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ECOLOGICAL INDICATORS IN THE SYSTEM OF NON-FINANCIAL REPORTING AT INDUSTRIAL ENTERPRISES

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sustainable development, concept of low-carbon development, ecological management, ecological and power engineering indicators, power intensity, greenhouse gases, non-financial reporting

ABSTRACT

Efficient economics of the modern society is impossible without keeping the balance between technological development, ecological safety and social prosperity, and it needs to be estimated and analyzed in the area of production and energy supply. The conventional economical criteria for estimation are insufficient for this purpose, thereby the complex system for estimation of economical, ecological and power engineering efficiency of works' activity is required. This problem is actual for energy-intensive industries of modern Russia that are trying to enter the way of low-carbon development. Analysis of reporting content, reflecting the results of ecological activity of industrial enterprises, allows to establish that classification of ecological indicators corresponds in general to methodical approach for forming of non-financial reporting. This reporting has been developed in the framework of the Global reporting initiative (GRI) and recommendations of the Russian Union of Industrialists and Entrepreneurs (RSPP), but it does not reveal information about greenhouse gases emissions and does not demonstrate effective activity in the direction of development of low-carbon economics. To solve this problem, the authors study the existing estimation system for ecological efficiency of Russian enterprises and suggest additional criteria and efficiency estimation indicators for ecological management system from the point of view of lowering of carbon intensity and rising of production energy efficiency. Introduction of additional indicators in corporate non-financial reporting, while these indicators reflect operating results of activity of the enterprise in the area of low-carbon development, orientates the aimed parameters of ecological management on varying the structure of energy consumption, lowering of greenhouse gases emission and realization of ecologically important measures directed on the development of low-carbon economics.

Survey of the problems and aim of the investigations

The problem of the environment degradation caused by expanding of production activity has led to necessity of changing relation to management of natural resources and society transition to sustainable development. This sustainable development provides economic prosperity, ecological safety and social justice for current and forthcoming generations. The concept of RF transition to sustainable development defines it as a stable social and economic development without destruction of its natural basis [1, 7].

The concept of sustainable development requires observation of three conditions: biospheric restrictions, social restrictions and economic efficiency. The maximal permissible fluctuation of local or global ecological system caused by human economic activity is considered as one of the main biospheric restrictions [4]. Exceeding of this restriction violated the functions of regulation and stabilization of the environment and leads to unstable state and degradation. At present time a row of technological processes moves carbon balance to the side of increase of carbon dioxide concentration in the atmosphere. This tendency leads to climate variation and has the effect on social and economic development [6]; increase of the global temperature by 3–4 °C is considered at the same time as maximal permissible fluctuation [1]. According to the predictions [5], elimination of warming consequences (such as extremal meteorological appearances, water-flooding of waterside areas, degradation of ecological systems) requires 5% of the global GDP, while timely prevention of the consequences of climate variation needs 1% of GDP.

In this connection, rise of power efficiency as a method for achievement of substantial power saving and cutting of greenhouse emissions are recognized as one of the priority tasks for providing of sustainable development of the national Russian social and economic system, as well as the key condition for achievement of economic, power engineering and ecological aims in the conditions of realization of the concept of low-carbon development.

Ecological management as a tool of the control system for managing of an economic subject plays the defining role in solving the problems of corporate, national and global level in the field of sustainable low-carbon development. This ecological management provides systematization of the approaches to the problems connected with environment state and inclusion of ecologically important aims in the business strategy.

At present time the essential ecological aspects remain the aimed and scheduled parameters of ecological management for many Russian enterprises. The following of such parameters can be mentioned: rational utilization of resources; emission and discharge of contaminants; forming and

dislocation of wastes; part of recycled or secondary used materials. However, the most of Russian enterprises don't include activity aimed on control and reduction of emission of greenhouse gases in their regular business perimeter.

In the meantime, actual features of ecological and economic evaluation of activity of an enterprise from the point of view of consumption of power resources and emission of greenhouse gases increase in correspondence with recognition of the global and defining effect of consequences of an enterprise operation on stability of the ecological systems. Significance of the input of an enterprise in climate variation as well as of its activity in achieving the aims of the ecological policy, national ideas and in implementation of the international obligations is also increasing.

