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Analysis and Calculation of Energy Indicators based on the Formation of the Predicted Value of the Total and Specific Energy Consumption

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Abstract- Accurate forecasting of electricity consumption determines the success of industrial enterprises. Each enterprise, having an accurate prediction of the amount of power consumed, strictly controls it, since deviations entail disruptions in work, is subject to fines. Power consumption forecasting for a certain period is the most urgent task in the today's electricity market. Existing forecasting methods have individual characteristics and have their own advantages and disadvantages. The choice of forecasting methods depends on such major factors as the time for which the forecasting is performed, as well as the amount of information.

Keywords: forecasting method, power consumption, specific energy consumption, products, raw materials, technological factors, production factors, calculation accuracy, energy indicators, components of the technological process.

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Abstract- Accurate forecasting of electricity consumption determines the success of industrial enterprises. Each enterprise, having an accurate prediction of the amount of power consumed, strictly controls it, since deviations entail disruptions in work, is subject to fines. Power consumption forecasting for a certain period is the most urgent task in the today's electricity market. Existing forecasting methods have individual characteristics and have their own advantages and disadvantages. The choice of forecasting methods depends on such major factors as the time for which the forecasting is performed, as well as the amount of information. When forecasting power consumption, it is necessary to take into account various factors related to the technological features of production, organization of equipment operation, etc.The present article describes the proposed method for determining the forecasted values of power consumption parameters in terms of total and specific power consumption, which differs from the existing methods in that it takes into account, when forecasting power consumption parameters, the features of production that characterize the production process, the power consumption modes of process equipment, and the impact of technological and operational factors on energy performance that affect the forecast of readings.Accounting for the above factors can significantly simplify and improve the accuracy of forecasting calculations. When determining the forecast values, the components of electricity consumption for the main, auxiliary and additional production are directly included in the calculation. In addition, the method allows to investigate and optimize the power consumption modes of both a separate production unit and the enterprise as a whole in conjunction with the indicators of processed products and components of the technological process used. The reliability of the method is justified by calculating the energy indicators of a specific section rolling shop of a steel industry.

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I. Introduction

The resulting indicators of energy saving are the reduction in the specific consumption of energy resources per unit of industrial production. The complexity of the problem of energy conservation lies in the fact that this indicator is a function of many variables - quantitative and qualitative indicators of production. Considering this problem in terms of power consumption, it can be argued that, in addition to electrical factors, both technological and operational, as well as factors causing deviations from the norms of consumption of raw materials, intermediate products and auxiliary

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components, should be involved in the analysis and calculation of specific energy consumption, as well as in identifying reserves of savings. technological process (compressed air, oxygen, water, etc.). The latter, to one degree or another, are usually taken into account, but are not directly included in the calculation of standards. In many cases, this interferes with an objective assessment of energy performance. The increasing scale of electrification of enterprises requires continuous improvement of methods for analysis, assessment and calculation of energy consumption levels, especially in industry, which accounts for more than half of all electricity produced. Although at present there are a fairly large number of methods for predicting energy consumption, the results of their application do not always reflect the real situation. In this regard, we set the task of scientifically-based calculation, analysis and forecasting of power consumption for each production, taking into account its specific features [1,2].

Ferrous metallurgy has a number of specific production features that distinguish it from other industries. Existing methods for forecasting electricity do not take into account these features that characterize the production process, modes of power consumption of technological equipment, as well as the influence of technological and operational factors on energy performance. In addition, energy services are forced to normalize, evaluate and distribute energy resources based on experience and intuition, taking into account data on the actual and planned performance of individual enterprises, which leads to certain inaccuracies and errors. It should be noted that power consumption depends on the quality of the metal, on the technical perfection of technological equipment and the production process. Sometimes, to obtain 1 ton of finished products, it is necessary to process several tons of metal. And if the organization of production is not perfect, then there may be excess losses and, accordingly, energy overruns. Therefore, today it is relevant to improve the work on forecasting electricity [2,3,4].

II. The Main Part

Assessment of the levels of absolute and specific energy consumption of integrated production, which includes a number of independent units, requires taking into account a large number of indicators.

