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Approximation algorithm of criterial estimate of psychophysiological state of the operator of technological processes of enterprises.

In the article, approximation algorithm of criterial estimate of psychophysiological state of the operator and working conditions (the factors that form them) was examined experimentally for the top-level database of the occupational health and safety management system. Since the behavior of the operator in the control system is determined by the variety and uncertainty, the course and result of the solution of the task in question depend on its solution.

Problem statement

The importance of studying the factors affecting the ability to work is that the «working tone» is an informative indicator of the state of a holistic human organism.

In the process of studying the conditions at workplaces in the technological process of enterprises [1] is established, that one worker is provided with a combined effect of several factors having different levels of influence and contributing to changes in his psychophysiological state. In the experiment, the task was to determine the quantitative values that determine the performance (fatigability) of the individual in the conditions of the production environment. It is worth noting that at present, an adequate model of accounting for all varied factors [2], which form the working conditions and affect human health, has not yet been developed, but it is necessary to use simplified models [3], limited to only some of them. Thus, at the objects of the company, from a set of factors affecting the state of human-operator, two or three are allocated, whose influence is dominant.

Assessment and forecasting of the person's ability to work, obtaining quantitative criteria for assessing the change in working capacity and determining the level of fatigue is a difficult task, first of all in terms of biology. From the biological point of view, the essential aspect of fatigue is the fact that the quality of activity, depending on the duration and intensity of work, when performing the targeted professional tasks is worsening (tiredness comes on). For example, under the influence of fatigue at the controllers and operators of aviation control panels, there is a violation of the timing, the test task (indirect indicator) and fine motor coordination. It is known that the effect of acute fatigue is mainly due to short-term violations of psychomotor reactions. With the accumulation of fatigue, these disorders psychomotor reactions progress, become more frequent and, consequently, lead to a decrease in overall performance. Such a decrease in efficiency causes an increase in the flow of errors until the termination of activity. For operatoric work is characterized by cumulative (accumulation) fatigue. Cumulative fatigue develops as a result of prolonged caretaking. It develops gradually over a number of days or weeks. As a result, the operator experiences a deterioration in the quality of the activity, similar to the effects of acute or chronic fatigue [4].

The purpose of the article

In this article it is proposed to experimentally validate the algorithm for the approximation of the criterion assessment of the psychophysiological state of the operator and the working conditions (factors that form them) of the work area for the database of the upper level of the system of management of industrial health and safety of the enterprise [5, 6].

Presentation of the main material

The state of the working and influencing factors are described by the multidimensional W and X vectors respectively. In order to simplify the complex biological task of quantifying the impact of the q-th factor on the health and efficiency of a person, we restrict ourselves to the physical parameters that are dominant. Then each component of the vector W is a function:

$$W_s = f(x, y) \quad (1)$$

fixing the value of one of the parameters, for example y, this expression is transformed into a system of two-dimensional dependencies:

$$W_s^t = f(x, y^t), \quad (2)$$

that is, in the map f: x → W for a given sample of experts who take part in the experiment.

Here W – time of testing (indirect indicator); x – ambient temperature, degrees; y – duration of working change, h; $t=\overline{1;z}$ (z – the number of measuring points); S = 1.2.

In the process of the experiment, about 300 workers were surveyed. In this case, the instrument developed by the National Aviation University [4] was used, whose program exercises allow us to judge the degree of readiness of the operator to production activities. The control group of the results is the experimental data obtained before the start of work. The research started 10 minutes before the work began and the working shift continued. Measurement of the duration of the test tasks was performed at certain intervals. During the observation period, the subjects were exposed to such factors as the time of spin and the duration of change, adaptation and temperature of the surrounding industrial environment.

The research was conducted with groups of specialists of different profile and several changes in their work. At the rate of reaction of the examinee, they were judged about his fatigue under the influence of the factor in the workplace at certain intervals. To do this, we first used a prepared blank test and a special questionnaire for filling.

Estimation is the average time of execution of test programs-exercises according to the display:

$$f: R \rightarrow W \quad (3)$$

where R = X x Y;

$$W_s = \frac{1}{r}\sum_{i=1}^{r} W_i^s \text{ at } W_i^s \in W_s$$

and

$$W = \frac{1}{S}\sum_{i}^{S} W_S \text{ and } W_S \in W \qquad (4)$$

Characteristic for the first change of the moment set as a result of the experiment is the time of 17 hours. The research covered the following jobs, for which the temperature was dominated by a combination of factors. After the grouping according to the duration of the test tasks, the results of the survey are given in Table 1.