It is declared that diversification and decarbonization of economics is a possibility to rise competitiveness due to decrease of dependence on hydrocarbon raw materials and its part in the cost of finished products as well as creation of the motivating system for innovative development of high efficient resource-saving and power-saving technologies. This possibility does not exclude importance of lowering of the negative effect of these processes on the environment due to decrease of emission of greenhouse gases [21]. On the contrary, lowering of competitiveness of Russian power resources and products [2] can occur as a result of restrictions introduced by European markets for import of power resources and products having price without complete account of ecological factor (e.g. with undervalued expenses for prevention of emission of greenhouse gases). In particular, this police can be resulted in rise of customs duties for export of metal products manufactured by the leading Russian metallurgical enterprises [12].

Taking into account the tendencies of global development directed to forming of the low-carbon economics, as well as economic and ecological risks, the economics based on export of raw materials that is typical for Russia can be considered as low-efficient and low-competitive. Economic risks are presented by dependence on global prices for hydrocarbons, while ecological ones – by climate variation, degradation and depletion of natural resources, contamination and wastes. In this connection the Power engineering strategy of Russia until 2030 envisages different scenarios of development of global power engineering industry and possibilities for adaptation to these scenarios, including the direction based on cutting of emission of greenhouse gases. Lowering of power intensity of Russian GDP by 40 % until 2030 is considered as one of the main aims and is substantiated by the results of the forecast (**fig. 1**).

Analysis of the structure of power saving volumes in correspondence with the State program "Power saving and rise of power engineering efficiency until 2020" (**fig. 2**) displays that it is necessary to realize substantial potential of power

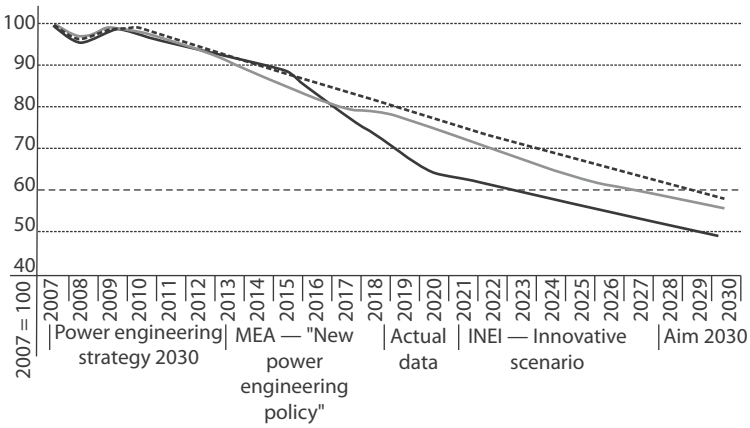

Fig. 1. Predicted dynamics of power intensity of RF GDP until 2030, %

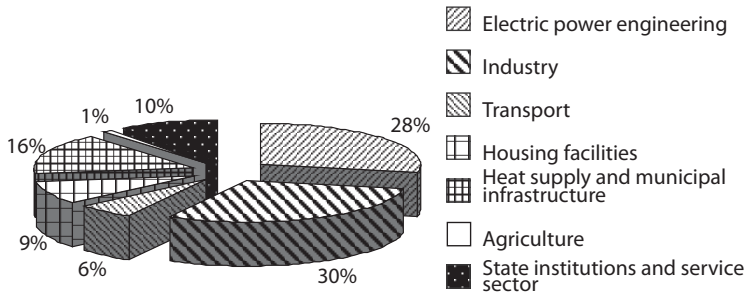

Fig. 2. Structure of volumes of power saving along the directions [15]

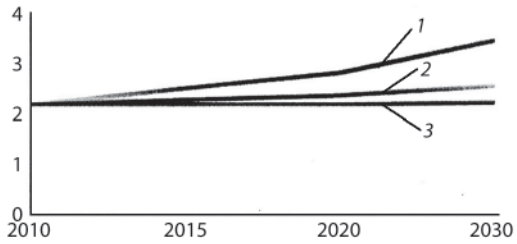

Fig. 3. Predicted evaluations of emissions of greenhouse gases in Russian Federation, bln. t of CO_2 equivalent:
1 — without any measures; *2* — with measures; *3* — with additional measures

saving via power efficiency rise, first of all, in power engineering and in the industry.