The complexity of the analysis of power consumption modes and the calculation of energy indicators of ferrous metallurgy enterprises is caused by a number of reasons. Firstly, the range of finished products of the enterprise is very wide, has dozens of items and various energy intensity. At the same time, energy accounting, both for each production and the plant as a whole, is single. Secondly, a number of industries receive part of the intermediate production through internal and external production relations, while at the same time, they sell a certain amount of their products to the side. At the same time, depending on which production unit received the intermediate products from the outside, and what is the number of processing conversions, differences in energy consumption are produced [5,6].

Currently, due to the lack of developed methods for accounting for the above features, forecasting is carried out according to the general indicators of energy consumed from the network and the number of finished products. Naturally, the results of such forecasting calculations in some cases are inaccurate or erroneous and do not reflect the actual level of power consumption.

The task is to find ways to take into account the characteristics of production with a prerequisite for reflection in the calculations for predicting the energy intensity

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2. Hoshimov F.A. (2005) *Optimization of use of energy resources in the textile industry*. Tashkent, Fan. 252 (in Russian).

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of processes. A technique is proposed for predicting energy indicators for a complex of industries as a whole, taking into account the above requirements.

To ensure reliable forecasting, it is necessary to study the patterns of change in the energy intensity of products and determine the conditions under which a change in time of energy consumption indicators can change significantly. In addition, the accuracy of forecasting is influenced by the development of new technologies, the improvement of equipment, the scale of modernization, which are different in each industry. The energy intensity of products and the level of energy consumption also depend on changes in the structure of energy consumption, and the latter depends on the need for such components of the process as: compressed air, oxygen, nitrogen, etc. [7,8,9].

Therefore, it is possible to formulate a set of tasks related to the above factors in order to increase the accuracy of forecasting. According to the proposed method, the projected total electric energy consumption of the enterprise is divided into the following components:

- Energy consumption by enterprises where equipment does not change during the entire forecast period and traditional technologies are applied (W_b);
- Energy consumption by enterprises where it is planned to modernize technological equipment, switch to a new technology (W_m);
- Energy consumption by new enterprises, with new equipment and technology (W_n).

The projected energy consumption will be:

$$W = W_b + W_m + W_n ; \quad (1)$$

or

$$W = \Pi(\beta_b d_b + \beta_m d_m + \beta_n d_n) ; \quad (2)$$

where Π is the number of planned products; $\beta_b, \beta_m, \beta_n$ - the share of planned types of products attributable to the relevant enterprises; d_b, d_m, d_n - respectively, the specific consumption of electricity.

The planned output for the forecast period (Π) and, accordingly, the shares of existing, modernized and new industries ($\beta_b, \beta_m, \beta_n$) are determined in accordance with the plan for the future development of the industry.

The I level of power consumption W_1 of the production unit for the production of intermediate product Π_1 includes the specific consumption e1 of electricity W_1 for the production of products Π_1 and the specific consumption q_1 of product Π_1 per unit of final product F.

The II level of power consumption W_2 of the production unit for the production of process components and secondary energy resources B includes specific costs e_2 of electricity W_2 for product B and specific consumption q_2 of product B per unit of final product F.

The III level of other electricity costs W_3 for the production of final products includes the specific consumption of e_3 electric power W_3 per unit of final product F.

It should be noted that the above levels, in addition to indicators of energy consumption, also include indicators of the consumption of raw materials and technological components.

