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EVALUATION OF THE FORECAST METHODS OF ELECTRIC ENERGY CONSUMPTION OF THE ENTERPRISES ON THE EXAMPLE OF COAL MINE

The paper considers the results of the comparison of energy consumption method of the enterprise on coal mine example («Centrosoyuz» State fuel energy company, Lugansk region), carried out, using the electric loads curves, multifactoral regressive models and time series. Main provisions of collection and processing of experimental data and model construction are suggested. Fields of application of the methods, intended for energy consumption forecast are recommended on the base of the research.

Key words: *methods of forecast, systems of electric power supply, multifactoral regressive models, time series.*

Introduction

As a result of the increase of coal mining processes mechanization, introduction of more powerful and productive coal mining machines electric energy consumption of coal mining enterprises constantly grows.

In these conditions, measures, aimed at the increase of the efficiency of electric energy consumption are of great importance, as the cost of electric energy, spent on coal mining, represents considerable share of its mining cost balance (up to 30 %). Usage of electrical energy is characterized by energy indices, allowing to determine the quality of energy enterprises operation and the quality of engineering at the stage of design work.

Among the problems aimed at determination of the quantity of electrical energy, consumed by the enterprise, the improvement of the methods of necessary quantity of electric energy calculation and development of new methods of electric energy consumption (EC) [1] is urgent, as methods of EC calculation, recommended by the regulatory documents and applied at present, give considerable error, that cannot be evaluated by means of mathematical criteria [2, 3].

Aim of the research – development of the methods of the forecast of energy consumption of mines and their structural subunits with preset accuracy within the limits and outside the limits of influencing factors change.

In practice of determination of electric loads and energy consumption calculation methods can be divided into two groups: empirical and analytical [3].

The drawback of these methods – limited sphere of application – low voltage sections and groups of consumers. Practice of design shows that loads calculations by the enterprise on the whole give considerable error (up to 135%).

Technique of collection and processing of experimental data

To realize tasks, put forward in the given research the technique, comprising the following stages was developed: collection of experimental data regarding the consumption of electric energy, analysis and prior processing of experimental data, evaluation of the possibility to apply conventional calculation methods (method of coefficients), selection of models type for carrying out the forecasts and checking of adequacy of the forecast results.

Energy consumption process is referred to random processes and to have the right to investigate characteristics of general population by sample, it must be random and correspond to the way of its formation [4].

For the analysis of the possibility to aplly the above-mentioned calculation methods of electrical loads, for the forecast schedules of loading were used: daily, monthly, annual – and coefficients, characterizing these schedules. According to loading schedules (annual) graphs of coefficients

change were built, the evaluation of the dynamics and the degree of basic factor change impact – coal mining on the indices of mine energy consumption was carried out.

For evaluation of coefficients change dynamics and possibility of their application for the forecast of electric loads and energy consumption relations of coefficients values of the consecutive to the previous $\left(\frac{Kcons}{Kprev}\right)$ are calculated. Such an approach is stipulated by the fact that for computation of loads and energy consumption the coefficients of the previous year of enterprise operation are used. Value of the relation allows to calculate the difference between the values of coefficients and introduced error while loads determination. Actual value of consecutive year coefficients was calculated according to the data of АСКУЭ system, collected during the current year.

Calculated values $\left(\frac{Kcons}{Kprev}\right)$ show that while planning of loads and energy consumption the error obtaining within the limits of 4 – 20% is possible.

On the basis of the survey performed regarding electrical loads calculations for long-term planning, we suggest to apply the method of regressive analysis, because it allows to perform the processing of experimental data by modern facilities and evaluation methods in conditions of heterogeneity of observations and possible availability of out bursts, contingency of independent variable regressions.

The given method also allows to perform the evaluation of regression parameters when measurements errors are available. These errors occur practically in any situation.

The obtained mathematical regressive model for short-term forecast of electric energy consumption by the indices of enterprise operation in September:

$$P = 58 + 0{,}407Q_1 + 2{,}7006L_2,$$

where P – consumption of electric energy, Q_1 – daily coal mining at the mine, L_2 – available working staft during the same period.

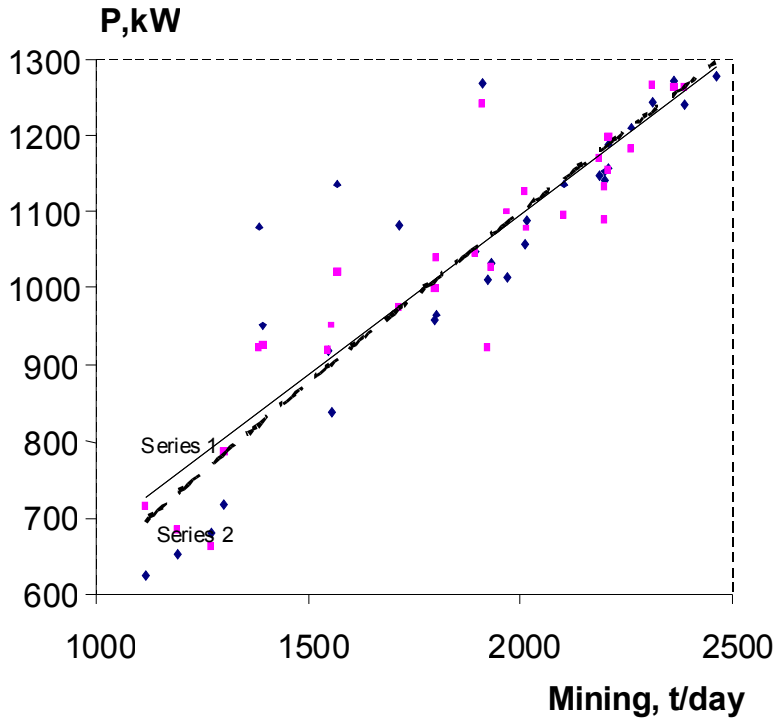

Fig. 1. Planning of energy consumption for the following period of time:
series 1 – consumption in September at the mine 2011;
series 2 – estimative forecast for October 2011

