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FUZZY MODEL OF THE EXPERT ASSESSMENT OF OCCUPATIONAL RISKS ON THE EXAMPLE OF THE WORKING CONDITIONS OF EMPLOYEES AT THE OIL REFINERY PLANTS

YULIYA BULAUKA, ALENA GALYNSKAYA
Polotsk State University, Belarus

Fuzzy model of the expert assessment of occupational risks to employees' health at oil refineries is presented in the article.

At the present stage of development of socio-technical systems, a convenient instrument of the modeling of complex dynamical processes under conditions of uncertainty and multicriteriality is the application of the fuzzy sets and fuzzy inference theory [1 – 3].

Impact of production factors on oil refinery employees is difficult to predict and depends on various circumstances and conditions. Therefore, the decision making procedure to determine the professional risks level is a complex of variables of different nature. For this reason it is expedient to use fuzzy model for occupational risk assessment.

This paper presents fuzzy model and results of using fuzzy model for occupational risks assessment of the employees' health at oil refineries.

The fuzzy model includes three fuzzy inference system FS_1, FS_2 and FS_3 (Figure 1) [4 – 5]. Input variables of the first fuzzy inference system are the probability (frequency) of hazard (P_i), which considers prescription of accident (K_i), severity of the consequences of hazards influence (S_i), and the duration of hazards exposure (D_i). An output variable of the first fuzzy inference system is occupational risks level ($R_{ОПФi}$), which caused by unsafe hazard. The occupational risks level is used as a basis for making a decision about the necessity of risk management actions.

Two variables are accepted in second fuzzy inference system: class of working conditions – ($КУТ_i$) and relative risks ($ОР_j$) for a certain class of diseases. The result of the fuzzy inference of the second system is a linguistic variable – "professional risks of occupational hazard effect "($R_{ВПФi}$).

The first variable of the third fuzzy inference system – is hazard index ($ИВ_k$) for a certain profession or a structural subdivision. The second variable ($FS_{3)}$ is a number of temporary disability cases due to all illnesses per 100 employees ($ЗВУТ_k$). An output variable of the third fuzzy inference system is "occupational risks of complex effect of production hazards" ($R_{ВПФk}$).

One of the steps of fuzzy inference is a development of rule base by expert. There are 125 rules for FS_1, and 25 rules each for FS_2 and FS_3.

On the basis of expert assessment and the principle of linguistic pattern recognition, it is determined that the changes of input variables can be most thoroughly described by terms, which have triangular membership functions (except the input variables OP_f and $ИВ_k$ and output variables $R_{ОПФi}$, $R_{ВПФi}$, $R_{ВПФk}$, which are characterized by trapezoidal membership functions).

As an algorithm for fuzzy inference algorithm Mamdani is adopted. Assessment of the professional risks level to employees of oil refineries caused by *i*-th hazard (for the *k*-th profession) consists of the following steps:

1) identify input parameters $FS_{1–3}$ by recognized expert and statistical methods;

2) perform fuzzification of input parameters values by finding appropriate graphic framework of the membership function terms ($X_{1j} – X_{7j}$) on the basis of the values of quantitative or qualitative criteria in step 1 (i.e, the values of P_i, S_i, D_i, $КУТ_i$, $ИВ_k$, OP_f, $ЗВУТ_k$);

3) determine the degree of validity conditions for each of the fuzzy rules productions;

4) construct the resulting membership function for the output parameters ($R_{ОПФi}$, $R_{ВПФi}$, $R_{ВПФk}$) in relation to the degree of the validity of all production rules;

5) calculate the resulting (fine) value of output parameters ($R_{ОПФi}$, $R_{ВПФi}$, $R_{ВПФk}$) by defuzzification using the center of mass method;

6) decide on the admissibility and the need for preventive managerial impacts on set in step 5 professional level.

