 https://doi.org/10.1051/e3sconf/202341703015

Expanding the level of forecasting and operational planning of electric consumption at mining enterprise

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Abstract. To calculate the energy consumption of open pits or enterprise as a whole without determining all components of the specific consumption of electricity it is advisable to use a method based on the use of models of power consumption regimes found by the results of multivariate regression analysis. The results of research can serve as a basis for making recommendations for increasing the level of forecasting and operational planning of power consumption in mining enterprises.

1 Introduction

Due to the rapid increase in the number of electricity consumers in the world, the demand for electricity is increasing. The share of electricity costs in the cost of production of mining enterprises reaches 30-35%, which is one of the main tasks of increasing the efficiency of electricity consumption.

The current state of development of mining enterprises in the world is characterized by increasing the importance of energy resource efficiency indicators. Currently, methods of assessing the state of the electricity consumption process, electricity consumption regimes characterized by balances, technological processes, which are characterized by energy intensity, do not take into account the influence of many geological, technological, climate-meteorological and other factors.

When analyzing the electricity consumption of mining enterprises in our country, it is necessary to pay attention to the following: conditions of electricity consumption, construction and operation costs; service life of energy-saving devices; the relative amount of electrical energy consumed by the product; efficient use of electricity; electricity loads calculated using methods that adequately reflect the accuracy of electricity consumption forecasting and planning [2].

The technological aspects of increasing the efficiency of electricity consumption in industrial enterprises are characterized by technical issues related to increasing efficiency, improving the power factor, increasing the useful work factor, reducing electricity losses, and others [3].

In the conditions of the market economy and with a significant increase in the price of energy resources, the task of efficient use of energy in various sectors of industry is gaining

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particular importance. This problem is multifaceted, each of which includes a number of tasks that are of great importance in solving energy saving issues. First of all, it is the calculation of energy resources and analysis of electricity consumption, determination of energy characteristics of equipment and its optimal operating modes, regulation and planning of energy consumption, operational management of energy flows, taking into account the efficiency of their use, at various levels of industrial production management increasing the need for predictive assessment and analysis of energy consumption.

Currently, scientific and technical research aimed at increasing the efficiency of the consumption of natural resources, as well as energy resources created and developed by our potential personnel in production, is gaining importance for the development of the industry of our country.

Due to the growth of the mining industry and the social sector in our country, it causes a shortage of electricity that is increasing day by day, which has increased the need to improve the energy efficiency of mining and enterprises in other areas of industry. This, in turn, causes an increase in the demand for scientific and technical research aimed at increasing the efficiency of electricity consumption.

Enrichment and processing of minerals, in particular, the share of electricity costs in the price of production of mining enterprises reaches 32-38 %, which determines as one of the main tasks of increasing the efficiency of electricity consumption and is important for the development of the country's economy.

The work on improving energy efficiency in mining enterprises includes the review and evaluation of the methodological bases of energy consumption studies, the dependence of energy consumption on production factors, the justification of energy consumption planning, regulation, accounting and control methods, the preparation of energy balance and the creation of rationalization methods.

Modern methods of calculating electricity consumption in mining enterprises are divided into two directions. One of them considers the methods of calculating electric loads based on the use of deterministic principles. The second direction considers methods based on mathematical statistics and probability theory methods. The first group includes: technological graphic method; demand coefficient method; duplicate formula method; calculation method of partial loads; a certain method of electricity consumption. [4]. The common disadvantages of all the methods included in the first group are: low accuracy, limited scope of application, weak adaptation to technology changes, number of electricity receivers, work order.

The technological graphic method is the most accurate. In this method, the load schedule of the enterprise must be in advance, which cannot be used to calculate the electricity consumption of the mining enterprise under construction. Therefore, this method can be used only in existing mining enterprises. From a mathematical point of view, the simplest method for calculations is the duplicate formula and the demand coefficient method. However, these methods have low accuracy and can be used to a certain extent [5].