Coefficients of multiple determination and multiple correlation are obtained for this model, evaluation of model parameters dispersion was performed, model adequacy testing according to Fisher and Student criteria was carried out. It is shown that the model is adequate to empirical data. Pointwise forecast of energy consumption with forecast evaluation 1043.47 кW and interval forecast of EE consumption was obtained as well as calculation of average and limiting indices was performed. Estimative forecast for the next month (October – series 2) is comparable with real data (series 1) and we see that it is rather accurate (see Fig. 1).

For medium-range forecast data, regarding energy consumption of the mine in the period of 2004 – 2010 are taken. These data are set of characteristics, consolidated in the array, which is the base for obtaining the forecast model.

For the analysis and preprocessing of data (time series), regarding energy consumption, we use program package Statistica 6. Technique of data processing is described in [7]. Energy consumption graphs with one month period for 7 years is given below.

Time series, consisting of monthly indices of mine energy consumption is uniform stationary. As basic model for its processing we take universal model of autoregressive integrated, sliding average (ARISA).

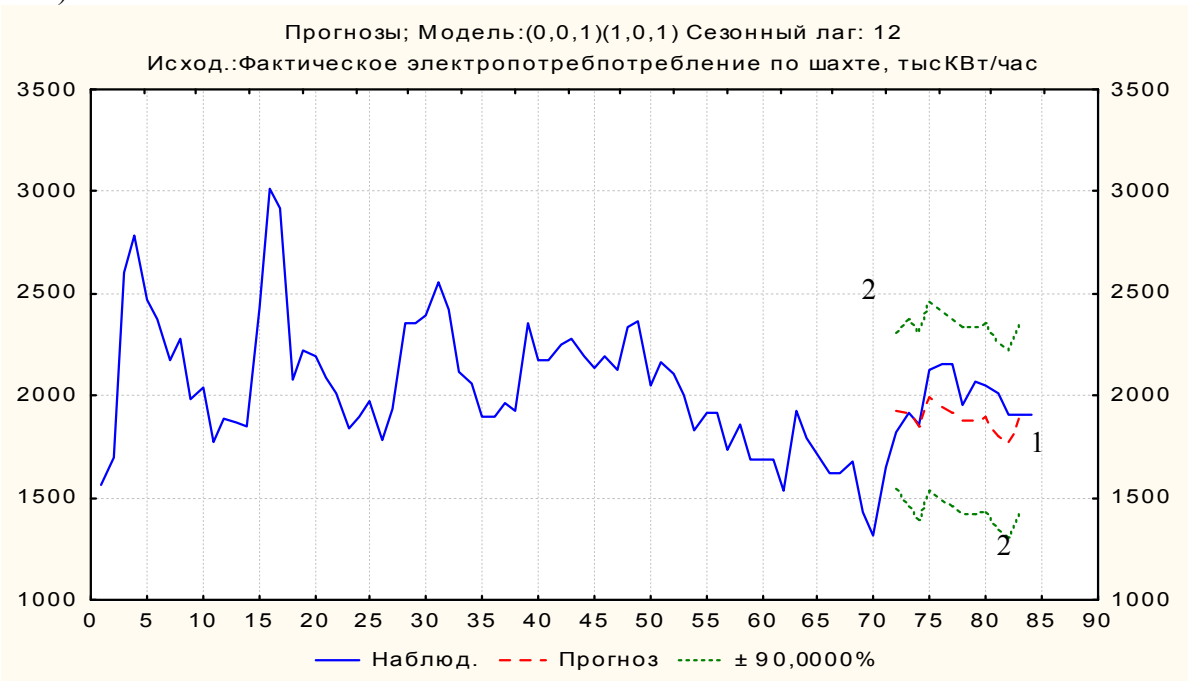

Fig. 2. Dynamics of energy consumption change during 7 years, and the forecast for 12 months

The curve of forecast data is shown by dotted red line – 1, and confidence intervals – by two green dotted lines – 2 showing the range of deviations and presented in Fig. 2.

It is seen from the graph in Fig. 2 that forecast curve practically repeats the fragment of initial series curve, and all the observed values of the series are within the confidence interval.

Conclusions

Methods of electric loads and electric energy consumption calculation by means of coefficients while planning and forecasting may produce considerable error, that is why the sphere of their application – is the control over the indices of enterprise energy consumption in real time mode.

Evaluation of these factors significance is performed, tasks of further research, aimed at enterprise energy consumption management are formulated. The investigation of electric energy consumption process by means of the suggested model allows to calculate the amount of electric energy, reserved by the enterprise for the future period with greater accuracy and mathematically substantiated error. Also by means of this technique it is possible to obtain regression models, taking into account other

factors.

It was established that application of modern statistical methods of experimental data processing allows to forecast with sufficient for industrial purposes, the demand in the electric energy for medium-range outlook. This allows to obtain considerable (up to 5%) economy.

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