that require the wearing of protective equipment, and secondly on the reducing numbers of workers in the industry.

In our country, reporting accidents is likely underestimated; some patients stated that trauma occurred at home. However, the medical and socioeconomic problem remains serious, the accidents causing suffering to the person and the family, often they need hospitalization and sick leave and sometimes disability.

Corneal foreign bodies are the most common type of eye injury occurred at work. At the Ophthalmology Clinic from the Hospital of St. Spiridon in Iasi, are presented several times a day, patients with this kind of trauma, over 1,000 visits per year**!**

The circumstances of injury are usually related to the using of fixed or portable grinder without using glasses - some patients consider that eyeglasses would provide protection for grinding, which is not real!

Foreign bodies are actually small incandescent metal fragments ("sparks" that occur during grinding) or tiny fragments detached from stone grinder at work.

The patient will experience pain eye and will present to the hospital for checkup (although sometimes the presentation is delayed a few days). Treatment consists of removal of the foreign body, ocular antibiotics and dressings. Healing is minimal sequel in most cases, patients often continue to ignore eye protection and be repeatedly presented to the hospital with similar problems.

There is a risk that an injury neglected to get complicated with corneal infection or eye infection, with important consequences for visual prognosis.

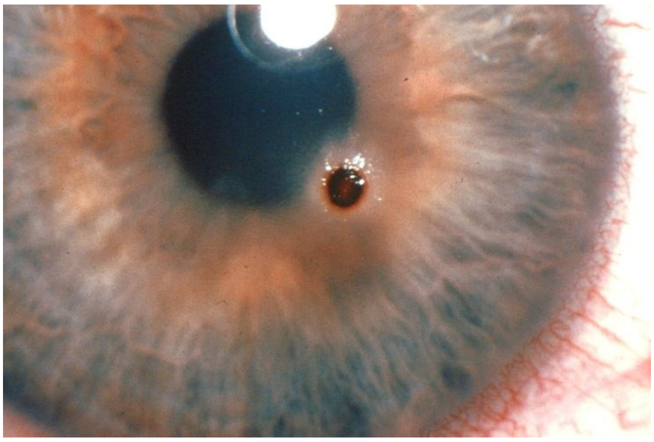
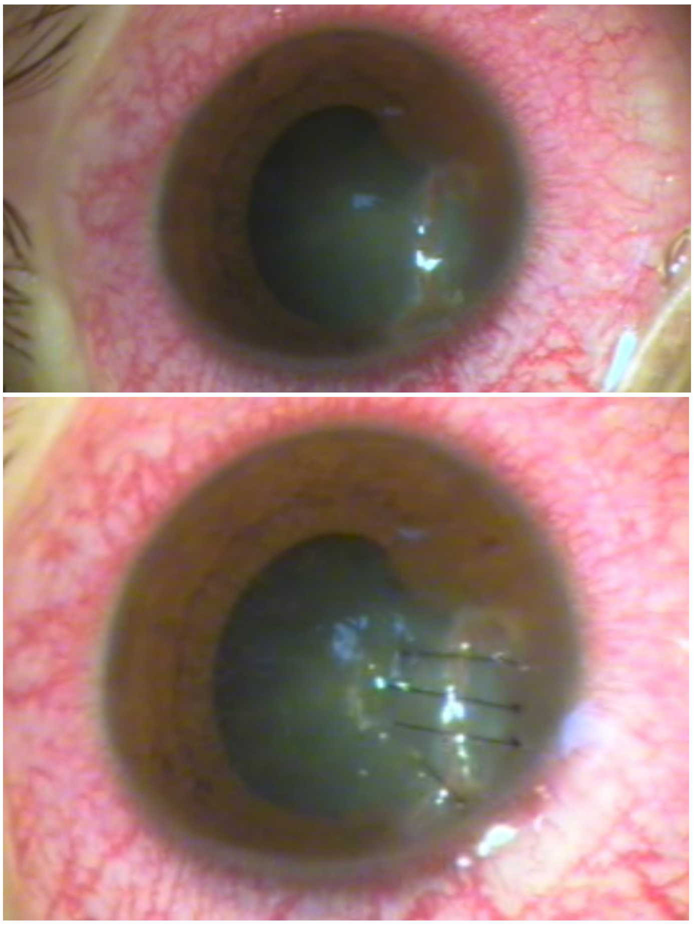


Fig.1 – Corneal foreign body.

Ophthalmic electric arc (the welder's fotokeratit) is occurring after 6…10 h, to the welder that welds without wearing protective equipment: screen, hand or head mask with filters with appropriate protection ("caught the flame"). Although the patient feels discomfort/important pain, healing is usually without sequel, so some people use to repeat this reckless behavior.

Plagues eye injuries are major injuries caused by sharp objects (*e.g.* knife blade or screwdriver used as levers, breaking and throwing of metal springs, wires, nails, etc.) Outstanding are injuries caused by a broken piece of stone grinder, which causes severe facial and eye injuries.



a

b

Fig. 2 – *a* – Wound and traumatic cataract eye caused by a nail;
b – appearance after suturing the wound (Dr. C. Danielescu personal archive).

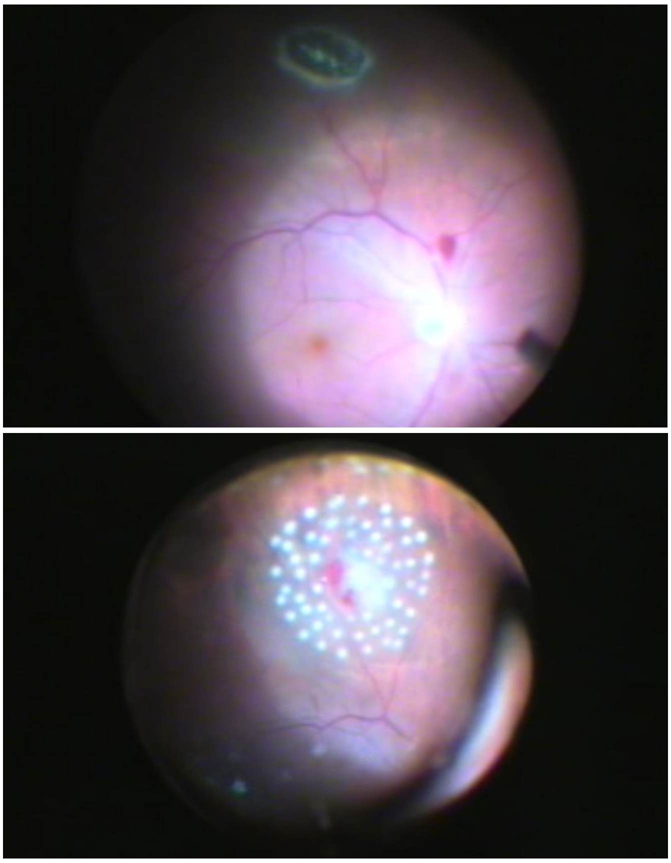
The person immediately complains of pain and significant sight reduction. The plagues can be followed by cataract (clouding of the lens), retinal detachment, and intraocular infection with the risk of severe functional and anatomical loss of the eye.

Treatment consists in emergency surgery, followed by the variable term hospitalization. In the future, the patient may require further intervention (*e.g*. Implantation of artificial lens) and long-term sick leave. Currently, patients can enjoy full or partial rehabilitation in a large percentage of these severe injuries.

Intraocular foreign bodies may typically result from hammering actions (on metal, stone, tile, etc.), where there can be thrower with great speed small and sharp pieces. Although the lathe metal cutting is often cited as a cause of foreign bodies throwing, in practice this circumstance is rare, (possibly due to a more effective protection of skilled workers in jobs better organized, but perhaps by reducing the level of industrial activity in Moldavia).

Besides input lesion, actually a plague in the anterior segment of the eye with/without traumatic cataract, these floaters will generally produce lesions in the posterior segment of the eye (retina). Surgery is laborious. It is practiced the suturing of the wound, foreign body extraction, intraocular repair other damage, possibly artificial lens implantation.

From the author's experience, a number of 18 intraocular foreign bodies operating in the last 2 years, 16 eyes achieved a final visual acuity greater than 10% (considered good end result, functional eye).



a

b

Fig. 3 – *a* – Metallic foreign body in the retina; *b* – appearance at the end of surgery, after foreign body extraction and application of laser impacts perilesional (Dr. C. Danielescu personal archive).

In conclusion, workplace eye injuries are a major source of ocular morbidity. Modern surgery can provide rehabilitation in a significant percentage of cases, but insists that prevention should be paramount. We hope that this review from the point of view of the ophthalmologist will serve as a warning signal in order to enhance the education and training of eye protection for workers.

ACCIDENTE DE MUNCĂ CU AFECTARE OCULARĂ

(Rezumat)

Se prezintă legislația românească şi europeană în domeniul protecției vederii lucrătorilor şi echipamentele de protecție recomandate. Sunt trecute în revistă afecțiunile oculare provocate de nepurtarea de către lucrători a echipamentelor individuale de protecție a ochilor în timpul lucrului.

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USE OF INOCULATED PIG IRON FOR INOCULATED CAST IRON MANUFACTURE

BY

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Abstract: Use of inoculated pig iron for inoculated cast iron manufacture is with reference for remanent graphite in liquid metallic matrix which, when heating rate of the metallic bath is great, has a little dissolving rate. When metallic matrix of inoculated pig iron is steel, it must great temperature for manufacturing – this methods is uneconomical. If metallic matrix of inoculated pig iron is iron, nodular graphite iron manufacture needs superheating temperature not so high, so manufacture being economical.