In order to simplify mathematical processing and exclude the influence of dimensions on the coefficients, the value of the factor and the indirect indicators are centrifuged and normalized, whose numerical values are within:

$$-1 \le X_q;\ W_q \le 1;\ -1 \le Y_q \le 0$$

At the same time, the temperature of the comfort zone is taken as the basis (State standard of Ukraine).

Table 1

Benchmarks

Working hours, approx. unit	Working groups			
	1	*2*	*3*	*4*
	Temperature X_i, approx. unit			
	-0,2	0,14	-0,09	-0,05
	Response time of the worker, approx. unit			
-1	-0,18	-0,15	-0,14	-0,12
-0,7	-0,4	-0,39	-0,35	-0,32
-0,3	-0,37	-0,36	-0,32	-0,26
0	-0,4	-0,37	-0,34	-0,28

Sanitary norms of the microclimate of industrial premises (DSN 3.3.6.042-99), optimal and limit time of testing in the execution of special programs, its assessment of the developed methodology [4]. In [4], it is shown that the optimal value of the time of execution of test programs for operators is W^t_{opt} = 50 s., and the limit value W^t_{lim} = 68 s.

To evaluate the efficiency (fatigue) as a function of temperature, we will use an approximating polynomial not to a high degree:

$$W_x = a_0 + a_1 x + a_2 x^2 \qquad (5)$$

The most effective method in the tasks of estimating unknown parameters from the sample, which leads to simple calculations is the least squares method, which consists in minimizing the deviations of experimental points (values of test measurements) from the points calculated from the theoretical curve:

$$Q = \sum_{i=1}^{n} (W_i - W_i(x))^2 = \min \qquad (6)$$

Given that W_i (x) is from the expression (5), we write the condition (6) as

function of three variables

The solution of the system of equations (7) is found using a computer. The algorithm for obtaining the coefficients of the approximating polynomial P_m (X) is shown in Fig. 1, their numerical values are given in Table 2.

Table 2

Value of coefficients

Coeffic	Numerical values		
	-	-	-0,2
	0,	0,	0,1
	0,	0,	0,4

Substituting the values of these coefficients into equation (5), we obtain a new system of equations whose solutions give the value of W_i a working change. Graph of the function , approximated by the method of least squares, shown in Fig. 2.

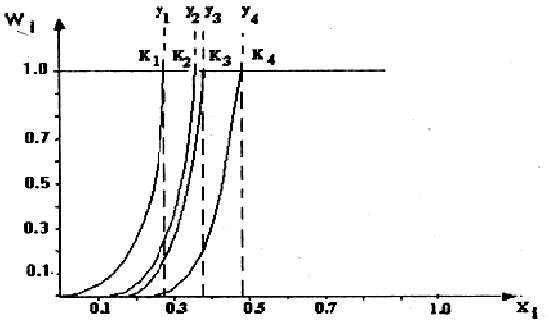

Fig. 2 Graph of confidence intervals

The limit value of the reaction of the operator W_{lim} is limited to a single straight line parallel to the axis of the abscissa. From the points of intersection K_1 of this line with the branches of the parabolic curves Y_i let down the perpendiculars on the axis X.

By performing these operations, we are able to establish confidence intervals of the influential factor.

For further analysis, we describe a family of circles with a radius relative to the points of intersection. It is known that the influence of factors on the human body is additive, and is determined by the value of the equivalent power of influence, that is, proportional to the square of the value of the parameters (4).

The value of influence (module) is based on the formula:

$$\| R \| = \sqrt{y^2 + x^2}, \quad (8)$$

where R– influence (integral parameter), conditional units.

Since we have a single straight line, then R = 1.

We solve expression (8) with respect to the parameters (y, x), we obtain numerical values, the values of which are given in Table 3.

Table 3

Numerical values

R	X	Y
1	0,28	0,83
1	0,38	0,79
1	0,39	0,73
1	0,49	0,72

Conclusions

As a result of the research carried out for the integrated assessment of factors affecting the person who form the working conditions in the workplace, it is possible to draw the following conclusions:

- the theory of criterion estimates is developed; it is suitable for practice;
- by the boundary curves it is possible to determine the length of working time for specialists of different professions under the conditions of maintaining the normal working conditions, which do not have a harmful effect on the health of the worker.

