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TO THE PROBLEM OF FORMALIZATION OF MANAGER PARAMETERS FOR THE DEVELOPMENT OF AUTOMATED CONTROL SYSTEM BY ENERGY FLOWS OF IRON ORE MINES

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Abstract. *Purpose:* development of theoretical aspects for the formalization of control parameters of the target function of the algorithm functioning of the automated control system (ACS) of energy flows of iron ore mines.

Methods: in this article, the method used for the main components, the method of «compression» of the outgoing information.

Scientific novelty: the method of forming the target function as an input parameter for the operation of the algorithm of control of electric power flows of iron ore mines is developed.

Practical significance: the tactics of the formation of input parameters for the operation of the scheme of the ACS of power flows is developed.

Results: the article presents the aspects of theoretical justification for the creation of a method for optimal management of electric power flows of iron ore mines by introducing an automated power flow control system.

It is noted that the expected level of electrical energy efficiency of iron ore raw materials (IORM) in the conditions of underground iron ore enterprises is achievable by introducing in their practice the work of the ACS general energy flows in general and the ACS in the electric power flows in particular. To develop the structure of the ACS it is necessary to have real control parameters and levels of influence on them of a complex of technological factors of enterprises. Existing theoretical methods do not allow obtaining the required quality of such factors.

It has been proved that the amount of electricity consumed by modern iron ore enterprises has changed little over the years, but tariffs for consumed energy are constantly increasing. This leads to an increase in the cost of extraction of this type of minerals. According to the protocols of the contracts for payment for consumed electricity, generating companies set for consumers daily tariffs for the released electricity. The daily electricity tariffs are used as inputs for the target function to obtain formula-solutions for minimizing the price according to the existing daily tariffs and maximize the change in the electrical loads of energy consumers in the preferential periods of the day. In the scenario of the electric power industry of iron ore mines of the Kryvyi Rih iron ore basin, the possibility of applying theoretical justifications for modelling the modes of electric streams in the hours of the day with the subsequent inclusion in the algorithm of the functioning of the ACS power flows is shown.

The methodology of further formalization of control parameters for the development of an ACS by energy flows of iron ore enterprises is proposed. This approach allows, by compaction of experimental data, and without introducing system-leading influential simplifications into the process of this process, to form input parameters for the development of an algorithm for the functioning of ACS by the energy flows of these types of enterprises.

Key words: automation, management, power flows, mining enterprises.

Introduction. The products of the mining and metals industry (IORM, cast iron) are the main product of Ukraine's exports [1,2].

Ukraine confidently is one of the top ten world leaders in the production and export of IORM.

The enterprises of the domestic mining and metallurgical industry successfully compete with their foreign counterparts.

Meanwhile, in recent decades due to a number of objective reasons, the cost of extraction of IORM by domestic ore mining enterprises is increasing year by year, and the cost of this type of minerals in the international market of raw materials, on the contrary, has tended to decrease [2].

It is logical that without solving the problem of reducing the annual growth of the cost of mining IORM by mining enterprises of Ukraine it will not be possible to retain leadership in the international arena of this type of minerals.

Materials and methods. In Ukraine, vendible iron ore is extracted in 11 underground enterprises (mines, industrial complex) and 6 mining and concentrating industrial complexes (GOKs).

More than 85% of domestic iron ore raw material is produced in the Kryvyi Rih iron ore basin, where the development of iron ores has been in progress for more than 140 years.

Mining enterprises of the Kryvyi Rih iron ore basin are still the main base of iron ore industry in Ukraine.

Meanwhile, the conditions for the extraction of IORM over the years become more complicated.

The main reason for this situation is lowering the levels of mining operations.

In the current period IORM at depths of 1500-2000 m.

Together with a decrease in the level of mining operations, the technical and economic indicators of the production of IORM deteriorate.

This, above all, is due to the shortage of new mining technologies and the lack of highly efficient mining machines and mechanisms.