Keywords: nodular graphite; graphite dissolving; metallic matrix.

1. Introduction

Inoculated pig iron, such as pig iron with nodular graphite, is used in practice, in the manufacture aggregates charge (Cojocaru-Filipiuc, 2006; Cojocaru-Filipiuc & Cimpoeşu, 2010). According to SR EN 10.001 for instance, casting pig iron has been standardized, marked Pig-Nod, which is actually a cast iron with nodular graphite containing 3.5…4.6%C, max. 3%Si, max. 0.1%Mn, max. 0.08%P, max. 0.03%S, 0.03% other elements and Fe for the rest.

Nodular graphite scrap iron found in scrap castings is equivalent to pig iron with nodular graphite.

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Nodular graphite pig iron is used in the rough cast state, without any thermal treatment.

Nodular graphite scrap iron was subjected to various thermal treatments, which means that the metallic matrix may contain both metallographic equilibrium constituents and metallographic constituents outside the thermodynamic equilibrium.

The structure of the metallic matrix of nodular graphite pig iron depends on the nature of the metallic matrix at the time of graphite nodule completion.

If the metallic matrix is a hypereutectoid steel, the metallic matrix is perlitic, and the perlite grains are included either in a secondary cementite network, or in a Widmannstäten secondary cementite network, with Widmannstäten cementite formations embedded in them, depending on case (Sofroni, 1975; Ripoşan & Sofroni, 1984; Cojocaru-Filipiuc, 2005, 2007). Nodular graphite is shown in Fig. 1 *a*.

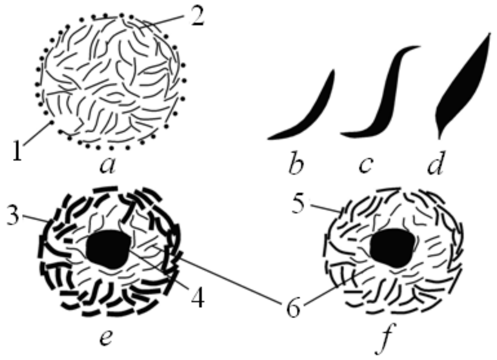

Fig. 1 − Graphite shapes in a nodular graphite pig iron: *a* – nodule formed in the liquid metallic matrix at temperatures higher than the liquidus line temperature; 1 – atoms of inoculating chemical elements or surface-active chemical elements; 2 – big graphite single crystals; *b* – eutectic flaky graphite; *c* – eutectic, secondary and tertiary flaky graphite; *d* – eutectic, secondary, eutectoid and tertiary flaky graphite; *e* – graphite nodule formed around a non-metallic inclusion; 3 – eutectic, secondary, eutectoid and tertiary graphite single crystals; 4 – non-metallic inclusion based on inoculating chemical element, with compact crystallographic lattice, for example; 5 – eutectic, secondary and tertiary graphite single crystals; 6 – small graphite single crystals.

For instance, nodular graphite looks as shown in Fig. 1 *a*, with its version e) or d) if the metallic matrix is ferritic, and as shown in Fig. 1 *a*, with its version *f* or *c*, if the metallic matrix is perlitic. The graphite shown in version *b* is eutectic flaky graphite. Version *c* bore version *b* increase with secondary graphite, and version *d* bore version *b* increase with secondary and eutectoid graphite (tertiary graphite was ignored). Fig. 1 shows the result of secondary graphite separation over the graphite nodule formed around certain non-metallic inclusions, and of secondary and eutectoid graphite separation over the graphite nodule formed around a non-metallic inclusion.

Anterior structure analysis occurs in unalloyed pig irons.

In nodular graphite scrap cast iron for instance, the metallic matrix may be very different, especially if the nodular graphite scrap cast iron is alloyed, due to the metallographic constituents resulted from the complex secondary thermal treatments and also due to the radical change of the shape of the Fe-C equilibrium diagram, which leads to very different metallic matrices.

If the metallic matrix is a steel, Fig. 1 *a*, at ambient temperature, all the graphite nodules have atoms of inoculating agent or surface-active elements, respectively, on the outside, and graphite 2 single crystals on the inside.

When nodular graphite pig irons are in the furnace for melting, their structural transformations occur in the reverse order of those occurring during the cooling.

The steel metallic matrix is suitable, since the graphite nodules take a long time to dissolve in the liquid metallic matrix when the heating temperature exceeds the solidus line temperature due to the adsorbed atoms mentioned above. Should there be areas on the surface of the nodules that lack those adsorbed atoms, the nodule dissolution phenomenon in the liquid metallic matrix is advanced. Actually, the higher the temperature against the liquidus line temperature, the more intense the dissolution process (Cojocaru-Filipiuc, 2005).

If the nodular graphite pig iron has graphite nodules formed around the non-metallic inclusions and flaky graphite, as the case may be, their dissolution occurs at higher rates.

As concerns steel-based metallic matrices, very high temperatures are required in order to achieve high liquid state overheating temperatures. From this point of view, nodular graphite pig iron with steel matrix is not recommended in the manufacture aggregate charge. Actually, if the metallic matrix is that of steel, nodular graphite pig iron should be called nodular graphite crude steel.

For practical reasons, nodular graphite pig iron should actually be pig iron, *i.e.* its metallic matrix should be that of hypoeutectic iron. According to SR EN 10.001, nodular graphite pig iron should have high contents of both carbon (3.5…4.6%) and silicon (max. 4%) precisely in order for the metallic matrix to be that of hypoeutectic iron, even with a lower degree of hypoeutecticity.

When the metallic matrix is that of hypoeutectic iron, at ambient temperature, the graphite nodules may be those shown in Fig. 1 *a*, in all the cases and to a large extent, formed in the liquid metallic matrix at temperatures higher than the liquidus line temperature, but also as shown in Fig. 1 *e*, where the solid metallic matrix is ferritic, or as in Fig. 1 *f*, where the solid metallic matrix is perlitic, for instance, and as in Figs. 1 *b*, *c* and *d*, as the case may be, (case *b*) applies when the solid metallic matrix is outside equilibrium, case *c* applies when the solid metallic matrix is perlitic and case *d* applies when the solid metallic matrix is ferritic, for instance. Fig. 1 *e* shows graphite nodules formed around a non-metallic inclusion mainly based on an inoculating chemical element, at eutectic temperature, where it is more likely for chemical compounds to form with the crystallographic lattice (*i.e.* there is enough time for this phenomenon to occur). One may also notice that the graphite single crystals on the graphite nodule surface are longer and thicker due to the amounts of secondary, eutectoid and tertiary graphite. The graphite single crystals, 6, around the non-metallic inclusions, 4), have the shape of the non-metallic inclusion curve, 4), whereas the graphite single crystals 2) have the shape of the inoculating agent bubble or drop curves.

When the pig iron is heated in the furnace, the tertiary graphite dissolves up to the eutectoid temperature, the eutectoid graphite, if any, dissolves at the eutectoid temperature, the secondary graphite dissolves between the eutectoid and eutectic temperatures, whereas the eutectic graphite dissolves at the eutectic temperature, at low heating rates. If the heating rate is higher, graphite dissolution will enjoy higher inertia in both the solid and the liquid metallic matrices. Therefore, if the metallic charge is made up of nodular graphite pig iron, high heating rates are required for its melting, since high heating rates turn all categories of graphite into genuine remanent graphite, which makes it possible to manufacture second fusion nodular graphite cast iron.

The analysis conducted on nodular graphite pig iron also applies to nodular graphite cast iron scraps.

2. Conclusions

1. Nodular graphite pig iron is like nodular graphite scrap iron.

2. Structure of the metallic matrix of nodular graphite pig iron depends on the nature of the metallic matrix at the time of graphite nodule completion.

3. As concerns steel-based metallic matrix, very high temperatures are required in order to achieve high liquid state overheating temperatures.

4. Nodular graphite pig iron should actually be pig iron, *i.e.* its metallic matrix should be that of hypoeutectic iron.

REFERENCES

Cojocaru-Filipiuc V., Cimpoeşu N., *Elaborarea fontei, asistată de calculator, în cuptoare electrice cu încălzire prin inducție, în creuzet, acide*. Edit. Universitas XXI, Iaşi, 2010.

Cojocaru-Filipiuc V., *Fonte, aspecte teoretico-practice ale obținerii*. Edit. „Samia”, Iaşi, 2005.

Cojocaru-Filipiuc V., *Nodulizarea grafitului în fonte − aspecte teoretice*. Edit. „Politehnium", Iaşi, 2007.
Cojocaru-Filipiuc V., *Obținerea oțelului şi aspecte structurale ale aliajelor feroase*. Edit. "Samia", Iaşi, 2005.
Cojocaru-Filipiuc V., *Pregătirea încărcăturii pentru elaborarea fontei în cuptoare cu inducție*. Edit. "Samia", Iaşi , 2006.
Ripoşan I., Sofroni L., *Fonta cu grafit vermicular*. Edit. Tehnică, Bucureşti, 1984.
Sofroni L., *Elaborarea şi turnarea aliajelor. Fonte. Oțeluri. Aliaje neferoase*. Edit. Didactică şi Pedagogică, Bucureşti, 1975.

UTILIZAREA FONTEI BRUTE MODIFICATE PENTRU ELABORAREA FONTEI CU GRAFIT NODULAR

(Rezumat)

Utilizarea fontei brute modificate cu grafit nodular pentru elaborarea fontei cu grafit nodular face referință la grafitul remanent din matricea metalică lichidă care, atunci când viteza de încălzire a băii metalice este mare, are o viteză de dizolvare mică. Atunci când matricea metalică a fontei brute cu grafit nodular este de oțel, trebuie o temperatură mare pentru elaborare – această metodă este neeconomicoasă. Dacă matricea metalică a fontei brute cu grafit nodular este de fontă, elaborarea fontei cu grafit nodular are nevoie de o temperatură de supraîncălzire nu prea mare, aşa, elaborarea fiind economicoasă.