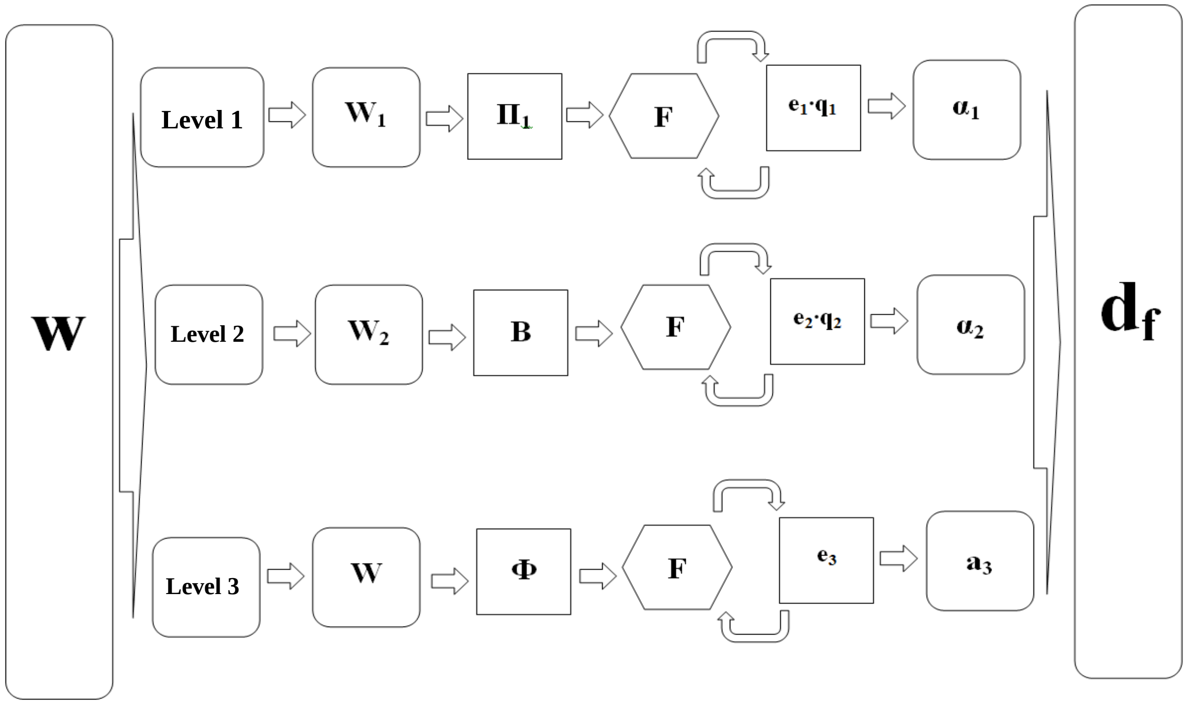

Fig. 1: The scheme for the formation of the predicted specific energy consumption

Notes

The predicted values of specific electricity consumption by levels are determined by the following expressions:

a) The specific energy consumption for the production of this workshop is calculated according to the following formulas:

for tier I

$$e_1 = \frac{W_{1.}}{\Pi_1}; \tag{3}$$

for tier II

$$e_2 = \frac{W_{2.}}{B}; \tag{4}$$

for tier III

$$e_3 = \alpha_3 = \frac{W_{3.}}{F} \quad . \tag{5}$$

b) The specific consumption of intermediate production products, technology components per unit of final product can be calculated by the formulas:

for tier I

$$q_1 = \frac{\Pi_1}{F}; \tag{6}$$

for tier II

$$q_2 = \frac{B_i}{F} \quad . \tag{7}$$

The specific energy consumption of the enterprise is determined by the components of each level, using the following expressions:

$$a_1 = \varepsilon_1 \cdot q_1 \, ; \tag{8}$$

$$a_2 = \varepsilon_2 \cdot q_2 \, ; \tag{9}$$

$$a_3 = e_3 \quad . \tag{10}$$

Therefore, the total specific energy consumption will be:

$$d_f = \sum_1^n \alpha_1 + \sum_1^{n'} \alpha_2 + \alpha_3 \, , \tag{11}$$

where *n, n′* are the number of levels of types I and II, respectively, which characterize the total value of the specific power consumption of the main and auxiliary industries.

The developed method for generating the predicted specific energy consumption by types of energy consumption and production processes (Fig. 1) can significantly simplify and improve the accuracy of calculations. This allows you to directly include in the calculation the component values of specific electricity consumption and indicators of individual energy-intensive facilities. The considered parameters are taken from the reporting data. In addition, they are considered, taken into account and controlled separately as in-plant indicators, without a direct link to the general production specific power consumption factors (for example, electric steel furnaces, compressors, etc.) [10,11].