All these factors have a negative impact on the efficiency of the operation of mining enterprises, including the increasing in time for the preparation of new underground horizons and do not allow increasing the efficiency of the production of IORM.

In fact, in the last decades, unlike 80-ies of the 20th century, mining costs IORM have increased and continue to grow on entire domestic iron ore enterprises without exception [2].

The specific gravity of the components of the entire complex of costs is also changing [3]

If the cost of extraction of 1 ton of iron ore (Hryvnia currency) grew by 72% from 2012 to 2016, then the share of the cost of electric energy in this complex indicator grew by 81%.

That is, obviously an imbalance in the ratio of price indicators.

This is explained by a combination of both natural and artificially created factors.

These factors need to be known and evaluated, as they are particularly important for further research in the pursuit of scientific research within the framework of the analysed direction.

At the same time, continuing analysis of the components of all the same cost of extracted IORM, while not departing from the previously declared purpose of scientific research, note the fact that the cost of all domestic plants without exception with underground mining has a direct connection with the volumes of energy consumed (Fig. 1) [2,3].

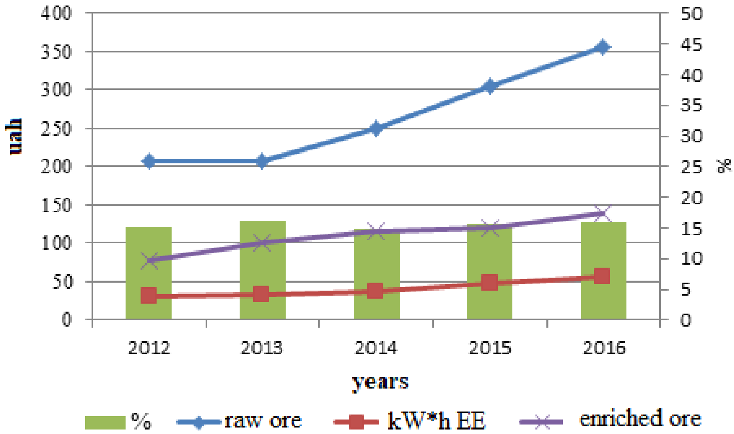

Figure 1. Indicators of the segment of electric power consumption in the cost of extracted IORM for iron ore mines of Ukraine

Moreover, and in this aspect, iron ore enterprises are unique, since about 90% of the total energy consumption for the production of IORM is made up of electricity, that is, electric energy (Fig. 2).

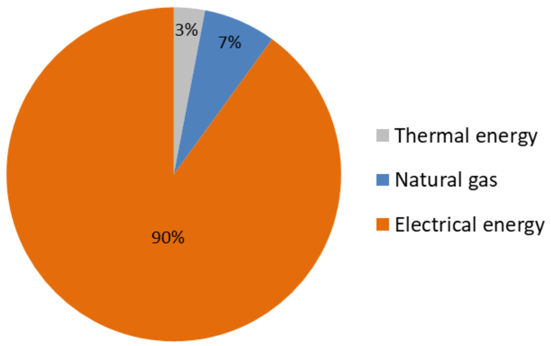

Figure 2. Diagram of energy inputs of iron ore enterprises of Ukraine with underground mining of IORM

Moreover, in recent years, the share of electricity consumption during the extraction of one ton of crude ore by underground has increased by almost 20% [3].

It is important to note that, with the general reduction of IORM on all mining plants of Ukraine without exception, as compared to 1990, the volume of electricity consumption (EC) for the analysed years practically remained unchanged, staying at 350 million KW a year.

Meanwhile, the volume of natural gas consumption by all, without exception, iron ore enterprises of Ukraine, since 2003, is constantly (annually) reducing [3].

In connection with this, the practical need of domestic mining enterprises in developing energy-efficient strategies, projects and programs with an emphasis on increasing the power sector's direction of solving this global problem is growing.

This, as a structure for the future, prompts the ISO 50001 Standard for Energy Management, which is a relatively new standard.

