

SECTION 2. Applied mathematics. Mathematical modeling.

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ASSESSMENT METHODS AND ALGORITHMS OF ENGINEERING EMPLOYEES' LABOUR POTENTIAL IN THE PROBLEMS OF PERSONNEL MANAGEMENT

***Abstract:** The paper considers the problem of assessing labour potential of engineers. The methods of decision support in the process of the assessment of engineers' labour potential is proposed. It is based on the methods of the system analysis, mathematical statistics and the theory of expert evaluation.*

***Key words:** labour potential of engineering and technical personnel, assessment of personnel, information system, expert evaluation.*

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Introduction

The lack of qualified engineering staff is among the staffing problems of the economy. It is important to carry out an integrated approach to the assessment to solve the problems of modernization of the economy, selection and professional development of the engineering employees as it is said in the Presidential professional development program of engineering staff. Professional competency requirements should take into account some specific nature of engineering and peculiarities of different economic sectors. So the development and implementation of new assessment methods and algorithms of engineering employees' labor potential are among scientific and practical tasks.

The greatest challenges of receiving the reliable figures comprise: the complicity of the development of the accurate engineering activity model due to impossibility of parameterization; engineering and management activities are evaluated by quantitative variables more than qualitative ones; there can exist a great estimation error because of the human factor; engineering activity is continuously changing because of the innovations in the technologic operations.

The process of the estimation of an engineering employee can be split into the following main stages:

- 1) Determination of estimation dimensions, the selection of scale.
- 2) Using selected values to evaluate the nominees.
- 3) Formalization of the received assessments, finding consistency between indicators.
- 4) Taking decision on the assessment results.

The problem of the assessment of engineering employees' labour potential by use of expert methods is considered hereafter.

Problem statement

Suppose there exists a set of nominees $Y = \{y_1, y_2, y_3, \dots, y_n\}$ to define the level of labour potential. Each nominee has a lot of competencies $\bar{K} = \{k_1, k_2, k_3, \dots, k_{\gamma_4}\}$ that determine the extent of labour productivity. Labour productivity has a set of key performance indicators $E = \{e_1, e_2, \dots, e_l\}$. Each indicator has one of the levels $L = \{L_1, L_2, L_3\}$ “high”, “mid” “low” respectively. The aim is to take a quick and grounded decision on the adequacy for the engineering activity.

The solution to the problem can be split into three sub problems:

1. Determine the structure of the indicators to assess engineering employees' labour potential.
2. Offer assessment algorithms of engineering employees' labour potential.
3. Develop a method of support in taking decisions in the process of assessment of engineering employees allowing the decision maker to draw conclusions about nominees for appointment.

Define the structure of indicators to assess engineering employees' labour potential.

Let us consider the engineering employees' labour potential in the focus of four groups of competencies: professional (including professionally important qualities and special competence ones); social and communicative ones; personal ones; cultural ones. Let define them as $\bar{K} = \{k_1, k_2, k_3, \dots, k_{\gamma_4}\}$. We have $\bar{K}_1 = \{k_1, k_2, \dots, k_{\gamma_1}\}$ – the first group of competencies (professional ones); $\bar{K}_2 = \{k_{\gamma_1+1}, \dots, k_{\gamma_2}\}$ – (the second group of competencies (social and communicative ones); $\bar{K}_3 = \{k_{\gamma_2+1}, \dots, k_{\gamma_3}\}$ – the third group of competencies (personal); $\bar{K}_4 = \{k_{\gamma_3+1}, \dots, k_{\gamma_4}\}$ – the fourth group of competencies (cultural).

The result of employee's activity can be evaluated by l key performance indicators and the nominees can be classified due to the results of effectiveness. Denote by $E = \{e_1, e_2, \dots, e_l\}$ a set of key performance indicators. Each indicator has one of the levels $L = \{L_1, L_2, L_3\}$ – “high”, “mid” “low” respectively. On the basis of a set of effectiveness indexes and initial vector of indexes there appear competencies affecting the extent of a nominee's adequacy for the job. The result is a vector $\bar{K}' = \{K'_1, K'_2, K'_3, K'_4\}$ – the level of a nominee's adequacy for the engineering activity. It is rested on the most informative indicators and due to the force of influence a peculiar weight number can be assigned to each group of competencies.

The evaluation procedure of engineering labour potential by the results of professional activities presented below has been developed on the basis of the proposed structure of the indicators.

Let us develop an assessment algorithm of engineering employees' labor potential, considering restrictions.