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THE MANAGEMENT OF PSYCHOSOCIAL FACTORS – MITIGATION TOOLS

BY

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Abstract: Psychosocial factors emerge through the interaction of psychological and social factors within a work system. The work system can be seen as an open, flexible and dynamic system within which external psychosocial factors trigger the interaction of the constitutive elements of the work system. In addition to financial performance, many companies have integrated in their development strategy social and ecological policies generically called management of corporate social responsibility (CSR). Its implementation occurs on the basis of an Ethical Behavior Code which showcases the values, the responsibilities and the obligations of the company with regard to: People working for the company (employees, suppliers, customers), Relationship with the local community, Care for the environment. By defining institutional relations with the employees, the company puts in place policies meant to diminish the negative influence of social factors while in external relations a positive image of the company takes shape, which can also contribute to reducing the impact of psychosocial factors on the employees. ISO 26000 standards provide the necessary conditions for the implementation and achievement of CSR.

Keywords: psychosocial factors; Corporate Social Responsibility ISO 26000.

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1. Introduction

The psychosocial factors emerge through the interaction of psychological and social factors within a work system. In general, the negative action of these factors is manifested by an act of rejection or of refusal at the workplace. In such a situation, the individual psyche cannot adapt to the social factors, altough in some cases it is the latter that are adverse to the individual. Within the work system the employee positions himself in relation to the work environment according to his goals, motives and actions. In his turn, the employer seeks to provide an optimal representation of the company's organizational climate by means of: motivation, job satisfaction and overall professional relationships. If the employee's attitude towards the organization overlaps entirely with the organizational framework created by the employer, then, at least in the current parametres, *i.e.*, stress being the most significant psychosocial factor, this may have a reduced negative influence. Otherwise, the negative effects can cause disruptions in the company's activity and bring about undesirable economic consequences. By analyzing various instances of "stress", one can conclude that the employee's attitude is influenced by:

a) the negative effects on one's general state of health and on one's psychological wellbeing in particular;

b) the psychological wellbeing, which highlights the subjective side of the employee, is difficult to assess and, should the need arise, treat, something that may scare and cause panic in the employee;

c) the employee's perception of the employer's behavior as inadequate leads to divergent views concerning the representations of psychosocial risks;

d) overall, this may lead to a lack of communication which impacts negatively on the activity of the company and the rest of the employees.

Psychosocial disorders (stress, violence, etc.) occur when there is an imbalance in the work system, generically made up of "*man*" and "*work environment*". This imbalance leads to impaired physical and mental health with multiple repercussions. In this context, the notion of risk must be understood as a likelihood of psychosocial disturbances generated by the professional environment in which the employee operates. Psychosocial disorders come into play both at the level of the individual and of his entourage, taking varied, often misleading forms. Psychosocial disorders occurring in professional and individual environments, against the backdrop of individual psychosomatic characteristics, are rather hard to distinguish. That is why resolving them is difficult and more often than not they have to be construed as interdependence and causality phenomena. It is in this sense that one should consider a new cumulative factor, viz. stress, resulting from the coexistence of two terms: "*personal - professional", "individual - collective", "subject - object*" in the definition of psychosocial risks.

2. Psychosocial Factors Characteristic of the Workplace

In the context outlined above the main psychosocial factors generating stress are:

A. Stress – *an essential attribute of our lives that involves a constant fluctuation between "adaptation - inadequacy"* (Baba, 1993). Stress can describe very different situations, having causes and effects, defining health, implying individual moods and feelings, explaining tense situations at work.

The European Agency for SSM defines stress as: *A state of stress occurs when there is an imbalance between the perception that a person has vis-à-vis the constraints imposed by the environment in which he operates and the perception that he has of his own resources to deal with constraints* (Brişcaru, 2012).

Personal stress phenomena should be analyzed together with professional stress phenomena because their cumulative effects affect the quality of life at work. A realistic approach should accept the existence of mutual influences between the personal and the professional. It is very unlikely that upon reaching the workplace an employee can actually "dispose" of personal stress altogether. Consequently, stress *has an individual, multifactor and cumulative character due to the overlap between the private and the professional sphere*.

Looking at the stress levels experienced by an employee at work, we should detect its highly *individual* character, visible in all its *physical*, *psychological* and *social* dimensions. The key factors of stress as well as its effects can be either individual or collective in nature, bearing the clear imprint of the specific work conditions and organization of work.

When defining stress one has to identify: the *symptoms* by means of which it manifests itself, the work system-specific *determinant factors* (organization of work and horizontal relations of subordination, importance of work relations), and the *effects* (damage to health, possible accidents at work, violent forms of expression) in terms of the *alteration of the activity*.

B. Harassment at the workplace may occur as:

a) *verbal* and *sexual harassment*, which refers to two instances of internal violence that differ from each other and come under distinct legal jurisdiction;

b) *psychological bullying* can be generated by the "confusion" caused by organizational and managerial dysfunctions in the work system.

Various forms of harassment may occur on the basis of *race, nationality, ethnicity, language, religion,* etc., which leads to creating an intimidating, hostile, degrading or offensive work environment.

C. Violence at the workplace may have different modes of expression:

a) *physical*: aggression, coercion, etc.

b) *psychological*: domination, humiliation, persecution, etc.

Violence may occur externally (aggression on the employee from clients) or internally (relations between colleagues, between groups) at all job levels.

D. Suffering at the workplace is frequently to do with the causality that exists between various psychosocial risks (stress and violence).

E. Burnout is a syndrome caused by "*physical and emotional exhaustion*" resulting in negative attitudes at work and loss of interest in the work.

3. Stress - Effect of Psychosocial Factors

The effects of professional psychosocial factors are "cumulated" with individual psychosocial factors and jointly give birth to psychosocial risks. A general presentation of psychosocial factors at the workplace makes possible an analysis of the phenomena they generate through "*aggregation*" with individual psychosocial factors. Looking into the psychosocial risks that impact the *performer* directly, we will observe that the latter receives from the exterior, sometimes continuously, various *information* that may cause dimensional changes in the work system. Different reactions of the *performer* can cause unwanted events, generically represented as "*human error*". This can be an appropriate way of approaching work-related stress (Framework Agreement signed in 2004 by European social partners). While acknowledging professional stress as a factor in the daily activity of the performer, one must also admit the existence of stress beyond the workplace (individual stress), a situation that leads to the existence of *cumulative stress*. Subjected to cumulative stress, the performer will every now and then manifest himself through unpredictable actions, being a permanent source of what we commonly label "human error" (Brişcaru, 2012). Cumulative stress is hard to quantify, track or diagnose, even medically. In a dimensional assessment, we cannot say that cumulative stress is the arithmetic sum of its parts, nor that cumulative stress would be represented as a linear equation, etc.

With regard to the possibility of intervening on stress, it cannot be stated that by "reducing" psychosocial risks we would eliminate stress at the workplace and therefore diminish the action of human error.

At macro level one can well admit the existence of subordination between: work place–company–external social environment, thus establishing two levels of overlap relations (Fig. 1).

It follows that the effect of psychosocial factors tends to reach maximum intensity at the workplace as a result of the cumulative effect created by the two successive levels.

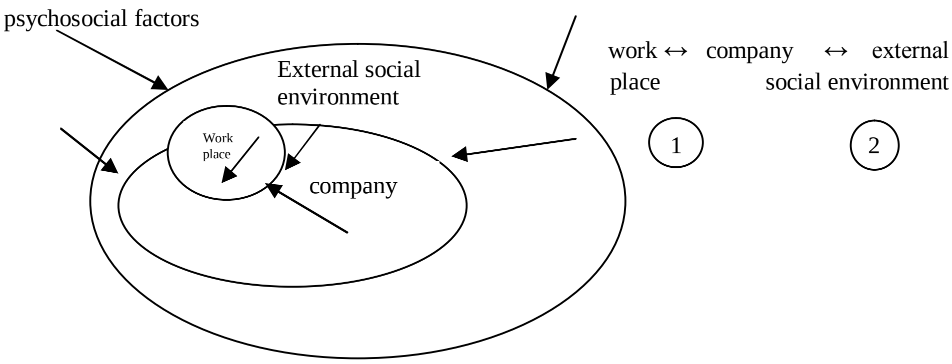

Fig 1 – The effect of psychosocial factors.

As such, cumulative stress at the workplace has the following components:

a) workplace specific stress generated by equipment, work load, nature of task and work environment;

b) stress generated by the specific activities carried out in the company;

c) stress located in the external social environment.

The existence of these levels of interdependence points to the impossibility of eliminating stress altogether. What can realistically be achieved is taking steps towards diminishing stress.

As a matter of fact, this line of reasoning can be equally applied to any of the psychosocial factors.

The global stress at the workplace may be due to each and every component of the work system, its magnitude being determined by the social importance of the activity.

Graphically represented, global stress is located at the intersection of the four areas that define the components of the work system (Fig. 2).

It is not always easy to assess the size of the overlap areas the sum total of which shows the overall global amount of stress at the workplace.

Naturally, jobs are different from each other in view of their social importance. That is why we have inserted the "social significance plane" (*P*) onto which the overlap area of global stress has been projected. It can be observed that an increase in the projection area for global stress is positively correlated with a higher inclination ($\alpha_{max} = 45°$) of the plane (*P*), that is, with the greater social importance of the job ($\alpha_1 > \alpha_0 = 0$, $S_1 > S_0$) (Fig. 2). Obviously, defining the job of maximum social importance (α_{max} = 45°) is a difficult undertaking.