It is worth pointing out that iron ore companies are beginning to invest in energy management systems (En MS), which in turn are based on this standard, to obtain the necessary information on the energy of the enterprise and to control the levels of energy use, or rather optimal redistribution of energy flows [4-14].

To achieve the goal, it is firstly necessary to determine the range of influential factors, their parameters and sources of manifestation of such a state.

It is the level of reliability of the estimation of these parameters, taking into account the ranges of their possible fluctuations, to determine the level of reach of the potential of the measures taken – the project to improve the energy efficiency of a particular enterprise.

As is well-known [4,5], the most significant contribution to the level of energy intensity of extraction of IORM is primarily in the area chosen by one or another mining technology enterprise.

However, this direction is not the subject of research data. In the context of this scientific research, we will focus on solving the problem of increasing energy efficiency of mining enterprises in the framework of already existing technologies.

Such an approach seems expedient because there is no plan for the next 20-30 years to build a new underground iron ore mine in Ukraine.

A number of scientific studies are devoted to the search for ways to reduce energy consumption during the extraction of IORM [4-14].

The results of the researches carried out in one or another degree of scientific research have allowed the domestic mining industry to restrain for some time a definitely negative, but logical, process of increasing energy expenditures in the extraction of IORM.

However, the problem has not disappeared, but on the contrary, a number of certain reasons have acquired new negative points. The current functioning of iron ore enterprises requires a new approach for solving the problem of a new logic for their solution.

Meanwhile, the most of the known scientific studies were conducted and tested in conditions for the extraction of IORM at depths up to 1000 m, which has become a history in the functioning of these enterprises.

It is clear that the volumes of EC at such depths, and hence their level of influence on the general indicators of the cost of IORM, grow and will grow in the future.

There is only way out – based on the results of well-known scientific research, to conduct additional research in the contemporary way of searching for new modern and sufficiently effective solutions.

The main directions of the solution of this problem in the author's version of the vision are defined and highlighted in a number of publications, including [3,5].

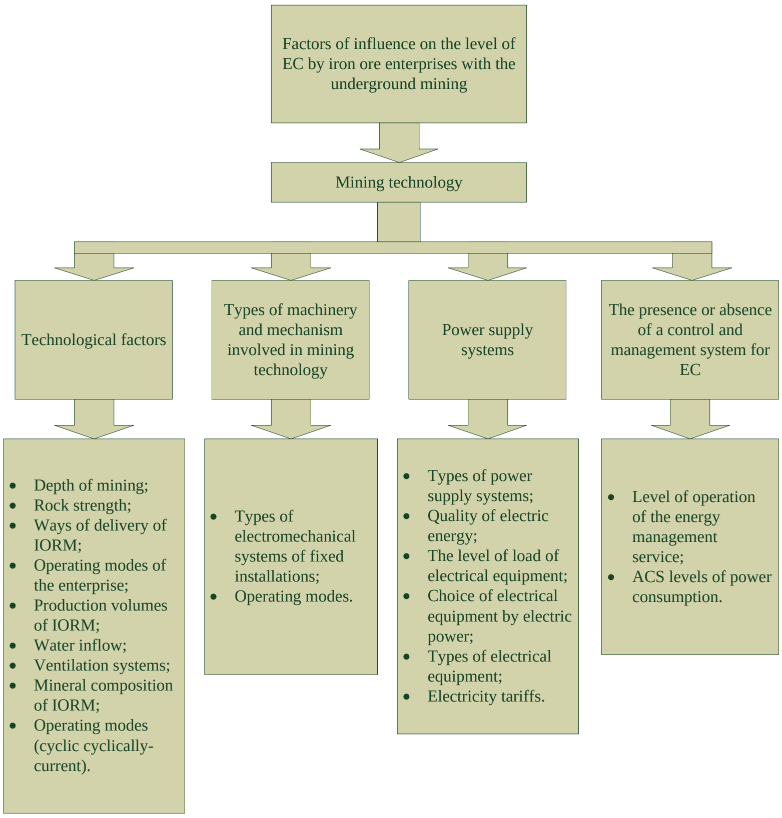

Figure 3. Structural reflection of the main factors of influence on the level of EC by mining enterprises with underground mining methods of IORM

In fig. 3. the structure of the influence of a number of technological and technical factors at the level of EC is presented.

