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Models and algorithms for processes management of energy saving

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ABSTRACT: The article considers the complex of tasks of optimal planning and operational management of the consumption of fuel and energy resources. The basic concepts of the energy management system of the oil and gas complex are presented, the main tasks of the energy management system are identified and methods for solving them are given. The paper considers the tasks of minimizing the cost of production of the oil and gas complex by minimizing the cost of fuel and energy resources. The main factors affecting the consumption indicators of fuel and energy resources are identified, a mathematical model for optimizing the indicators of the need for fuel and energy resources is proposed.

KEY WORDS: Method, algorithm, objective function, task, system, optimization, fuel and energy resources, energy saving, information systems.

I. INTRODUCTION

In the world in recent years, many scientists conduct research in the field of cost reduction, rational use of fuel and energy resources(FER) and effective management of their consumption. In particular, research in this area is actively carried out by such foreign scientists as I.A.Bashmakov, P.W.O'Callaghan, S.D.Probert, E.A.Abdelaziz, K.Bunse, S.A.Ates, N.M.Durakbasa, R.Saidur, V.V.Bushuev , M.I.Yavorsky, A.A.Andrievsky, V.A.Golstrem, N.I.Danilov and others.

Scientists T.Kh.Nosyrov, K.R.Allaev, R.A. Zakhidov, R.A. Sitdikov, T.S.Kamalov, a made a significant contribution to the field of effective management and rational use of fuel and energy resources in our republic. Sh.Shaislomov, M.A.Koroli and A.A.Badalov. In the field of automation of the management processes of manufacturing enterprises and the development of information systems for making reliable decisions in the management process, research was carried out by such scientists as M.Mesarovich, I.Takakhara, T.Saati, N.P.Buslenko, R.A.Aliev, V.K.Kabulov, M.M.Kamilov, T.F.Bekmuratov, O.M.Nabiev, N.R.Yusupbekov, Sh.Kh.Fazilov and others.

The main goal of the energy saving management system of an industrial enterprise of the fuel and energy complex (FEC) is to increase the productivity of enterprises without increasing the consumption of FER, to reduce the energy component in the overall cost structure of the enterprise and, therefore, to ensure the competitiveness of manufactured products in the domestic and foreign markets. The task of improving the management system in industrial enterprises creates the need to develop such an information management system for energy conservation that would objectively reflect the resources, processes, and phenomena actually existing in real conditions that explain the dynamics of all indicators under the influence of a set of factors. Due to the dynamic and probabilistic nature of the production process, more or less uncertainty of its future state is created. And therefore, in modern conditions, it is almost impossible to manage the production process and make optimal, science-based decisions on managing this process.

One of the most important aspects of the successful operation of industrial enterprises is the presence of a systematic structured approach to managing the basic processes of production and sales of products. The multifactorial nature and diversity of energy conservation in sectoral contexts in the real sector of the economy have influenced the fact that research in this area is diverse and fragmented. Conceptual provisions, tools and methods for assessing the results of energy saving policies, principles, directions and methods for its implementation, methodological foundations for assessing the republican potential for energy conservation and energy-saving measures have not been fully defined and worked out.

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The main and most effective methods for the optimal solution of the tasks of the energy-saving management system and the efficient use of energy resources are the use by enterprises of an energy-saving information management system [1].

The most important complex tasks in energy management information systems are the tasks of energy planning and calculation of planned consumption of fuel and energy resources. The energy policy of enterprises largely depends on the quality of their long-term, strategic, current and operational energy planning, which are closely related to conducting energy analysis and determining basic criteria. It also depends on energy performance indicators, setting goals, objectives and developing action plans necessary to achieve results on improving energy efficiency in accordance with the energy policy of the enterprise [2].

II. STATEMENT OF A PROBLEM

In general, the main goal of effective energy consumption management of fuel and energy resources is the production of low-cost products and the receipt of high-quality goods with minimal costs. Therefore, in the process of energy planning, the task of calculating the cost of production costs in oil and gas companies was performed using the method of mathematical programming.

The main costs affecting the cost of oil and gas produced in oil and gas companies of the fuel and energy complex are fuel and energy resources, which include electricity, fuel gas, thermal energy, water, steam, gasoline, diesel fuel, kerosene and oil.

Thus, the task of minimizing the costs of fuel and energy resources, affecting the main indicator - the cost of production in the form of mathematical programming tasks, is written as follows:

$$T(x) = H_1 x_1 + H_2 x_2 + \ldots + H_n x_n = \sum_{j=1}^{n} H_j x_j \to \min \qquad (1)$$

under restrictions

$$\begin{cases} \frac{1}{S_{11}} x_1 + \frac{1}{S_{12}} x_2 + \ldots + \frac{1}{S_{1n}} x_n = \sum_{j=1}^{n} \frac{1}{S_{1j}} x_j \geq Q_1 \\ \frac{1}{S_{21}} x_1 + \frac{1}{S_{22}} x_2 + \ldots + \frac{1}{S_{2n}} x_n = \sum_{j=1}^{n} \frac{1}{S_{2j}} x_j \geq Q_2 \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ \frac{1}{S_{m1}} x_1 + \frac{1}{S_{m2}} x_2 + \ldots + \frac{1}{S_{mn}} x_n = \sum_{j=1}^{n} \frac{1}{S_{mj}} x_j \geq Q_m \end{cases}$$

and conditions

$$x_j \geq 0,\ Q_i \geq 0 \quad j = 1,\ldots,n\ ,\ \ i = 1,\ldots,m$$

where H_j is the cost of the *j*-th fuel and energy resources; S_{ij} - the specific consumption of the *j*-th fuel and energy resources for the *i*-th product; Q_i - the volume of the first *i*-th product; x_j - values of the optimal parameters of the *j*-th fuel and energy resources; *n* is the amount of fuel and energy resources; *m* - the number of products.