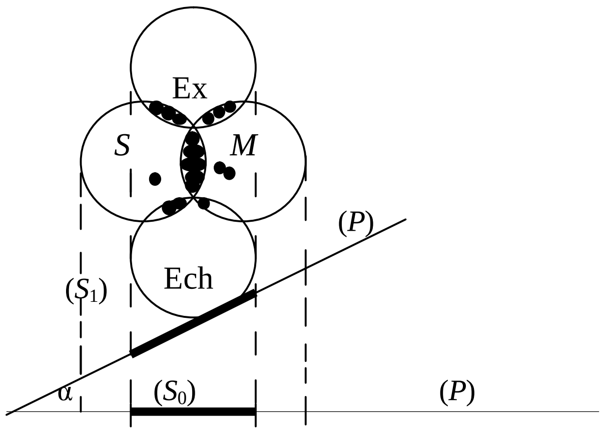

Fig. 2 – Representation of global stress formation and the variation determined by the position of the social significance plane.

4. The Management of Corporate Social Responsibility and the Code of Ethical Behavior – Impact of Psychosocial Factors and Mitigation Tools

The European strategy "Investors in People" has stirred the interest of SME employers in the quality of human resources and in promoting the concept of Corporate Social Responsibility (CSR) characterized by specific management policies (Albulescu & Scripcaru, 2012).

ISO 26000 covers seven areas of social responsibility (management of the organization, human rights, work relations and environment, loyal practices, issues related to consumers, the community and local development), each equally relevant for the public and the private sector.

The CSR Management (Dafinoiu, 2002) of a company has three main functions:

a) the normative function, of a disciplinary nature, meant to ensure compliance with legal provisions;

b) the informative function pertaining to actions for the promotion of ethical corporate governance strategies;

c) the transformative function, a direct outcome of the "Plan - Act - Revise" policy, including steps towards an ongoing reform of the company with a view to making work more effective;

The working tool in CSR Management is the Ethical Behavior Code (EBC) which includes the following areas:

a) people working in companies, customers, suppliers and business partners; relations with the local community, care for the environment. EBC can thus contribute towards mitigating the negative effects of psychosocial factors:

b) the cumulative stress at company level will be diminished both directly, by improving working conditions, and indirectly, by eliminating the daily problems of the employees;

c) harassment at the workplace and psychological bullying will be stopped by treating employees as real shareholders in the company;

d) violence will be curbed when all members of civil society learn to respect the reputation of the company and its employees;

e) professional burnout, manifested as "physical and emotional exhaustion", will be eliminated by improved management of the company (e.g. appropriate wages will put an end to the need of having part-time jobs outside the main working hours).

The existence of an effective EBC is bound to have positive effects both internally and externally. Internally, this will show in a higher degree of employee satisfaction which will in turn lead to increased responsibility and loyalty. Externally, the company's overall image also stands to gain significantly.

By implementing the EBC, companies pledge to ensure decision making transparency, enable an efficient, ongoing information flow in the employer-employee relationship, take into account and analyze the social partners' proposals and assume full responsibility towards forming a united team, totally devoted to the development policies of the company.

The existence of psychosocial risks with such a wide range of manifestations makes mandatory the inclusion of this component in the occupational risk assessment report. When drawing the report, the work system will have to be seen as open, flexible and dynamic, subject to a large number of external factors with a considerable impact on its components (Scripcaru, 2012).

Work accidents frequently occur as the action of a mechanism through which a risk factor can set in motion collateral factors as well.

5. Conclusions

1. There is a large number of psychosocial factors that have a direct bearing on the “performer” component of the work system. The performer’s reactions can lead to unwanted events, generically represented as human errors.

2. The cumulative stress borne by the performer has two main components: work-related stress (occupational stress) and individual stress (generated by sources other than work).

3. Taking into account the two levels of interaction between workplace ↔ company (SME) ↔ external social environment, the result is cumulative stress which can be diminished but not eliminated altogether.

4. The degree of cumulative stress increases directly with the social importance of the activity at the workplace.

5. The same type of analysis can be applied to the other psychosocial factors specific to the work environment: bullying, violence, burnout, etc.

6. The Management of Corporate Social Responsibility and the Ethical Behavior Code are tools meant to diminish the negative effects of psychosocial factors.

7. The existence of psychosocial risks in a wide range of manifestations makes mandatory the inclusion of this component in the occupational risk assessment report.

REFERENCES

Albulescu A.G., Scripcaru D., *Evaluarea riscurilor psihosociale conduce spre un nou concept legat de sistemul de muncă*. S.C. Medicarom Group S.R.L., 2012.

Baba A.I., *Stresul, adaptare şi patologie*. Edit. Academiei Romane, Bucureşti, 1993.

Brişcaru A., *Ce este, cum se poate clădi şi care sunt beneficiile unei culturi corporative colaborative*. Conf. Naț. de Psihol., 2012.

Dafinoiu I., *Personalitatea – metode calitative de abordare*. Edit. Polirom, Iaşi, 2002.

Motronea M., *Dominante ale succesului organizațional*. Conf. Naț. de Psihol., 2012.

Scripcaru D., *Influența factorilor unui eveniment nedorit asupra accidentului de muncă*. Săptămâna Europeană a Securității şi Sănătății în Muncă, Gura Humorului, 2011.

Scripcaru D., *Precizări privind alegerea domeniului de aplicare a – studiului de evaluare a riscului şi determinarea claselor de risc în cazul IMM-urilor*. S.C. Medicarom Group S.R.L., 2012.

MANAGEMENTUL GESTIONĂRII FACTORILOR PSIHOSOCIALI, INSTRUMENT DE REDUCERE A EFECTELOR NEGATIVE ALE ACESTORA

(Rezumat)

Factorii psihosociali apar ca urmare a interacțiunii factorilor psihologici şi cei sociali în cadrul unui sistem de muncă. Sistemul de muncă poate fi considerat ca un sistem deschis, elastic şi dinamic, în care factorii psihosociali pot acționa şi din exteriorul sistemului, determinind interacțiunea elementelor componente ale sistemului de muncă. Multe companii au integrat în strategia activităților şi dezvoltării lor, pe lângă performanțe financiare şi politici sociale şi ecologice, cunoscute sub denumirea de management al Responsabilității Sociale Corporatiste (RSC). Implementarea se face în baza unui Cod de Conduită Etică, în care se evidențiază valorile, responsabilitățile şi obligațiile companiei privind: oamenii ce lucrează pentru companie (angajați, furnizori,

clienți), relația cu comunitatea localț, grija pentru mediul înconjurător. În definirea relațiilor cu angajații se realizează politici de reducere a influențelor negative a factorilor sociali, iar în relațiile exterioare, se crează o imagine pozitivă a companiei, care poate contribuit la reducerea acțiunii factorilor psihosociali asupra angajaților. Standardul ISO 26000 oferă condițiile de implementare şi realizare a RSC.

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THE ROLE OF EXTERNAL SERVICE FOR WORKPLACE PREVENTION AND PROTECTION IN PREVENTING THE RISKS SPECIFIC TO EDUCATIONAL ACTIVITIES

BY

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Abstract: The role of external service for workplace prevention and protection, in preventing the risks specific to educational activities (namely, for the workplaces where the educational process is carried out, starting from kindergartens to universities) is to advising all the persons involved in the educational process (professors and other teaching staff, workers with responsibilities for safety and health at work) in respect of the implementation, enforcement and compliance with the minimum requirements for the safety and health at work, applicable at the level of all the educational institutions.

The risks for safety and health at work in the educational sector could affect not only employees, but also pupils, students and visitors.

Implementation of occupational safety and health norms in the educational system is an essential component to develop a culture of risk prevention. It gives the opportunity to everyone, starting from teachers to pupils and students, to learn living and working in a safety environment.

Keywords: safety; health; education; prevention; protection; pupils; students; professors; workers.

1. Introduction

Prevention and protection activities in educational institutions aim both to provide the best possible working conditions and prevent the accidents and

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occupational diseases among teachers, support staff, pupils and students, in the context of the progress of science and technology.

The conditions in which the educational process takes place in schools of all levels, the complexity of technical facilities existing in the staff training rooms, the productive work developed in universities, students` participation in industrial and agricultural production processes require the organization and conduct of work and academic activities based on knowledge, understanding and application of the minimum requirements for safety and health at work.

In our country, the safety and health at work is a matter of State and is regulated by the Constitution (art. 41), the Labour Code of Romania (title V), the Law No. *319*/2006 on occupational health and safety, as well as by other normative acts.

According to these regulations, the obligation to ensure the safety and health in every aspect related to work devolves upon the manager of the institution, and the obligations of employees, pupils and students shall not affect the principle of the responsibility of the employer.

Where and to whom should the regulations on health and safety at work be applied?

They must be applied in all places of work. They are applied to all employees and apprentices, pupils and students during their professional practice/internship.

Safety and health objectives in educational institutions:

a) be familiar and compliance with the occupational safety and health requirements for the arrangement, endowment and use of educational premises in order to prevent accidents at work and occupational diseases;

b) systematic training of apprentices, pupils and/or students to make sure that along with the attainment of their future profession, they also acquire the necessary skills for proper performance of any operations in the field of specialty, in complete safety;

c) application of specific measures for the safety of work, for the prevention of accidents and occupational diseases during school activities and when organizing extra-curricular activities and, especially during the production practice/internship within the educational institution or directly in the economic, industrial, agricultural units, etc.