A number of directions indicated in this structure are «coming into life».

As objective reality in the analytical direction of scientific research, we note that in assessing the current economic situation and the tendency of constant growth of electricity tariffs, mining companies, as enterprises with continuous cycle technology, have somewhat rebuilt the operating modes of their electricity consumers in the last 10-15 years.

First of all, these are the terms of operation of the complex of energy-consuming electric energy receivers, transferring them, in accordance with the technology of mining, into preferential economic zones of the day, which are differentiated as «peak», «semi-peak» and «night» hours (Fig. 4)

It is such a «division» that determines tariffs for EC according to the prices for certain times of the day.

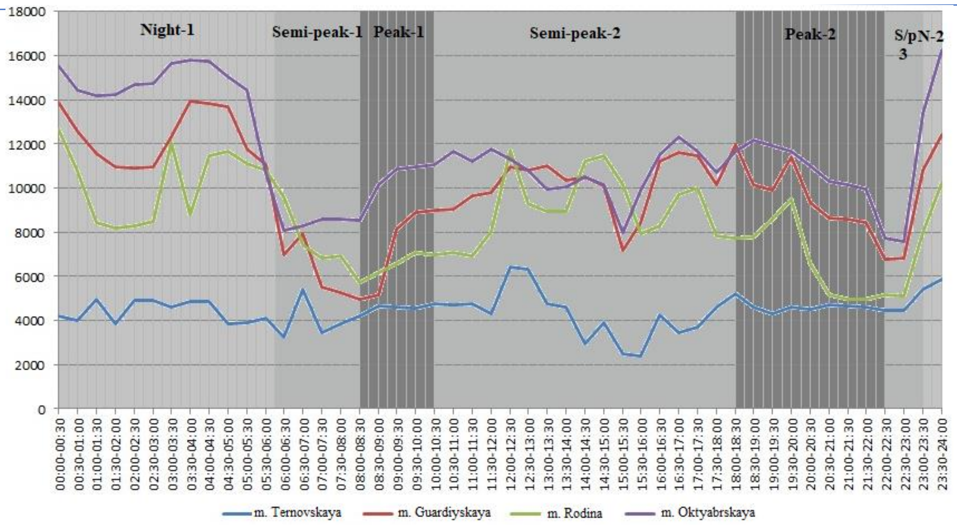

Figure 4. Dynamics of EC by iron ore mines Kryvyi Rih iron ore region

In the context of such a solution, the automated system for monitoring the levels of electricity consumption has been introduced and successfully operates at the enterprises of the industry.

However, today only to control the level of EC is not enough, today it is necessary to manage this process.

Meanwhile, the level of EC as the object of management represents a complicated multifactorial complex of varying levels of influence of various factors.

Moreover, often there is a fact of uncertainty and incompleteness of input information for the development of a complex of filling of control parameters.

For the time being, the theoretical methods of estimating the processes of the electric power system of electricity supply-electricity consumption, for a number of reasons, do not adequately take into account the probabilistic and statistical nature of the processes of significant levels of fluctuations in the modes of electrical loads, the energy intensity of technological processes, balances and electricity consumption, and the impact on them of a multitude of mining-technological, climatic-meteorological and other factors of the ore production [5-17].

Therefore, for the «purity» of obtaining the appropriate amount of input data, it is expedient to conduct a complex of large-scale and time-consuming experimental studies of EC regimes at the existing iron ore enterprises.

Such studies were conducted with the participation and under the management of author Sinchuk I.O., and a team of authors and energy services. The results of these studies have once again confirmed the discrepancies between the «theory» and «practice» in estimating the modes of EC by mining enterprises [3].