2 Materials and methods

At present, the process of determining and applying limits for electricity at enterprises is carried out practically without sufficient analysis of power consumption and volume of work, which often leads to a deviation of the actual power consumption from the application values. When adjusting the limits, it is not always taken into account the current performance of the enterprise, the forecast of technological factors and, as a consequence, the declared limits on electricity are used inefficiently.

If the electricity limit is exceeded from the enterprise, the penalty for the amount of electricity sampling shall be charged without penalty. In this regard, the definition of prospective electricity consumption levels for the correct and timely application of the required limits is not possible without the use of forecast procedures.

The main source material for forecasting is the statistical analysis of the history of the projected process. When predicting power consumption, such a prehistory is the reporting data on electricity consumption for different time intervals.

A series of consecutive values of electricity consumption for the analyzed period of time (which depends on the type of forecast) reflects a separate pattern in the change in the process of power consumption, each specific value of this index containing an element of randomness caused by local changes in the electricity supply system, measurement and calculation errors, etc. Therefore, it is advisable to study the processes of electric power consumption within the framework of the theory of random processes [1,2,6].

To conduct large-scale calculations of power consumption of quarries or an enterprise as a whole without determining all the components of the specific consumption of electricity, it is advisable to use a method based on the use of models of power consumption regimes found by the results of multivariate regression analysis [3,4].

Thus, the multifactor model of specific power consumption has the form:

$$\omega = A_0 + A_1F_1(t) + A_2F_2(t) \quad (1)$$

where ω - specific electricity consumption by months, kWt*h/m^3; A_0,A_1,A_2 parameters of the regression equation that quantify the degree of influence of factors on the specific electricity consumption; F1 (t) - the annual volume of the mining mass of quarries, m3; F2 (t) - annual volume of drilling, m.

To obtain the model of the specific consumption of electric energy of quarries by months, statistical data of electric power consumption and volumes of rock mass for 9 years were collected. On the basis of these data, the values of the actual specific energy consumption of quarries by months and the method of multifactor regression analysis were derived models of specific electricity consumption, which are given in Table 1.

The resulting models of the monthly specific electricity consumption shown in Table 1 can be used in the normalization of energy costs, in planning, as well as in the initial stages of plan development.

Based on the processing of statistical data on the volume of rock mass, drilling volume, the annual model of specific power consumption has the following form:

– for the Muruntau quarry

$$\omega(t) = 0{,}1474 + 2{,}14E - 7^{*}F_1(t) + 7{,}49E - 6^{*}F_2(t) \quad (2)$$

– for the plant of "7-GMZ"

$$W(t) = 0{,}9698 - 1{,}89E - 7^{*}F_1(t) - 1{,}04E - 5^{*}F_2(t) \quad (3)$$

where $\omega(t)$ - annual specific power consumption, kW * h / m^3; - annual volume of mining mass of quarries m^3; - annual volume of drilling, m.

Table 1. Models of specific electricity consumption by months of quarries (kWh / m^3).

Month	Forecast models of monthly electricity consumption	coefficient of multiple co-relation
Quarry "Muruntau"		
January	$\omega(t) = 0{,}262 + 1{,}06E - 7^{*}F_1(t) + 8{,}72E - 6^{*}F_2(t)$	0.89
February	$\omega(t) = 0{,}817 + 5{,}14E - 7^{*}F_1(t) - 1{,}16E - 5^{*}F_2(t)$	0.97
March	$\omega(t) = 1{,}871 - 2{,}94E - 7^{*}F_1(t) - 2{,}40E - 6^{*}F_2(t)$	0.99
April	$\omega(t) = 1{,}845 - 1{,}95E - 7^{*}F_1(t) - 5{,}50E - 6^{*}F_2(t)$	0.99