Together with the operational information on the person's psychophysiological state (health) and working conditions (factors that form it) in the work area in the database of the upper level of the system of management of industrial health and safety [6, 7] should receive the results of professional selection conducted medical examinations. Integrated electron computing processing of these information flows on the basis of comparison with the normative base will allow to have a dynamics of changes in the organism of each member of the team in the previous period, to predict the duration of the labor process, to set the timing of periodic reviews in time, taking into account occupations, age groups, and others.

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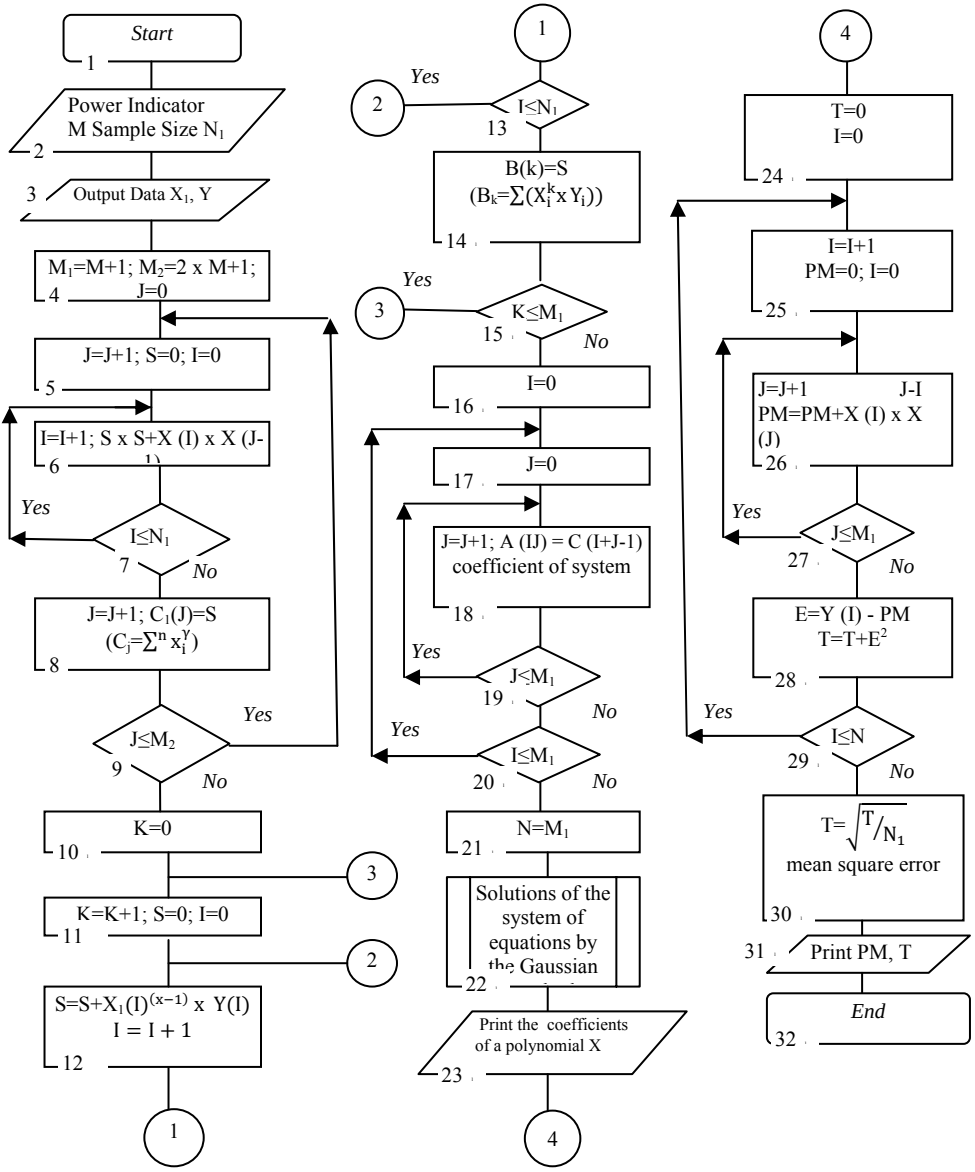

Fig.1. Approximation algorithm