In this regard, based on the results of statistical analysis of experimental studies, it is advisable to put forward such ideas:

1) EC of iron ore mines depends on a significant number of influential factors. Influence of factors on the process of electricity supply (ES) has a complex and diverse character, the description of which within the framework of both deterministic and classical statistical methods is not always possible due to unpredictability of conditions that determine the effect of factors. In this regard, it can be stated that ES of mining enterprises is formed under the influence of factors whose prediction of influence is not sufficiently reliable. A large number of diverse factors represent some difficulties in assessing their impact on EC in both methodological and technical and economic aspects.

2) Information on the process of EC contains various sets of empirical data and characterizes its multidimensional random features. A significant number of features make it difficult to identify links between features. In this case, a description of the ES is required by a smaller number of generalized characteristics, which reflect the internal objectively existing patterns that are not directly observable.

3) These features lead to the need to use methods for estimating the states of EC regimes of mining enterprises, which allow to obtain solutions in the conditions of incomplete information when the size of the raw data («compression» of information) of the investigated process decreases. In this case, the task arises to analyse the data on electrical energy, the solution of which is based on the use of methods of factor analysis and the establishment of the typology of the objects under study.

4) In this aspect, the assessment of the state of the process of EC with all the diversity of analysis models relies on the situation, which is that in the examination or experiment, when the empirical material contains a large number of parameters, many of which are combined correlation links between itself This is explained by the fact that the observed «external» parameters only indirectly characterize the process of EC. Along with the large number of these «external» parameters (factors) there is a small number of «internal» (essential) parameters that are difficult or impossible to measure, but they determine the behaviour of «external» parameters. Finding these hypothetical essential parameters is the purpose of the analysis of the state of the process of EC.

5) Based on the above-mentioned positions, it is possible to distinguish between the various sets of parameters that determine the process of EC. Among these sets are groups of factors of mining-geological, mining-technological, climatic-meteorological, electric power, organizational nature.

Such parameters (factors) of the mining and technological group as the depth of occurrence, the size of the deposits, the temperature of the rock masses, the type of technology, the parameters of the systems of opening and development, types of machines used and equipment, etc., affect the power consumption of products. Climate-meteorological factors determine the seasonality of EC, forming the annual trend of its change. Electricity factors – structural parameters of electric circuits, quantity, power, efficiency factor of electric collectors, etc. – cause formation of modes of electrical loads. Organizational and operational factors determine the degree of use of electrical equipment, the level of increased electricity losses due to deterioration of the characteristics of electrical equipment, machinery and mechanisms.

There are a number of methods for estimating the levels of EC [16-19]. The essence of these methods is that with the help of orthogonal transformations, the best projection of the set of points of observation in the space of smaller dimension is located. At the same time, the newly obtained vectors are distributed in the transformed space: in the method of the main components (MMC) – on the criterion of maximum dispersion; in the Karunen-Loev expansion (KLE) – on the criterion of the minimum of the mean square error. Thus, KLE decomposition provides an opportunity to represent the most stable state of the system, which meets the minimum of the mean square error, and the MMC allows a smaller number of vectors than the original, to describe the maximum dispersion of the system, that is, to give the most probable boundaries change the original experimental matrix. It is logical that this tactic is the operation of methods with the general idea of «compressing» the source information [18].

For the application of compression methods, the source information about the ES should be presented in the form of a matrix:

$$X = [X_i] = \begin{matrix} X_{l1} & X_{1j} & X_{1m} \\ X_{i1} & X_{ij} & X_{im} \\ X_{n1} & X_{nj} & X_{nm} \end{matrix} , \qquad (1)$$

where $[X_i]$ – vector row that displays information about EC at i-this meaning of the sign; X_{ij} – value of the EC of the I-th characteristic of the J-th dimension (object); i = 1, n – number of values of the sign; j = 1, m – number of measurements (objects).