The basis of the proposed method for forecasting energy consumption is, firstly, the division of the total value of this consumption into three categories:

1) Electricity consumption by existing and newly commissioned enterprises, in which existing equipment is stored in the forecast period;
2) Energy consumption by modernized enterprises;
3) Energy consumption by enterprises commissioned in the forecast period with new equipment and new technologies.

Secondly, differentiation is carried out within each category:

1) Electricity consumption by the main production units;
2) Energy consumption by type of energy-intensive auxiliary needs;
3) Other expenses.

As a result, all energy consumption by the industry and its units is differentiated and each calculation can be performed by levels, i.e. make it extremely easy. The calculation allows you to take into account the specifics of technological progress in each of the links in production.

As the basic (initial) data for metallurgical enterprises, the energy consumption indicators of the corresponding production facilities with operating equipment are taken.

As a result, the electricity demand for a given perspective in the industry (W_b) can be determined based on the values of Π_b, B_b, F_b,

Ref

10. I.U.Rakhmonov, K.M.Reymov. Regularities of change of energy indicators of the basic technological equipment of the cotton-cleaning industry. Journal of Physics: Conference Series. APITECH-2019. 1399 (2019) 055038 doi:10.1088/1742-6596/1399/5/055038.

Where

$$W_b = d_b \cdot F_b \ . \quad (12)$$

The proposed method for determining the predicted value of specific electricity consumption can be applied in industrial enterprises, as well as by type of product of the main divisions of the enterprise for short-term forecasting [12-14].

The reliability of the proposed method is demonstrated as an example by determining the energy indicators of the section rolling shop №1 equipped with traditional technology equipment for the main types of products.

The initial data for the calculation is the products of the section rolling shop №1, shown in table 1.

The value of the specific energy consumption for the production of a given technological cycle by production units is calculated according to formulas 2-4:

for block I:

for ball rolling Ø 100 - $e_{100} = \frac{111959{,}4}{3167} = 35{,}3\, kW \cdot h / t$;

Table 1: The main energy indicators of the rolling shop №1

№	Type of product	Output volume	Heat consumption	Power consumption		
				For technology W_{tech}, kWh	For auxiliary needs W_{aux}, kWh	For other needs W_{oth}, kWh
1	Ball rolling Ø 100	3167	1254	111959,4	66782,8	17677,8
2	Ball rolling Ø 68	8573	3568	351861	209882	55557
3	Ball rolling Ø 40	431	568	36879	21998	5823
	the section rolling shop №1	12171	5390	500699	298663	79057,8

for ball rolling Ø 68 - $e_{68} = \frac{351861}{8573} = 41\, kW \cdot h / t$;

for ball rolling Ø 40 - $e_{40} = \frac{36879}{431} = 85{,}6\, kW \cdot h / t$.

The specific consumption of intermediate production products, technology components per unit of final product is calculated according to formulas 5-6:

for block I:

Ball rolling Ø 100 - $q_{100} = \frac{3167}{12171} = 0{,}26\, t / t$;

Ref

12. I.U.Rakhmonov, N.N.Niyozov. Optimization setting of steel-smelting industry in the issue of alloy steels. E3S Web Conf. Volume 139, 2019. Rudenko International Conference "Methodological problems in reliability study of large energy systems" (RSES 2019) 01077. 1-3 p. https://doi.org/10.1051/e3sconf/201913901077.

$$\text{Ball rolling Ø 68 - } q_{68} = \frac{8573}{12171} = 0{,}7\, t/t\,;$$

$$\text{Ball rolling Ø 40 - } q_{40} = \frac{431}{12171} = 0{,}03\, t/t\,.$$

Notes

The total specific energy consumption for the I block is determined by the formula (8):

$$\sum_{1}^{n} e_i = 35{,}3 \cdot 0{,}26 + 41 \cdot 0{,}7 + 85{,}6 \cdot 0{,}03 = 40{,}5\, kW \cdot h/t.$$