What is the external service for prevention and protection?

The external service for prevention and protection is represented by legal or natural persons from outside the enterprise/establishment, empowered to provide protection and prevention services in the field of safety and health at work, in accordance with the law.

The external service for prevention and protection ensures, on a contract basis, prevention and protection activities in the field.

What about the role of the external service for prevention and protection?

Awareness of how job security is addressed at the level of educational institutions plays an important role on the teachers, because in their turn, they are the leaders of the workplaces where the pupils and students work. The need to consult an external partner appears when it is desirable to have an objective and somewhat neutral look from the outside on the actual situation of the occupational safety available in the school/university, in accordance with the occupational safety and health legislation in force.

This depends on how the employer perceives the benefits of such collaboration, on how the employer views the cooperation between a public/private institution with an external service for prevention and protection, and, last but not least, on the financial support to be provided.

The actual involvement of external service for prevention and protection is far more important when discussing about the education sector as being a source of skilled workers, a creator of new job leaders who will have responsibilities in the field of occupational safety and health.

Unfortunately, the process of informing and training of the pupils/students is embedded in a legal system that focuses primarily on the worker (*i.e*. the person employed by an employer according to the law) who has the skills, education or qualifications required by the position they occupy.

The training, in terms of occupational safety and health for the students and pupils who are making internship (*i.e*. the period during which pupils/students receive practical training, specific to their profession or to the specialty they prepare for) allows a pretty broad space of interpretation if we take into account the fact that their skills are scarcely shaped on the basis of the knowledge they are taught. This is emphasized by regulations enacting workers' health monitoring, and implicitly pupils/students` health monitoring during internship.

These statements are supported by a powerful surge of information that appears in various forms and by an evident dynamic in the field of education (of any form and level of preparation), not only on the areas and objects of study that attempt to adapt and meet the requirements of the labour market, but also on a growing technological level.

These factors, which can influence the perception of the importance of certain issues, such as occupational safety and not only, can be used in the common interest of implementing principles of healthy conduct and attitude, of accountability both to teachers and their disciples in order to apply and meet the minimum occupational safety and health requirements specific to the educational institutions for maintaining a high level of security.

In the educational institutions there may be the same risks as in any other job. However, in the educational sector the place of work is shared with students or pupils. These people may be vulnerable because they are young, without experience and often lacking in knowledge about the risks to their safety and health. Also, they can be a danger to themselves.

Employers are required to assess the risks to the safety and health of workers and take action in order to prevent or control these risks by appealing to the services of specialized personnel (external services for prevention and protection).

Risk assessment can be carried out in a sequence of stages:

a) planning the assessment in consultation with employees;

b) identification of risks;

c) identifying people who may be harmed, how, and where;

d) assessing the level of risk and deciding on the mode of action;

e) taking measures to eliminate or reduce the risk;

f) monitoring and analysis of activities.

An educational institution should be *a safe and healthy working environment, propitious to education*. To accomplish this, the risk assessment should take into account the design, the organization and formation of the working environment, and in particular, the presence of vulnerable groups (*i.e.* very young pupils/students) and the needs of the persons with disabilities must also be taken into consideration.

For this reason, we must have regard to the following:

a) indoor workplaces, be it a classroom, staffroom or a kitchen must be properly lit and ventilated, have an adequate level of humidity and enough space, and most of all, they must be clean;

b) if vehicles enter inside the premises of the institution, the signalling must be clear and where possible, the delineation between the roadway and the pedestrian area should be made;

c) the floors must be well maintained, kept clean to reduce the risk of slipping and tripping;

d) particular attention will be paid to the protection against falls from height, in areas such as balconies and stairwells. It might be necessary extra protection of railings for very young children.

e) transparent doors and windows must be clearly marked and made of a suitable material.

Occupational Safety and Health in School Laboratories and Workshops

School laboratories and workshops are places where learners are most exposed to risks caused by toxic substances and hazardous work equipment. The level of education will significantly influence the type of hazard and the level of risk, but there are some common points:

a) written instructions must be displayed in a visible place and security rules highlighted;

b) safety instructions should be presented orally and communicated at the beginning of each experiment;

c) teachers must have exemplary behaviour in terms of safety at work;

d) there must be adequate supervision at all times;

e) any person working with work equipment should be fully familiar with the instructions for the use and maintenance of such equipment, and also with the health and safety requirements;

f) one must wear appropriate personal protective equipment;

g) equipment and tools must be checked and maintained on a regular basis;

h) dangerous substances, tools and equipment must be stored in safe places to prevent their unauthorized use;

i) the laboratory or workshop of school must be clean, with well-maintained equipment;

j) one must ensure proper endowment for first aid, such as showers, for use in the event of an emergency or situation.

The integration of occupational safety and health (OSH) in education constitutes an essential component of the development of risk prevention culture. It affords everyone, starting from teachers to pupils/students, the opportunity to learn living and working safely.

These healthy principles can be perceived and highlighted in a way beneficial to future activities through:

a) including occupational safety and health as an object of study in the school curriculum;

b) creating a specific legal framework in the domain of education defining a system which, in addition to a training conducted by the work leader, the pupils or the students to succeed to discover by themselves the benefits of a safe and healthy activity for them but also for the other participants in the activity, in order to be able to manage their actions/activities in a responsible way.

REFERENCES

* * * https://osha.europa.eu

ROLUL SERVICIULUI EXTERN DE PREVENIRE ŞI PROTECȚIE ÎN PREVENIREA RISCURILOR SPECIFICE ACTIVITĂȚILOR DESFĂŞURATE ÎN PROCESUL DE ÎNVĂȚĂMÎNT

(Rezumat)

Rolul serviciului extern de prevenire si protecție în prevenirea riscurilor specifice activităților desfăşurate în procesul de învățământ, respectiv a locurilor de

muncă unde se desfăşoară procesul educaţional, de la grădiniţe până la universităţi, este de consiliere a tuturor persoanelor implicate în procesul de învăţământ, a corpului profesoral şi altor tipuri de personal didactic, a lucrătorilor cu atribuţii pentru securitate şi sănătate în muncă privind implementarea, aplicarea şi respectarea cerinţelor minime de securitatea şi sănătate în muncă aplicabile la nivelul unităţilor de învăţământ.

Riscurile pentru securitatea şi sănătatea în muncă din sectorul învăţământ ar putea afecta nu numai lucrătorii, dar şi elevii, studenţii şi vizitatorii.

Implementarea securităţii şi sănătăţii în muncă în învăţământ constituie o componentă esenţială a dezvoltării culturii de prevenire a riscurilor. Acordă posibilitatea tuturor, de la profesori până la elevi, studenţi, de a învăţa să trăiască şi să lucreze în siguranţă.

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MATHEMATICAL MODELING OF INERTIA CHARACTERISTICS OF A MULTI-COORDINATE WORKING MACHINE PRESENTED IN THE FORM OF A ROD STRUCTURE

BY

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Abstract: An important task of the working machine design is taking into account dynamic processes that depend essentially on the manipulator inertia properties. In order to determine dynamic processes, a mathematical model of the manipulator is used, which takes into account an inertia tensor with fuzzy values of the movable members. Fuzzy changes in the manipulator inertia parameters are taken into account by introduction of an additional inertia tensor. The additional tensor components are fuzzy sets with membership functions in the form of Gaussian curves. For mathematical modeling of fuzzy changes of the inertia tensor components, a random number generator is used. It determines a set of centered random quantities with a normal distribution law. The determined quantities are used to calculate ordinates of the membership functions. The inertia tensor components are assumed to be proportional to the membership function ordinate.

Keywords: working machine; manipulator inertia properties; mathematical model; fuzzy changes in the inertia tensor components.

1. Introduction

Current tendencies in the development of working machines are characterized by a reduced consumption of materials and increased speed of

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response. Dynamic properties of machines are changed accordingly. Therefore, investigation of dynamic processes in working machines is of current importance.

In general terms, the problem is to improve dynamic performance of working machines in the form of rod structures.

The problem is connected with scientific and practical tasks in the development of working machines. Improving their dynamic characteristics is a basis for the development of advanced designs of manipulators of construction and road machines.

Recent research and publications pay considerable attention to the problem of improving working machines based on manipulators (Павленко, 2007) investigation of their kinematics (Павленко & Мажара, 2010). A number of publications study working processes in the machines, particularly, the accuracy of their positioning (Kim Han & Choi Yong, 2000). Dynamic oscillatory processes are shown to be important in this respect (Струтинський, 2013). For studying spatial movements inertia parameters of a mechanism are used in the form of a tensor of inertia moments (Лойцянский & Лурье, 1983).

In the literature no research results have been found where fuzzy inertia characteristics of working machines are considered.

Taking into account fuzziness of the inertia parameters of working machines in studying their dynamics is considered to be an unsolved aspect of the general problem.

The research is aimed at the development of a method for taking into account fuzziness of working machine inertia parameters. Research tasks include the analysis of a working machine design solution, defining the tensor of the machine inertia parameters using the theory of fuzzy sets.