In this case, it is permissible to describe the power consumption as an n-dimensional vector. When modelling the process of EC with the help of the KLE, the main transformations are the following.

In the real process of EC distinguish the characteristic orthogonal (independent) components (representative vectors) describing the power consumption in a space of lesser dimension when extracting from the results of observations maximum information. This procedure is performed by linearly transforming the coordinate system of the output n-dimensional vector of EC X according to the equation:

$$X = A \cdot Y , \qquad (2)$$

where A – the transformation matrix, $A = \{a_{ij}\}$, $i, j = I, n$; Y – representation of an n-dimensional vector describing the process of the EC in the space of new variables $Y = \{Y_{ij}\}$, $i = I, n, j = I, m$; I – unit matrix.

The transformation matrix A is located on the output matrix X and represents n eigenvectors of the covariance matrix K_x:

$$K_X = \begin{matrix} K_{l1} & K_{1l} & K_{1n} \\ K_{i1} & K_{il} & K_{in} \\ K_{in} & K_{nl} & K_{nn} \end{matrix}, \quad (3)$$

where K_{il} – selective moving estimates of elements of the covariance matrix, which are defined by the expression:

$$K_{IL} = \frac{1}{m-1} = \sum_{j=1}^{m} \left(X_{ij} - \bar{X}_i\right) \cdot \left(X_{lj} - X_l\right), \quad (4)$$

where x_j, x_l – are secondary j-th and l-th components n-dimensional vector of power consumption X.

The eigenvectors U_i of the matrix K_x are contained in the eigenvalues λ_{ki} of the equation:

$$K_x \cdot U_i = \lambda_{ki} \cdot U_i, \quad (5)$$

Own numbers result from the solution of the equation:

$$K_x - \lambda_{ki} \cdot I = 0 \quad (6)$$

To observe the condition of orthonormalization it is necessary to perform the normalization of eigenvectors, after which the transformation matrix is obtained:

$$A = [A] = \begin{matrix} a_{l1} & a_{1r} & a_{1n} \\ a_{j1} & a_{ir} & a_{in} \\ a_{n1} & a_{nr} & a_{nn} \end{matrix}, \quad (7)$$

When the orthonormal condition is satisfied, the vector in the space of new variables is determined by the matrix equation:

$$Y = A^T \cdot X \quad (8)$$

The following conditions are met.

Representative vectors Y_j are uncorrelated; therefore the following condition is fulfilled:

$$\left\{\left(Y_{ij} - \bar{Y}_j\right) \cdot \left(Y_{lj} - \bar{Y}_l\right)\right\} = \begin{cases} \lambda_i atl = 1 \\ 0 atl \neq 1 \end{cases} \quad (9)$$

Mean-square error when using to represent the vector X is minimal for only N first representative vectors Y_j ($N<n$) is:

$$\bar{\varepsilon}^2 = (N)_{min} = \sum_{i=N+1}^{n} \lambda_{ki} \quad (10)$$

Thus, for the investigated process of EC, the model of «brief» information has the form:

$$X_{ij} = \sum_{r=0}^{n} a_{ir} \cdot Y_{rj} \quad (11)$$

When modelling the process of EC using the PCM, the main pre-formations are as follows.

The values of the matrix of the initial data on the ES process are standardized and a standardized matrix is obtained:

$$Z = \{Z_{ij}\}$$

$$Z_{ij} = \frac{X_{ij} - \bar{X}_j}{\delta_j}, \quad (12)$$

where X_j – the average value for the column j; $\bar{\delta}_j$ – the mean deviation of X values in column j.