May	$\omega(t) = 1{,}506 - 1{,}71E - 7{*}F_1(t) - 1{,}10E - 6{*}F_2(t)$	0.89
June	$\omega(t) = 1{,}338 - 1{,}08E - 7{*}F_1(t) - 8{,}10E - 7{*}F_2(t)$	0.99
July	$\omega(t) = 1{,}083 - 1{,}18E - 8{*}F_1(t) + 2{,}51E - 7{*}F_2(t)$	0.99
Augest	$\omega(t) = 1{,}305 - 1{,}29E - 7{*}F_1(t) - 1{,}97E - 7{*}F_2(t)$	0.99
September	$\omega(t) = 1{,}160 - 7{,}78E - 9{*}F_1(t) - 1{,}68E - 6{*}F_2(t)$	0.89
October	$\omega(t) = 1{,}161 - 1{,}50E - 7{*}F_1(t) + 3{,}23E - 6{*}F_2(t)$	0.89
November	$\omega(t) = 1{,}194 - 1{,}24E - 7{*}F_1(t) + 2{,}08E - 6{*}F_2(t)$	0.89
December	$\omega(t) = 1{,}210 - 1{,}02E - 7{*}F_1(t) + 1{,}48E - 6{*}F_2(t)$	0.89
Plant "7-GMZ"		
January	$\omega(t) = 1{,}029 - 3{,}09E - 7{*}F_1(t) + 4{,}12E - 6{*}F_2(t)$	0.98
February	$\omega(t) = 0{,}963 - 9{,}94E - 8{*}F_1(t) - 1{,}27E - 5{*}F_2(t)$	0.97
March	$\omega(t) = 0{,}967 - 1{,}68E - 7{*}F_1(t) - 4{,}87E - 6{*}F_2(t)$	0.98
April	$\omega(t) = 0{,}975 - 1{,}94E - 7{*}F_1(t) - 4{,}58E - 6{*}F_2(t)$	0.98
May	$\omega(t) = 0{,}752 - 9{,}12E - 8{*}F_1(t) - 2{,}62E - 6{*}F_2(t)$	0.97
June	$\omega(t) = 0{,}731 - 5{,}40E - 8{*}F_1(t) - 6{,}70E - 7{*}F_2(t)$	0.98
July	$\omega(t) = 0{,}773 - 9{,}46E - 8{*}F_1(t) - 1{,}76E - 6{*}F_2(t)$	0.97
Augest	$\omega(t) = 0{,}954 - 1{,}76E - 7{*}F_1(t) - 4{,}93E - 6{*}F_2(t)$	0.97
September	$\omega(t) = 0{,}772 - 4{,}76E - 8{*}F_1(t) - 4{,}50E - 6{*}F_2(t)$	0.98
October	$\omega(t) = 0{,}790 - 6{,}60E - 9{*}F_1(t) - 7{,}88E - 6{*}F_2(t)$	0.97
November	$\omega(t) = 0{,}819 - 6{,}89E - 9{*}F_1(t) - 1{,}12E - 5{*}F_2(t)$	0.98
December	$\omega(t) = 0{,}832 - 6{,}77E - 8{*}F_1(t) - 8{,}86E - 6{*}F_2(t)$	0.97

To verify the adequacy of the model of specific power consumption, 1, a comparison is made between the values of the simulation of electric power consumption per unit volume of rock mass with the actual value of the specific consumption of electricity. Graphical interpretation of the annual model of specific power consumption is presented in Figures 1-2.