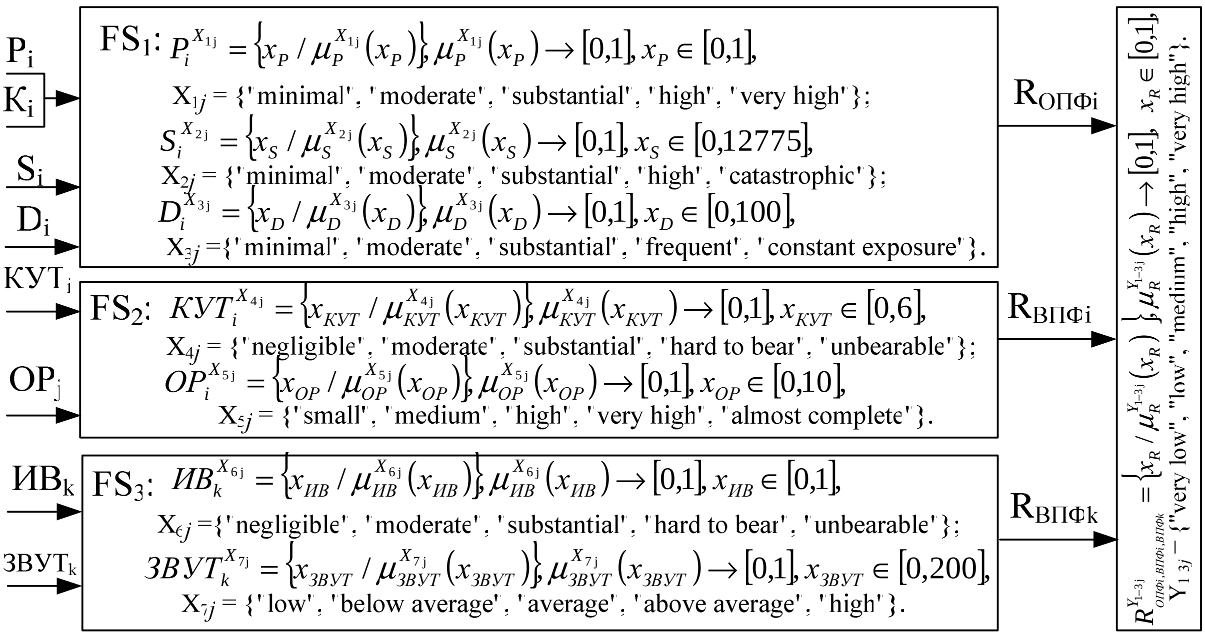

Fig. 1. Fuzzy inference system in occupational risks assessment model: X_j, Y_j – values of linguistic variables (terms). Expression: A = $\{x/\ \mu_A(x)\}$ – a set of ordered pairs of fuzzy subsets of A, where μ (x) – the membership function of the underlying variable x to a subset A

This model is used for simplification and improvement of the quality assessment of the level of occupational risks. The model was implemented in software on programming language C# in the development environment of Microsoft Visual Studio 2010 Express Edition. The results of occupational risks assessment for workers at JSC «Naftan» which were obtained based on FS_3 software are presented in table 1.

Table 1 – Occupational risks assessment for workers at JSC «Naftan»

Structural subdivision	Level of the risks	Confidence level, %	Risk category
Petroleum fuels and aromatic hydrocarbons	0,47	100	middle
Production of lubricating oils and bitumens	0,51	100	middle
Repair production	0,70	100	high
Production of electricity and wastewater treatment plants	0,54	100	middle
Tankage facilities	0,70	100	high
Workshop electricity	0,50	100	middle
Workshop of instrumentation and automation	0,56	94	middle
Central Laboratory	0,50	100	middle
Motor transport workshop	0,51	100	middle
Workshop equipment base	0,70	100	high
Production of additives	0,54	100	middle
Oil refinery as a whole	0,59	56	middle

According to presented result employees of following subdivisions are exposed to high level risk of complex influence work environment: tankage facilities, base equipment and repair department. There is a need to develop preventive control solutions to reduce risks.

Application of the proposed fuzzy model of occupational risks assessment for the health of employees at oil refinery plant could facilitate taking adequate administrative decisions on elimination or limitation of the negative impact of production factors under uncertainty and, as a result, improve the quality of the occupational health and safety management system.

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APPLICATION OF TECHNOLOGY OF LASER SINTERING OF METAL POWDER

HENADZI ZDOR, YAUHENI LIVSHITS, ANDREI RUBAN
Polotsk State University, Belarus

One of perspective directions of creation of automated production is using technology of direct metal laser sintering (DMLS). The essence of this technology is paired computer-aided design (CAD) with auto manufacturing parts using special devices – 3D printers.

In view of the development of scientific and technical progress, we have an actual problem of complex automatic and robotic equipment. Moreover, due to the massive creation of flexible production it is necessary to develop mobile, single and small-scale manufacturing units. A feature of these developments is that most of the issues involved in creating technological complexes fall in the conjugation technologies, such as mechanics and electronics, electronics and IT. That is why most discoveries nowadays raise issues of interfacing technologies. This technology covers metallurgy, electronics, optics, quantum physics and IT.

Laser sintering of metal is a kind of additive synthesis technology.

Direct metal laser sintering (**DMLS**) is an additive manufacturing technique used for the low volume production of prototype models and functional components (fig.1) [1].

The technology has many benefits over traditional manufacturing techniques. The ability to produce quickly a unique part is the most obvious advantage because no special tooling is required and parts can be built in a matter of hours. Additionally, DMLS allows for more rigorous testing of prototypes. Since DMLS can use most alloys, prototypes can now be functional hardware made out of the same material as production components [2].

So, the benefits are:

- a significant increase in production flexibility;
- an excellent mechanical properties of items;
- improving the competitiveness of production;
- reduction of production costs, especially for a small-scale production;
- greatly reduces computer numerical control (CNC) & electrical discharge machining (EDM) costs;
- reduction the time to market new products;
- the integration of computer technology and CAD systems [3].

The main problem is the hardware to ensure accuracy in the manufactured products. Key issues to ensure accuracy are the following:

- preparation of metal powder for sintering;
- selection of lasing mode;
- ensuring of the positioning of the reflecting mirror;
- focusing of laser beam.