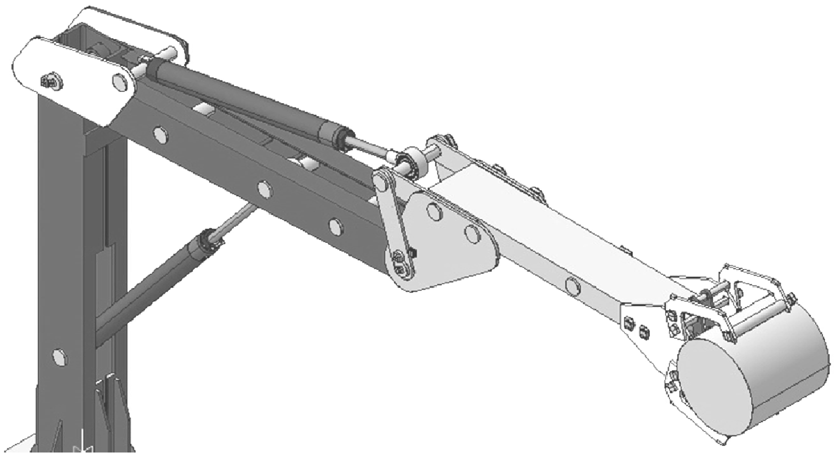
2. Design Circuit of the Manipulator and its Dynamic Model

Manipulator of a working machine is a complex dynamic system with articulated joints. In the process of operation there is a rotational movement of the manipulator relative to the main mounting assembly (Fig. 1).

The manipulator has several massive series-connected parts. The action of the dynamic-force drives changes mutual arrangement of the parts and characteristics of the articulated joints. In the process of its positioning the manipulator executes spatial movements in relation to the general support point of the mounting assembly.

The manipulator is a complex rod structure with articulated joints. Each joint has a contact rigidity, clearances and plays. Therefore, during manipulator positioning each rod member in the monoaxial hinge has additional degrees of freedom. Joint1 could be considered as a hinge point with elastic-dissipative connections over angular displacements.

In the process of manipulator operation mutual location of the rods, forming a kinematic chain, is changed. This causes changes in the inertia properties of the system while it rotates about articulated support assembly. The



manipulator inertia parameters are presented in the form of fuzzy inertia parameters as the system inertia tensor components.

Fig. 1 – The manipulator design circuit that shows movement of the manipulator working member during its positioning.

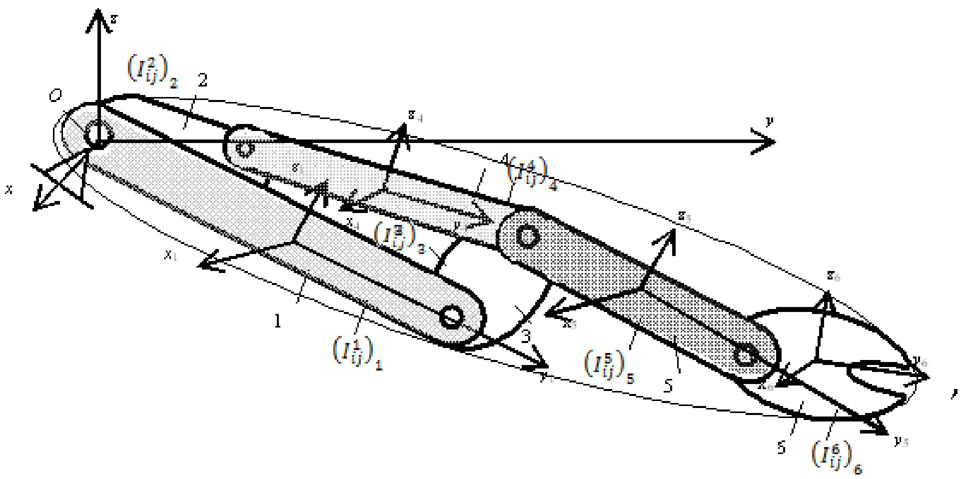


Fig. 2 – Manipulator of the working machine presented in the form of a rod structure that executes spatial motion.

In order to take into account changes of the inertia parameters, a special dynamic model of the manipulator in the form of a pivotal rod structure is proposed. In the pivotal rods the basic mass of the manipulator is concentrated. Therefore, inertia properties of the pivotal rods determine the manipulator inertia properties during its positioning. The dynamic model has a limited number of rod members. Mostly, they correspond to the members of the manipulator carrying system (Fig.2).

Each of the rod members 1,…,6 has a centre of masses where a centre of the local system of the rod coordinates is located. Each local coordinate system is rotated with respect to the fixed system of coordinates *x*, *y*, *z*. In the process of the manipulator operation there are changes in the position of each pivotal rod and in the angular position of the local coordinate system. The changes are of a fuzzy character.

Motion of each manipulator rods is viewed as a motion of separate material points. For each pivotal rod a tensor of inertia moments is defined for the rotational motion of the rod relative to the manipulator support hinge (Fig. 3).

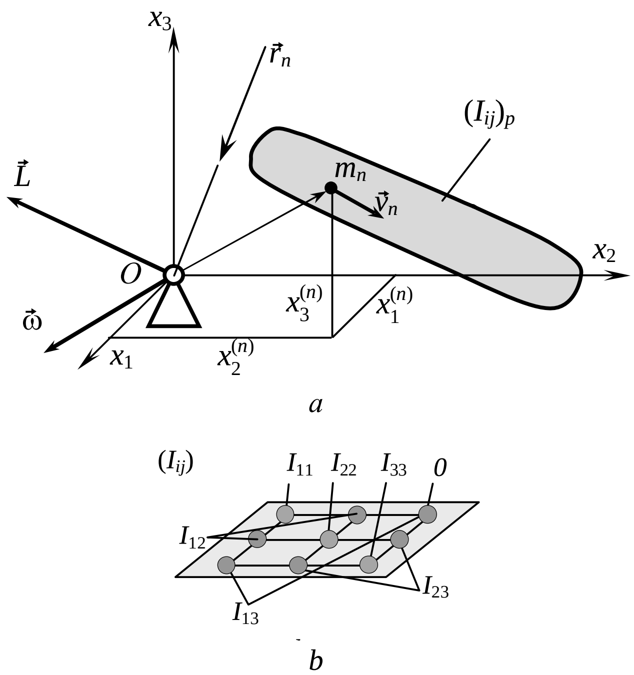


Fig. 3 – Rotational motion of a rod, presented as a system of material points, relative to the coordinate system (*a*) and geometric interpretation of the inertia moment tensor for the system of points (*b*).

The angular momentum vector for the system of material points of a separate *p*-th rod relative to the origin of the coordinate system (x_1, x_2, x_3) is determined by the formula:

$$\vec{L}=\sum_{n=1}^{N} m_n\left(\vec{r}_n\times\vec{v}_n\right), \qquad (1)$$

where: m_n is a mass of the n-th material point; N – total number of material points; $\vec{v}_n$ – velocity vector of a separate material point; $\vec{r}_n$ – radius vector that characterizes position of point n relative to the coordinate origin.

In the process of the manipulator operation the radius vector varies. These variations are the result of addition of the deterministic (definite) displacements and additional indefinite (fuzzy) displacements.

Let us consider a system of points for which distance $\left|\vec{r}_n-\vec{r}_p\right|$ remains unchanged. This is true for the rod in the form of a solid body. Distances of the points from the origin of the coordinates will be presented as a sum of the rod rotation $\left|\vec{r}_n\right|=\text{const.}$ and additional change of the rotation point $\vec{r}^{\,*}_{no}$. In this case we assume that

$$\vec{r}^{\,*}_{no} << \vec{r}^{\,(2)}_n. \qquad (2)$$

Let us consider rotation of the pivotal rod and changes in the rotational point position separately. For pure rotation of the rod radius vector r_n has a constant modulus.

For a given system of points that corresponds to a single solid body:

$$\vec{v}_n=\vec{\omega}\times\vec{r}_n,$$

where: $\vec{\omega}$ is a vector of the instantaneous angular velocity of the rod rotation.

For the doubled vector product of the three vectors we have

$$\vec{a}\times\left(\vec{b}\times\vec{c}\right)=\vec{b}\left(\vec{a}\vec{c}\right)-\vec{c}\left(\vec{a}\vec{b}\right).$$

Taking into account this relationship, we obtain an angular momentum vector for the system of material points corresponding to a single rod in the form of

$$\vec{\boldsymbol{L}}=\sum_{n=1}^{N} m_n\left[\vec{\boldsymbol{r}}_n\times\left(\vec{\boldsymbol{\omega}}\times\vec{\boldsymbol{r}}_n\right)\right]=\sum_{n=1}^{N} m_n\left[\vec{\boldsymbol{\omega}}\left(\vec{\boldsymbol{r}}_n\times\vec{\boldsymbol{r}}_n\right)-\vec{\boldsymbol{r}}_n\left(\vec{\boldsymbol{r}}_n\times\vec{\boldsymbol{\omega}}\right)\right]. \qquad (3)$$

In projections on the axes of Cartesian coordinate system this formula takes the form of

$$L_i = \sum_{n=1}^{N} m_n \omega_i \sum_{l=1}^{3} x_l^{(n)} x_l^{(n)} - x_i^{(n)} \sum_{k=1}^{3} \omega_k x_k^{(n)}, \tag{4}$$

where: $x_1^{(n)}$, $x_i^{(n)}$, $x_k^{(n)}$ are the coordinates of the *n*-th material point of a separate *p*-th rod; ω_i – projection of the angular momentum vector of the rod on axis x_i .