New variables are as uncorrelated normalization of linear combinations of output characteristics. In the matrix form we have:

$$F = B^T \cdot Z, \quad (13)$$

where F – matrix of new variables (main components)

$$F = -\{f_{ij}\};\ i = \bar{I}, \bar{n};\ j = \bar{I}, \bar{m} \quad (14)$$

B – transformation matrix

$$B = A \cdot \lambda^{\frac{1}{2}} \quad (15)$$

where A – the orthogonal matrix in which the r-th column is the r-th eigenvector corresponding to the r-th eigenvalue of the correlation matrix R_x; λ – diagonal matrix, on the diagonal of which are the eigenvalues of the correlation matrix of the R_x vector X.

The elements in the matrix λ are arranged in descending order:

$$\lambda_1 \geq \lambda_2 \geq \lambda_3 \geq ... \geq \lambda_m \geq 0 \quad (16)$$

New variables are located in the space of signs in descending order of their variances, i.e.:

$$\delta^2(f_1) \geq \delta^2(f_2) \geq ... \geq \delta^2(f_n), \quad (17)$$

where f_1, f_2 ... f_n – respectively, first, second, n-th main components.

For the research process, the model of «brief» information will look like:

$$X_{ij} = \sum_{r=1}^{n} bir \cdot f_{ij}, \quad (18)$$

where n – the number of main f_{ir}, components that contribute to the overall dispersion with sufficient reliability is given.

By approximating the transformation vectors (A_r,B_r) and representative vectors Y_r (the main components f_r) by analytic functions, we obtain adequate models of the process of EC:

$$F_{xij}\left(\gamma_a \varphi_y\right) = \sum_{r=1}^{n} \gamma_a, r_i(T) \cdot \varphi_{Yrj}\ , \qquad (19)$$

where γ_a, φ_y – analytic functions approximating the vectors A_r and Y_r, including into the matrices A and Y respectively.

The described procedures give an opportunity in the conditions of uncertainty and weak information of the observed signs that determine the process of EC, the most complete use of the initial statistical information for the estimates that adequately describe all the options for EC.

As the research shows, a large number of processors of mining enterprises form energy regimes that have a heterogeneous (in terms of probability distribution) character. In this case, the probability distribution of the values of the attributes of the original statistical information and the transformed («compressed») information about the EC processes are polymodal. This circumstance introduces certain difficulties in modeling EC processes .

In the case of a non-uniform power mode of operation of electrical consumers (with polymodal distribution of electric load values), it is advisable to perform EC modelling with selection of stable levels from the entire load change area, around which mean individual load values change with a certain degree of dissipation.

To implement this procedure, it is advisable to apply a statistical classification based on sampling observations and allows you to bring a lot of the observed load values into the system of ranked levels (classes).

The task of classifying electrical loads at the level falls into two: the allocation of the number and properties of classes in the space of images of loads; identification of random values of loads, that is, their assignment to one of the classes.

To isolate classes from experimental samples, it is necessary to generate hypotheses using cluster analysis.

The selection of the number and properties of clusters in the space of changes in the images of electrical loads represented by: polymodal samples, is associated with uncertainty, since the clusters are not sufficiently spaced. In this case, the generation of hypotheses should be carried out as follows.

By the nature of the distribution and the number of sample modes that characterize the electrical load, the number of clusters is established.

In order to identify the random values of loads as a group measure of intimacy, the intragroup sum of the squares of deviations between each image and the mean of the cluster is taken. The quality of clustering is ensured by minimizing the selected proximity measure:

$$y = \sum_{i=1 xeep}^{n} \sum \left\| x - m_i \right\|^2 = min\ , \qquad (20)$$

where n – the number of clusters; P_i – the set of images included in the i-th cluster; X – the vector of electrical load measurements; m_i – the vector of sample means for the set P_i.

Clustering electrical loads according to the above scheme allows you to get a lot of sustainable load levels and the time of their action:

$$P = \{P_1, P_2, ..., P_n\} \qquad (21)$$

$$t = \{t_1, t_2, ..., t_n\} \qquad (22)$$

The definition of EC modes changes the traditional understanding of the nature of the distribution of electrical loads in the form of a normal, underlying calculation method for determining electrical loads.