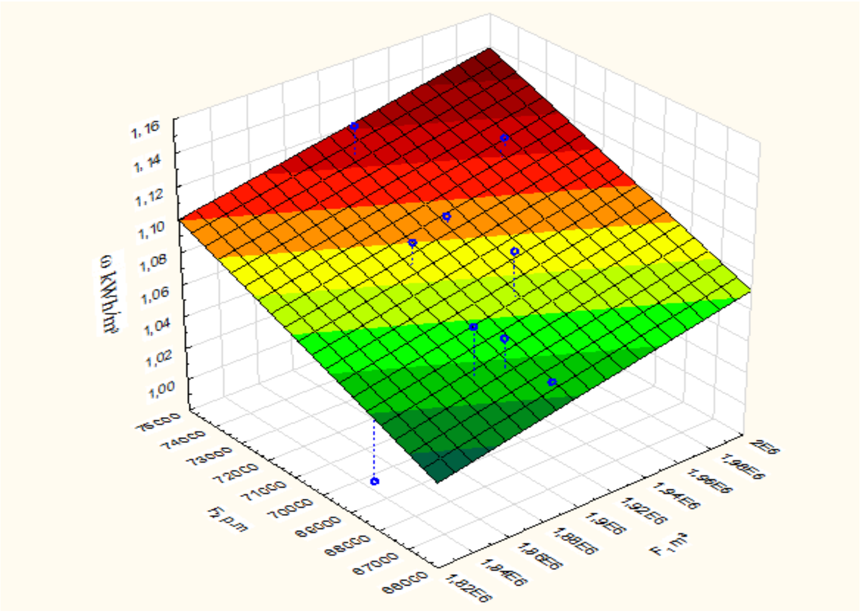

Fig. 1. Model of the annual specific power consumption of the quarry "Muruntau".

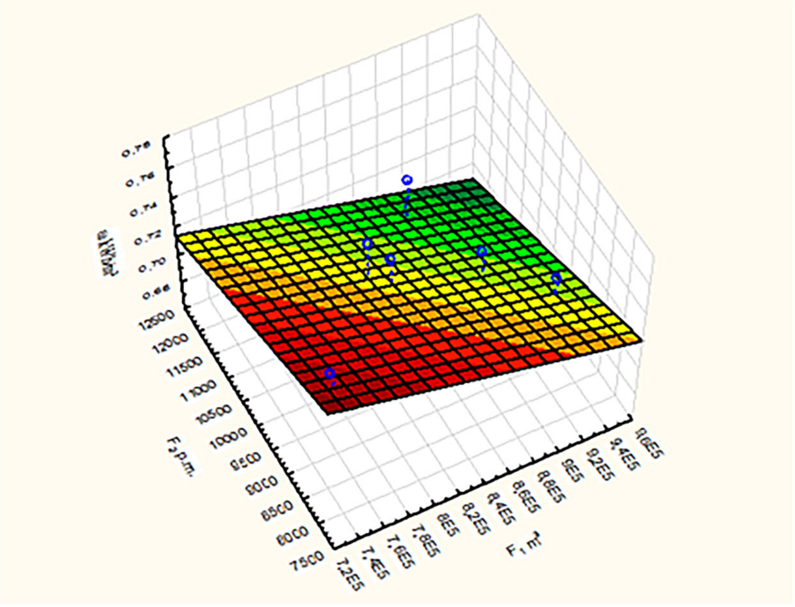

Fig. 2. Model of the annual specific power consumption of the plant "7-GMZ".

A check on the adequacy of the model shows that the discrepancy between the simulation results and the actual data of the specific electricity consumption for the Muruntau quarry is no more than 4.48%, and for the 7-GMZ plant no more than 4.96%. A low percentage of the discrepancy of the results confirms the adequacy of the obtained model of specific power consumption.

By results of researches, it is possible to draw following conclusions:

– the aggregate influence of the factors determining of power consumption regimes can be estimated indirectly, using the planned production indicators of quarrying and plants;
– To improve the reliability of estimating the prospective levels of electricity consumption of mining enterprises, it is advisable to carry out the forecast of power consumption in an interval form, with an estimate of both the point forecasted value of power consumption and the upper and lower values of the confidence interval limits.

The results of the research can serve as a basis for drawing up recommendations for increasing the level of forecasting and operational planning of power consumption in mining enterprises.

3 Conclusion

Today, mining enterprises do not pay enough attention to the issues of increasing the efficiency of electricity consumption by creating information and analysis systems in modern conditions. This is due, on the one hand, to the certain novelty of the problems associated with these developments, on the other hand, to the practical lack of methodological materials, recommendations for the creation of such systems, as well as developed principles of saving energy resources using information and analytical systems of energy efficiency improvement, lack of methods and techniques.

It is desirable that the development of these information-analytical systems is based on scientific studies of the process of consumption of energy resources.

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