III. THE CONCEPT OF THE PROBLEM DECISION

The algorithm for solving the problem of minimizing the consumption of fuel and energy resources that affect the cost of production, presented as a mathematical programming problem, is as follows [3, 4].

Step 1. To solve the problem, we introduce the values of the initial parameters, i.e. *n* is the number of values of the determined parameters and *m* is the number of restrictions.

Step 2. It is checked whether the mathematical programming problem is in canonical form. If not, then you need to convert it.

Step 3. The initial basis tables are determined. In the basis table, basic variables, independent variables, values of free terms, and coefficients of our objective function are recorded (Table 1).

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Step 4. The coefficients of the H_j objective function are checked under the condition $H_j \le 0$. If the condition is satisfied, then our problem is solved; otherwise, we proceed to step 5.

Step 5. The leading columns of the basis table (a variable introduced into the basis) are determined. The leading column is determined based on the following expression:

$$x_{column} = \max\{H_j\}, \quad j = 1, \dots, n+m$$

Table 1
Source basis table

Basis	Variables							Q_i
	x_1	x_2	$\dots$	x_n	x_{n+1}	$\dots$	x_{n+m}	
x_{n+1}	S'_{11}	S'_{12}	$\dots$	S'_{1n}	1	$\dots$	0	Q'_1
x_{n+2}	S'_{21}	S'_{22}	$\dots$	S'_{2n}	0	$\dots$	0	Q'_2
$\dots$	$\dots$	$\dots$	$\dots$	$\dots$	$\dots$	$\dots$	$\dots$	$\dots$
x_{n+m}	S'_{m1}	S'_{m2}	$\dots$	S'_{mn}	0	$\dots$	0	Q'_m
H_j	H'_1	H'_2	$\dots$	H'_n	0	$\dots$	0	Z'

When determining the resolving column, the last row of the basis table is scanned and the largest positive element is found in it.

Step 6. Values of the leading column are checked based on the condition $S'_{icolumn} \le 0$ ($j = column$). If the condition is satisfied, then the objective function is not limited and there is no solution, otherwise, go to step 7.

Step 7. The resolving row from the basis table is determined based on the following expression:

$$x_{string} = \min\left\{\frac{Q_i}{S'_{icolumn}}\right\}, \; i = 1, \dots, m, \; S'_{icolumn} > 0$$

Step 8. The values of the base variables of the basis table are recalculated. The calculation of the values of the variables is carried out according to the following formulas:

$$Q^+_{column\,j} = Q'_{column} / S'_{string\,column},$$

$$S^+_{column\,j} = S'_{column\,j} / S'_{string\,column} \quad Q^+_i = Q'_i - S'_{i\,column} Q'_{string} / S'_{string\,column}, \quad S^+_{ij} = S'_{ij} - S'_{i\,column} S'_{string\,j} / S'_{string\,column},$$

$$H^+_j = H'_j - S'_{string\,j} H'_{column} / S'_{string\,column} \text{ and } Z^+ = Z' - H'_{column} H'_{string} / S'_{string\,column}$$

Based on the values of the calculated variables, a new initial basis table is created (Table 2).

Then we go to step 4 and again calculate the steps of the 8th from the values of the variables in the new base table.

The indicated actions will continue until the optimal parameters of the given task are determined, i.e. until the conditions in step 4 are met. After determining the values of the optimal parameters, the algorithm ends, and the optimal values are displayed.

Table 2
New source basis table

Basis	Variables							Q_i
	x_1	x_2	$\dots$	x_n	x_{n+1}	$\dots$	x_{n+m}	
x_{n+1}	S^+_{11}	S^+_{12}	$\dots$	S^+_{1n}	1	$\dots$	0	Q^+_1
x_{n+2}	S^+_{21}	S^+_{22}	$\dots$	S^+_{2n}	0	$\dots$	0	Q^+_2
$\dots$	$\dots$	$\dots$	$\dots$	$\dots$	$\dots$	$\dots$	$\dots$	$\dots$
x_{n+m}	S^+_{m1}	S^+_{m2}	$\dots$	S^+_{mn}	0	$\dots$	0	Q^+_m
H_j	H^+_1	H^+_2	$\dots$	H^+_n	0	$\dots$	0	Z^+

IV. CONCLUSION

The methods used in the algorithm for determining the optimal parameter values developed have been successfully tested and used to solve a large number of optimization problems. Table 3 below shows the results obtained on the basis of the enterprise's calculations of the costs that make up the cost of oil and gas products produced at the oil and gas production enterprise.

Table 3
The results obtained on the basis of the calculations of the enterprise

Name of products produced	x_1, kW/s	x_2, m^3	x_3, Gcal	x_4, m^3	x_5, Гкал	x_6, liter	x_7, liter	x_8, ton	x_9, ton
Oil	389	472	2,16	267	1,74	5,2	3,5	0,025	0,036
Gas	364	84	1,25	230	1,05	6,1	4,4	0,015	0,017

Table 4 shows the results of the algorithm for solving the problem of minimizing the consumption of basic fuel and energy resources, which affects the cost of the product, given in the form of mathematical programming.

Table 4

Research Results

Name of products produced	x_1, kW/s	x_2, m^3	x_3, Gcal	x_4, m^3	x_5, Гкал	x_6, liter	x_7, liter	x_8, ton	x_9, ton
Oil	269	553	362	217	1,15	4,2	3,1	0,016	0,024
Gas	257	553	68	185	0,64	5,5	3,8	0,011	0,013

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