In connection with an unconventional representation of EC modes, it is necessary to consider general expressions for determining the values used in the calculations of electrical loads.

For the electric power consumption for the considered period (for example, one shift) taking into accounts the received: sets it is possible to write down:

$$P_c \cdot t_{st} = \sum_{i=1}^{n} P_i \cdot t_i\ , \qquad (23)$$

where P_c – the average electric load per shift t_{st}.

The distribution of the left and right parts on the P_{nom} $*t_{st}$ also introducing the notation: P_c = P_c/P_{nom}, we obtain:

$$P_i^* = \frac{P_i}{P_{nom}}; t_i^* = \frac{t_i}{t_{st}}; K_r = \frac{P_i^*}{P_i}, (r = 2,3,...,n), \qquad (24)$$

and taking for the maximum load level P, we have:

$$P_c^* = P_1^* \cdot t_1^* + K_2 \cdot P_1^* \left(1 - \sum_{t=1;t\neq 2}^{n} t_i\right) + ... + + K_n \cdot P_1^* \left(1 - \sum_{t=1;t\neq 2}^{n} t_i\right) \qquad (25)$$

or

$$P_c^* = P_1\left[t_1 + \sum_{r=2}^{n} K_r \cdot P_1^*\left(1 - \sum_{t=1;i\neq r}^{n} t_i\right)\right] \quad (26)$$

The obtained expression (26) allows us to describe the electric load modes for power consumers with a non-uniform nature of work in the form of a multi-level additive model and compare the theoretical calculations obtained with the experimental one.

The described procedures of theoretical conclusions make it possible to evaluate the processes of EC, sufficient for visual perception, as separate technological mechanisms, and of a particular mining enterprise as a whole, and may be acceptable for the implementation of basic ideas when developing an algorithm for implementing an ACS of iron ore energy sources

Results. The article presents aspects of a theoretical justification for the creation of an optimal methodology: the management of electric energy flows of iron ore mines.

It is noted that the expected level of electrical energy efficiency of IORM mining in the conditions of underground iron ore enterprises is achievable by introducing into the practice of these types of enterprises ACS energy flows. For the development of the structure of the ACS, it is necessary to have real control parameters and levels of impact on them of a complex of technological factors of enterprises. Existing theoretical methods do not allow obtaining the required quality of such factors.

The scenario of the electric power industry of the iron ore mines of the Kryvyi Rih iron ore basin shows the possibility of applying theoretical justifications for modelling electric flow regimes in the hours of the day with the subsequent inclusion of energy flows into the algorithm of functioning of the ACS.

It has been proven that the consumption volumes of electric energy by modern iron ore enterprises change insignificantly over the years, but the tariffs for the energy consumed are constantly increasing. This leads to an increase in the cost of production of this type of minerals. According to the protocols of the contracts for the payment of consumed electricity, generating organizations set daily tariffs for consumers for the type of electricity they receive. It is the daily electricity tariffs that are used as input data for the objective function in order to obtain solution formulas for minimizing prices according to the existing daily tariffs and maximize the change in electrical loads of consumers-energy regulators during preferential periods of the day.

Based on a set of experimental studies, a methodology is proposed for further formalization of control parameters for the development of an ACS for iron ore enterprises.

Such an approach allows, by compiling experimental data and without introducing system-forming influential simplifications in the procedure of this process, to form input parameters for the development of an algorithm for the functioning of an ACS for the energy flows of these types of enterprises.

Conclusion. 1. The development of the algorithm for managing the levels of control of the flow of electricity in the conditions of iron ore mines should be based on the results of a statistical analysis of the functioning of the energy complex: electricity consumption and electrical supply as a function of a number of technological parameters of each individual enterprise.

2. The tactics of processing and analyzing numerous experimental studies of the levels of electricity consumption by iron ore enterprises should be accompanied by methods of «compressing» initial information about the levels of electricity consumption, which will correctly reduce the amount of information for selecting control solutions in the software implementation of the ACS for energy flows.

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