It is necessary to collect information about the nominees in terms of efficiency As one of the initial steps. Production volume, penetration rate, the amount of overburden, the periodicity of the plan, the amount of stimulations (penalties) for the reporting period, the frequency of accidents, downtime, etc. can be viewed as efficiency indicators. As a result, employees with best and average indicators are selected. With an expert assessment of the level of competences we get recommendations on professional development, training, retraining, enrolling in a personnel reserve or rejecting a candidate. It should be noted that the analysis of the effectiveness of the candidate's probationary or training is almost impossible and then this step of the algorithm is omitted. To select the experts the method of snowball sampling is modified in order to form an expert group from among people most knowledgeable about professional activity of a specialist. The detailed description of this method and modification is presented in [1, 2, 3].

The discordance of opinions analysis is run after the evaluation of the employee by a group of experts. Biased experts formalizing given procedure or having little knowledge on the professional activity of the person being assessed are brought to light while analyzing the discordance of opinions. For this purpose, *coefficient of variation* CV and Cronbach's Alpha [4, 5].

Key performance indicators are set for each employment (KPI). Their values refer each nominee to one of the three levels $L = \{L_1, L_2, L_3\}$ of engineering activity effectiveness. Here L_1 is a «high level», L_2 is a «middle level», and L_3 is a «low level» respectively.

In each group of nominees classified by performance indicators it is necessary to analyze assessment by competencies. So the competencies not affecting actual labour result are not taken into account when defining the value of the employee's performance potential. The description of the developed method is presented below.

The results of the assessment of nominees of each group after the expert opinion consistency and defining a vector $R'_x = (r'_1 \dots r'_{\gamma_4})$ can be presented as a matrix R'_E . Here p is number of performance class, matrix rows represent the assessment of a nominee, the columns show the assessment of each competency, n_p is a number of nominees included in p class.

For each matrix column there is a coefficient of variation characterizing relative deviation measure of an individual value from the average.

After excluding those competencies which coefficient of variation is greater than permissible value there appears a vector $K' = \{K'_1, K'_2, K'_3, K'_4\}$. Here K'_1, K'_2, K'_3, K'_4 – are additive convolutions on tangible parametric variable of each group of competencies.

Result vector K' is assigned to the value of Φ – that is the level of employee's labour potential [6].

$$\Phi = \sqrt[A_1 + A_2 + A_3 + A_4]{K'^{A_1}_1 K'^{A_2}_2 K'^{A_3}_3 K'^{A_4}_4}, \quad (1)$$

here A_1, A_2, A_3, A_4 are weight numbers of competence groups.

The advantage of this approach is that there is no simple data averaging of different qualitative characteristic groups of competences and it excludes the compensation weak competencies by stronger ones.

Let us develop a method of support of taking managerial decisions to define the extent of coherence to the job profile so that the restriction is satisfied.

The process of taking managerial decisions on the results of the assessment made is implemented in four stages:

- 1) The formation of the job profile
- 2) The selection of the nominees suitable for the job
- 3) Comparing of actual estimate with the reference profile
- 4) Processing of the received data

First the job profile is formed – «reference» presentation of the nominee on the basis of expert opinions and company's needs. For the corresponding assessment data bank the values and (or) the levels of development for each competency are presented; potential limits Φ_{\min} and Φ_{\max} are calculated on low bound of the meanings and their supremum for the relevant competence level in accordance with formula (1). Then the selection of nominees is implemented with their potential to fall within the range $(\Phi_{\min}, \Phi_{\max})$.

At the third stage we define the coherence of the received assessments with the job profile. We make ranking on pre-set reference meanings of competence levels or their values for that. In the case of level coherence (numerical values) the smaller rank is assigned to the competence that has the greatest weight number.

The assessment of coherence of the actual and reference ranks is done on the basis of Spearman's rank-order correlation and that of Kendall's. Spearman and Kendall's coefficients characterize the degree of similarity of this given rank to the one taken as reference, and take values in the interval $[-1, 1]$. Values of the coefficients in connection with the defining the coherence of the nominee to the job profile are interpreted as follows [7, 8]. Positive values of the coefficients indicate the presence of coherence of getting the rating in the criteria range $(\varphi_{\min}, \varphi_{\max})$ and that of required degree of competence. In the case of negative values, we can conclude that despite the sufficing of potential value (rating) to the criteria its value is received due to those competencies that have greater rank.

The proposed method of decision taking support is implemented in information system of engineering employees' comprehensive assessment «SKO ITR». It allows to make validated assessment rapidly and to get reliable data on the connection between the level of competence and performance indicators [9, 10]. The information system includes a database, knowledge base, and four functional units (subsystem): user registration module, testing module, nominees' estimation module, decision-directed module.

The proposed methods and algorithms provide the arrangement and taking grounded decisions when selecting a nominee for the given employment. Besides the conclusions made help to find out problems and to define the content of the professional development programme for each employee. The improvement of the quality of assessment and selection of engineering employees is achieved by means of management of the engineering labour potential assessment process. It allows to cut the time of result analysis, to make intellectual analysis of data and minimize possible mistakes while taking managerial decisions.

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