According to the formula (4), we calculate the value of the specific energy consumption for the production of a given technological cycle by production units:

for block I:

$$\text{for ball rolling Ø 100 - } \gamma_{100} = \frac{66782{,}8}{1254} = 53{,}2\, kW \cdot h/Gkal\,;$$

$$\text{for ball rolling Ø 68 - } \gamma_{68} = \frac{209882}{3568} = 58{,}8\, kW \cdot h/Gkal\,;$$

$$\text{for ball rolling Ø 40 - } \gamma_{40} = \frac{21998}{568} = 38{,}7\, kW \cdot h/Gkal\,.$$

By the formula (7), we calculate the specific heat energy consumption per unit of final product:

for block II:

$$\text{for ball rolling Ø 100 - } \omega_{100} = \frac{1254}{12171} = 0{,}1\, Gkal/t\,;$$

$$\text{for ball rolling Ø 68 - } \omega_{68} = \frac{3568}{12171} = 0{,}3\, Gkal/t\,;$$

$$\text{for ball rolling Ø 40 - } \omega_{40} = \frac{568}{12171} = 0{,}05\, Gkal/t\,.$$

The total specific energy consumption for block II is determined by the formula (3.9):

$$\sum_{1}^{n} \alpha_i = 53{,}2 \cdot 0{,}1 + 58{,}8 \cdot 0{,}3 + 38{,}7 \cdot 0{,}05 = 25\, kW \cdot h/t$$

According to the formula (5), we calculate the value of the specific energy consumption by production units for block III:

$$\text{for ball rolling Ø 100 - } \mu_{100} = \frac{17677{,}8}{12171} = 1{,}56\, kW \cdot h/t\,;$$

$$\text{for ball rolling Ø 68 - } \mu_{68} = \frac{55557}{12171} = 4{,}56\, kW \cdot h / t;$$

$$\text{for ball rolling Ø 40 - } \mu_{40} = \frac{5823}{12171} = 0{,}5\, kW \cdot h / t.$$

The total specific energy consumption for block III will be:

$$\alpha_{np} = 1{,}56 + 4{,}56 + 0{,}5 = 6{,}56\, kW \cdot h / t.$$

According to the formula (10), we calculate the total specific energy consumption for the workshop:

$$d_z = 40{,}5 + 25 + 6{,}56 = 72\, kW \cdot h / t.$$

According to formula (11), the need for electricity for a given perspective in the industry (W_b) is determined:

$$W_b = 72 \cdot 12171 = 876312\ kW \cdot h.$$

According to the calculation indices db, it is possible to determine the predicted values of the specific and absolute energy consumption of the enterprises where modernization is planned (d_m, W_m), and for each level, in accordance with the scheme (Fig. 1), the following are calculated:

for tier I

$$d_{m_1} = \frac{e_b \cdot \Pi_b \pm \sum_{1}^{m} \Delta W_m}{\Pi_b + \Delta \Pi_m}; \tag{13}$$

for tier II

$$d_{m_2} = \frac{\alpha_b \cdot B_b \pm \sum_{1}^{m} \Delta W_m}{B_b + \Delta B_m}, \tag{14}$$

where m is the number of units or processes to be modernized; ΔW_m– energy saving due to modernization of technological equipment.

Using the formula (9), the predicted values of the consumed raw materials and the flow rate of the components of the technological process q_2 are determined.

For enterprises with new, more advanced technologies and equipment ($d_н$ and $W_н$) for given Π, B, F, the calculation of electricity demand is performed by the same method as on the basis of design data.

Values of reliable data for individual indicators - projected products, consumption of process components, etc. can be determined by expert judgment.

Thus, according to the proposed method, for each industry, it is possible to obtain the necessary set of mathematical models that can improve the accuracy of forecasting power consumption, as well as flexibly and quickly carry out their correction for any technical and technological changes in individual links of each production.

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III. Conclusions

1. A method for forecasting power consumption parameters has been developed, which allows one to study and optimize power consumption modes of both a separate production unit and the enterprise as a whole in conjunction with indicators of processed products and used components of the technological process.
2. It has been established that the method for determining the predicted specific energy consumption allows us to more fully investigate the trends and patterns of changes in the specific and total energy consumption, taking into account the complex influence of technological and production factors, and allows us to significantly simplify and improve the accuracy of calculations.

Notes

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