We write projections of the rod angular velocity as

$$\omega_i = \sum_{k=1}^{3} e_{ik} \omega_k , \tag{5}$$

where a unit tensor is characterized by the matrix:

$$e_{ik} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}.$$

Substituting the value of the angular velocity projections from (5) to formula (3), we obtain projections of the angular momentum vector of the rod in the form of

$$L_i = \sum_{k=1}^{3} \sum_{n=1}^{N} m_n \omega_k \left(\sum_{l=1}^{3} e_{ik} x_l^{(n)} x_l^{(n)} - x_i^{(n)} x_k^{(n)} \right) = \sum_{k=1}^{3} \omega_k I_{ik} .$$

This formula includes a tensor quantity – an inertia moment tensor $(I_{ik})_p$ for the p-th rod, the components of which in a general form are defined as

$$\left(I_{ik}\right)_p^0 = \sum_{n=1}^{N} m_n \sum_{l=1}^{3} e_{ik} x_l^{(n)} x_l^{(n)} - x_i^{(n)} x_k^{(n)} . \tag{6}$$

Let us consider an additional motion of the rod as a solid body. As a result of this motion, the rod position varies in accordance with variations of the radius of vector $\vec{r}_n^{\,*}$. Taking into account relationship (2), this motion could be considered to be independent from the basic motion. Accordingly, all the calculations, given in formulas (1), (3) – (6), are valid for the additional motion. Therefore, for the additional motion we have an additional kinematic moment

$$L_i^* = \sum_{k=1}^{3} \omega_k^* I_{ik}^* ,$$

where: I_{ik} is an additional inertia tensor determined by the presence of the indefinite (fuzzy) additional motion of the rod characterized by angular velocity ω_k^*.

Hence, the total inertia tensor for the p-th rod

$$\left(I_{ik}\right)_p = \left(I_{ik}\right)_p^0 | + \left(I_{ik}\right)_p^* .$$

Inertia moment tensor for the system of material points is a symmetric one. Respectively

$$\left(I_{ik}\right)_p = \left(I_{ik}\right)_p^' .$$

Tensor components in expanded form are determined by the inertia moments of the system of points relative to separate axes. For the basic inertia tensor

$$\begin{aligned}
&\left(I_{11}\right)_{\mathrm{p}}^0 = \sum_{n=1}^{N} m_n \left[\left(x_2^{(n)}\right)^2 + \left(x_3^{(n)}\right)^2\right] = I_{x_1x_1}^0 ;\\
&\left(I_{22}\right)_p^0 = \sum_{n=1}^{N} m_n \left[\left(x_3^{(n)}\right)^2 + \left(x_1^{(n)}\right)^2\right] = I_{x_2x_2}^0 ;\\
&\left(I_{33}\right)_p^0 = \sum_{n=1}^{N} m_n \left[\left(x_1^{(n)}\right)^2 + \left(x_2^{(n)}\right)^2\right] = I_{x_3x_3}^0 ;\\
&\left(I_{12}\right)_p^0 = I_{21} = -\sum_{n=1}^{N} m_n x_1^{(n)} x_2^{(n)} = I_{x_1x_2}^0 ;\\
&\left(I_{13}\right)_p^0 = I_{31} = -\sum_{n=1}^{N} m_n x_1^{(n)} x_3^{(n)} = I_{x_1x_3}^0 ;\\
&\left(I_{23}\right)_p^0 = I_{32} = -\sum_{n=1}^{N} m_n x_2^{(n)} x_3^{(n)} = I_{x_2x_3}^0 .
\end{aligned} \tag{7}$$

The first three formulas of (7) determine the inertia moments for the system of material points of a single rod relative to coordinate axes x_1, x_2, x_3. The rest of the formulas correspond to the centrifugal inertia moments.

Additional motion of the rod differs little from the basic one. Therefore, we can assume that $\omega_k = \omega_k^*$.

Components of the additional inertia tensor are determined by the dependences (6), which are displacements of the rod caused by the additional motion. Designating the displacements along the coordinate axes as $\Delta_1, \Delta_2, \Delta_3$, we obtain

$$I_{11}^{*} = \sum_{n=1}^{N} m_n \left[\left(\Delta_2^{(n)} \right)^2 + \left(\Delta_3^{(n)} \right)^2 \right] = I_{x_1 x_1}^{*} ;$$

$$I_{22}^{*} = \sum_{n=1}^{N} m_n \left[\left(\Delta_3^{(n)} \right)^2 + \left(\Delta_1^{(n)} \right)^2 \right] = I_{x_2 x_2}^{*} ;$$

$$I_{33}^{*} = \sum_{n=1}^{N} m_n \left[\left(\Delta_1^{(n)} \right)^2 + \left(\Delta_2^{(n)} \right)^2 \right] = I_{x_3 x_3}^{*} ;$$

$$I_{12}^{*} = I_{21} = -\sum_{n=1}^{N} m_n \Delta_1^{(n)} \Delta_2^{(n)} = I_{x_1 x_2}^{*} ;$$

$$I_{13}^{*} = I_{31} = -\sum_{n=1}^{N} m_n \Delta_1^{(n)} \Delta_3^{(n)} = I_{x_1 x_3}^{*} ;$$

$$I_{14}^{*} = I_{32} = -\sum_{n=1}^{N} m_n \Delta_2^{(n)} \Delta_3^{(n)} = I_{x_2 x_3}^{*} .$$

Displacement of the separate points of the rod in the additional motion is inconsiderable and, therefore, the additional tensor components in a general form could be defined as percentages of the basic tensor. The estimate gives values of the maximal changes in the tensor components in the range of 5…10%.

The inertia tensor components are defined in a certain coordinate system. For each rod the inertia moment is found in a local central coordinate system that passes through the center of the rod masses in the direction of main inertia axes. *E.g.*, for the first rod (see Fig. 1) it is the system of coordinates *x*, *y*, *z*.

Inertia tensor components in the basic coordinate system are found on the basis of the known relationships [5]. For the rod with p number we obtain the basic component of the tensor in the form of

$$\left(I_y \right)_p^0 = I_{kl}^c + x_c^2 M_p ,$$

$$\sum_{k=1}^{3} \sum_{l=1}^{3} f_k^i f_l^j \left(I_{kl}^c + x_c^2 M_p \right)$$

where I_{kl}^{c} is a component of the rod inertia tensor in the central coordinate system; x_c^2 – distance between the axes of the coordinate systems; f_k^i – orthogonal transition matrix between the coordinate systems.

The total inertia moment of the manipulator will be composed from the inertia moments of all manipulator rods. Respectively:

$$\left(I_y\right)^0 = \sum_{p=1}^{N}\left(I_{ij}\right)_p^0 .$$

The additional inertia tensor is given as a proportion of the fundamental tensor of inertia moments.

In accordance with mathematical description of spatial motion of the manipulator with rod structures, a mathematical model is adopted in the form of an equivalent solid body with a variable inertia tensor (Fig. 4).

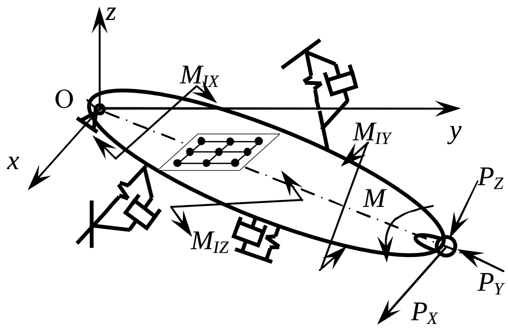


Fig. 4 – Dynamic model of the manipulator in the form of an equivalent solid body with a variable tensor of inertia moments, the components of which are fuzzy sets.

For building the mathematical model it is assumed that the components of additional inertia tensor $\left(I_{iki}\right)^{*}$ are fuzzy sets that cannot be accurately determined. They are determined by a random law that is assumed to be close to a normal one with a certain degree of probability. Respectively, for fuzzy sets that define the inertia tensor components a characteristic membership function is adopted in the form of a Gaussian curve

$$\mu_{ij(\Delta)} = \mathrm{e}^{-\alpha_{ij}\Delta^2} ,$$

where: α is a coefficient that determines the degree of fuzziness for the values of tensor components; Δ – random value of the equivalent average displacement of the rod.

Actual value of the tensor components is found by multiplication of its maximum value by the realization value of the membership function that corresponds to the respective value Δ defined by a generator of random numbers with a normal distribution law.

Calculation of each component of the additional inertia tensor is performed using the structural model (Fig. 5).

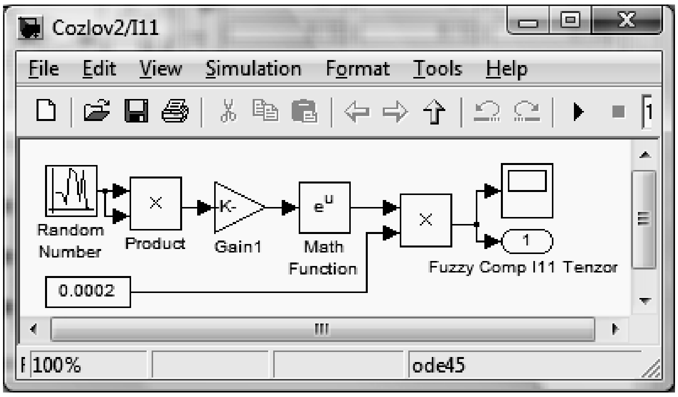


Fig. 5 – Structural mathematical model intended for calculating the fuzzy inertia tensor component equivalent to the manipulator dynamic system.

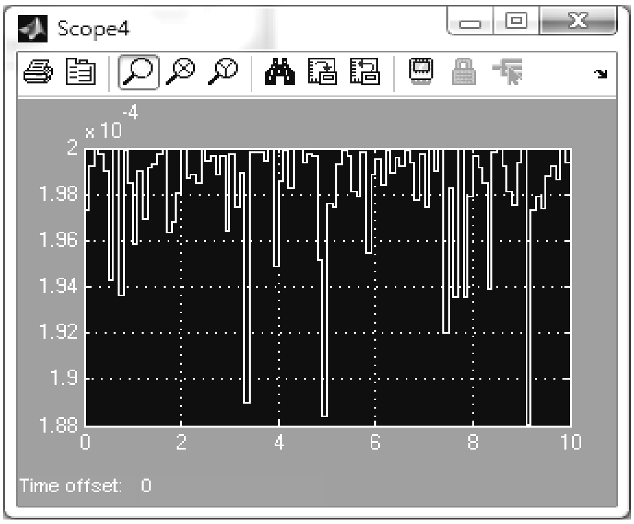


Fig. 6 – A characteristic example of time changes in the fuzzy inertia tensor component of the equivalent dynamic manipulator system.

The fuzzy tensor component is calculated in the following way. The Random Number generator with the required discretion in time defines a random number that is used as an argument for calculating the characteristic membership function of the fuzzy set in the form of a Gaussian curve. The calculated value of the membership function is multiplied by the biggest possible value of the fuzzy part of tensor component (in this case – 0.0002 kg/m). In this way a piecewise constant value of tensor components is formed.

In this case the calculated fuzzy values of the components differ from the maximum value by 10…12%. On the average, fuzzy values of the components are 2…4% less than the maximum value.

The calculated fuzzy components of the tensor are combined into a matrix, that defines an additional inertia tensor component, and are added to the constant deterministic tensor component in a special structural model (Fig. 7).

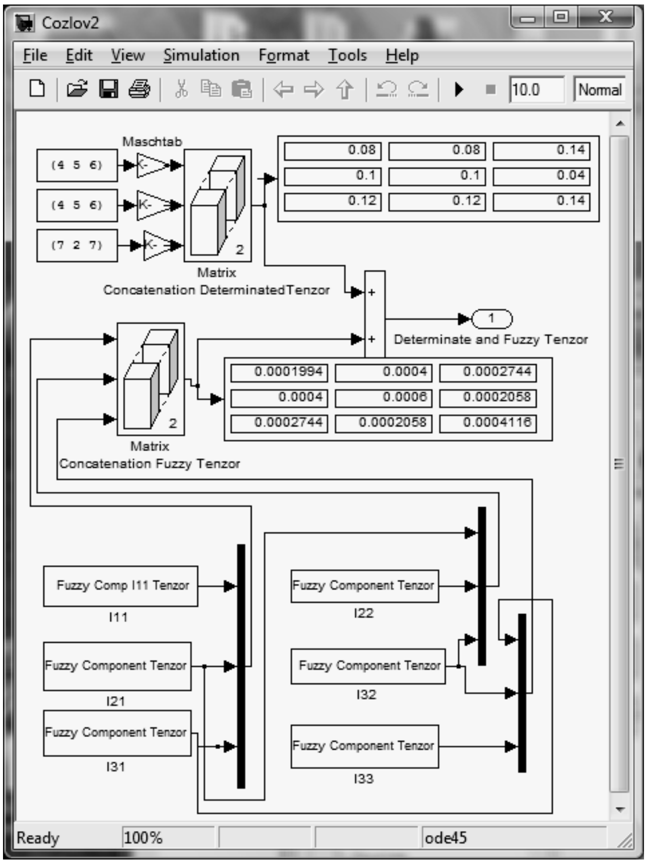


Fig.7. A structural model of forming the inertia tensor of the equivalent dynamic manipulator system that includes a fuzzy and a deterministic components.

For controlling the operation, the procedures of changing the deterministic and fuzzy tensor components are displayed on the screen in the form of tables.

The inertia tensor is a matrix with fuzzy coefficients. Tensor components vary in time. The matrix, which defines the tensor, has the symmetry property. According to the definition of inertia tensor, the matrix has three real positive values I_1, I_2, I_3. Respectively, three mutually orthogonal main directions of the inertia tensor are determined – x_0, y_0, z_0. For geometric interpretation of the fuzzy inertia tensor a tensor surface – ellipsoid of inertia – is used (Fig. 8).

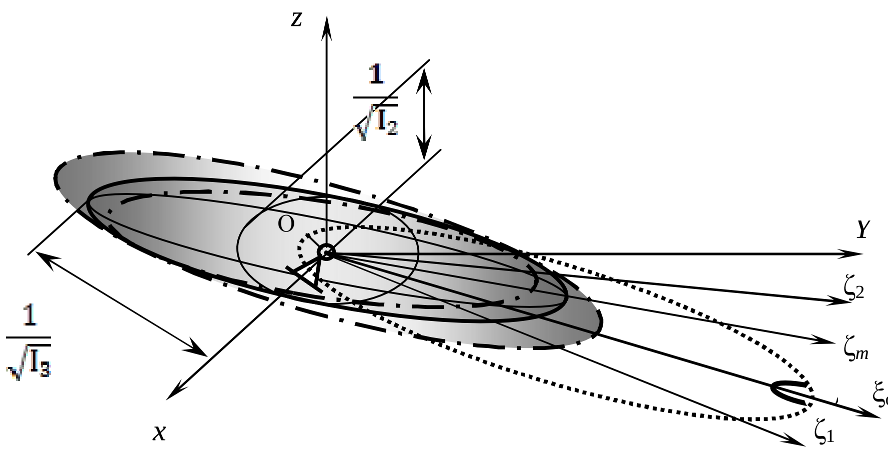


Fig. 8 – Geometric interpretation of the fuzzy inertia tensor of the equivalent dynamic manipulator system in the form of an inertia ellipsoid.

Stochastic changes of the inertia tensor lead to the changes of the ellipsoid axes and to its rotation in space.

3. Conclusions

It has been established that dynamic accuracy of a working machine positioning is determined by a spherical motion of the manipulator relative to a certain fixed point in the manipulator base. In order to determine dynamic processes, it is expedient to use a dynamic model of the manipulator in the form of an equivalent system that executes spherical motion, inertia properties of the system being determined by the inertia tensor that has fuzzy values of the components.

It is shown that fuzzy changes of the parameters are expedient to be taken into account by introduction of an additional inertia tensor of the system, the components of which are fuzzy sets with membership functions of Gaussian curves that have maximal values corresponding to the possible maximal changes of the component of the total system inertia tensor.

For mathematical modeling of the fuzzy changes in the inertia tensor components it is expedient to use a generator of random numbers that determines a set of centered random values with a normal distribution law. These random values are used to calculate the values of membership function ordinates, and a tensor component is assumed to be proportional to the membership function ordinate.

REFERENCES

Kim Han S., Choi Yong J., *The Kinematic Error Bound Analysis of the Stewart Platform*. J. of Robotic Syst., **17**, *1*, 63-73 (2000).

Лойцянский Л.Г., Лурье А.И., Курс теоретической механики: в 2-х томах. Т. II. Динамика. – 6-е изд. перераб. и доп. – М.: Наука, 1983. – 640 с.

Павленко І.І., Мажара В.А., Роботизовані технологічні комплекси: Навчальний посібник. Кіровоград, КНТУ, 2010, 392 с.

Павленко І.І., Промислові роботи: Основи розрахунку та проектування. Кіровоград, КНТУ, 2007, 420 с.

Павловський М.А., Теоретична механіка. Підручник. – К.: Техніка, 2002. – 512 с. – ISBN 966-575-184-0./uk/09vvboat_ua.pdf.

Симонюк В.П., Теоретичні дослідження процесу віброобробки з математичним аналізом елементарної моделі коливальної системи / В.П. Симонюк, В.Б. Струтинський, Р.Н. Пастернак // Міжвузівський збірник "Наукові нотатки". - 2011. – №30. – С.163-167.

Струтинський С.В., Гуржій А.А., Забезпечення раціонального стохастичного балансу точності просторової системи приводів з використанням теорії нечітких множин/ Вісник СевНТУ Серія: машиноприладобудування та транспорт. Випуск 119/2012.- 2012.- С. 60-67.

Струтинський С.В., Гуржій А.А., Експериментальне визначення динамічних характеристик та побудова на їх основі математичної моделі просторової системи приводів / Технологічні комплекси. Міжнародний науковий журнал №1 (7)/ ISSN: 2304-4519/ - 2013. – С.10-18.

Струтинський С.В., Математичне моделювання просторових поперечно-кутових мікропереміщень сферичного шарніра з використанням рекурсивних зв'язків / Всеукраїнський щомісячний науково-технічний і виробничий журнал «Машинознавство». – 2009. - №1. – С.37-43.

Струтинський С.В., Просторові Системи приводів: Монографія/ав. Струтинський С.В., Гуржій А.А. – К.: Педагогічна думка, 2013. – 492 с.

MODELAREA MATEMATICĂ A CARACTERISTICILOR INERŢIALE A UNEI MAŞINI MULTICOORDONATE PREZENTATĂ ÎN FORMĂ DE TRAVERSĂ

(Rezumat)

O sarcină importantă a proiectului unei maşini de lucru este luarea în considerare a proceselor dinamice care depind în mod esenţial de proprietăţile de inerţie ale manipulatorului. În scopul determinării proceselor dinamice este utilizat un model

matematic al manipulatorului care ia în considerare un tensor de inerție cu valori fuzzi ale elementelor mobile. Modificările fuzzy ai parametrilor de inerție ai manipulatorului sunt luate în considerare prin introducerea unui tensor de inerție adițional. Componentele tensorului adițional sunt seturi fuzzy cu funcții membre de forma curbei lui Gauss. Pentru modelarea matematică a modificărilor fuzzy ale componentelor tensorului de inerție este utilizat un generator de numere aleatoare. Acesta determină de cantități al;eatoare centrate cu o lege de distribuție normală. Cantitățile determinate sunt utilizate pentru a calcula ordonatele funcțiilor membru. Componentele tensorului de inerție se presupun a fi proporționale cu ordonate funcției membru.