The scenarios of variation of joint anthropogenous emission of greenhouse gases in CO_2 equivalent until 2030 are formed on the base of suggestions on dynamics of power capacity and carbon capacity in the economic sectors, taking into account efficiency of realization of the measures providing the preset volume of emission of greenhouse gases [3]. These scenarios are classified in three families mostly meeting the criteria "without any measures", "with measures" and "with additional measures" (**fig. 3**).

Achievement of the predicted aimed parameters of cutting of emissions in the scale of economics in general and in the metallurgical industry in particular is a result of realization of the measures directed on efficiency rise and variation

of structure of used fuel, as well as on decrease, absorption and compensation of emissions of greenhouse gases. To provide objective evaluation of efficiency of the ecological management system, meaning its correspondence to preset aims in the conditions of realization of the concept of low-carbon development, the additional ecological and power engineering indicators are required. These indicators describe activity of an enterprise in the field of control of emissions of greenhouse gases and consumption of hydrocarbon fuel. It is the reason why the problem of evaluation of efficiency of ecological management at the enterprise level needs its additional examination, especially in the conditions of realization of the concept of low-carbon development and ecologization of production, with required variation of its technological base.

Despite of substantial volume of the works in the researched area, the problems of ecological management in the field of efficiency of operation of the enterprise and state of the environment are still not solved in methodical aspects. In this connection, investigation of criteria and creation of the system of indicators allows to expand and rise objectivity of ecological and economic evaluation of production facilities in the conditions of development of low-carbon economics. These indicators characterize ecological results of activity of the enterprise in complex way and include the following positions: usage of resources; forming of wastes; emission of greenhouse gases; adapting actions for preservation of quality of the environment and stability of ecological systems.

Theoretical and practical results of investigation

The general system of ecological indicators of activity of the enterprise is necessary to meet the requirement of the main standard of the system of ecological management ISO 14001 aimed on permanent improvement of ecological aspects of activity of the enterprise. This system is envisaged by the standard ISO 14031, and distribution according to ecological indicators in the field of operation and state of the environment provide actual evaluation in correspondence with this standard (**fig. 4**). The subjects of evaluation are the following:

• ecological aspects of activity of the enterprise from a perspective of consumption of materials, fuel, power as well as operation of equipment and forming of wastes, contaminations and emissions;

• environment quality according to the levels of concentration of contaminants in atmosphere, water, ground as well as influence on people's health, state of flora and fauna, variation of climate related with these factors;

• activity that is directed on achievement of the aims of the ecological policy, national ideas, correspondence to standard regulations, implementation of the international obligations.

The unified logic of construction of the system of indicators is observed. It characterizes the ecological results of activity of the enterprise in correspondence with recommendations of the standard ISO 14031 and ecological indicators used in global practice [16-20].

Such approach to evaluation of the efficiency of ecological management from the perspective of correspondence to the preset aims in the field of lowering and prevention of negative effect on the environment seems to be the most expedient. It is substantiated by the complex characterization of correlation between commercial usage of resources - from one side - and emission of contaminants and wastes (effect), preservation of quality of the environment and stability of biosphere (state) and adapting actions aimed on elimination of discontinuity between commercial activity and ecological problems caused by this activity (response) – from other side (**fig. 5**).

Analysis of composition and structure of corporate non-financial reporting, reflecting the results of ecological management of the enterprise is executed [10, 13, 14]. It allows to establish that distribution of ecological indicators of non-financial reporting corresponds in general to the methodical approach to evaluation of efficiency of ecological management that has been considered previously. This approach evaluates efficiency of ecological management from the perspective of correspondence to the preset aims in the field of lowering and prevention of negative effect on the environment. It also helps to develop and increase informational value of non-financial reporting by the following factors characterizing low-carbon development:

• gross and specific consumption of fuel and other power resources, gross and specific emissions of greenhouse gases (effect);

• adapting actions – the results of putting ecological management into practice in the direction of efficient usage of different kinds of power and cutting of emissions of greenhouse gases (response).

The results of investigation and analysis of the principles of forming the system of key operating parameters of activity at the corporate level [8, 9] have displayed possibility

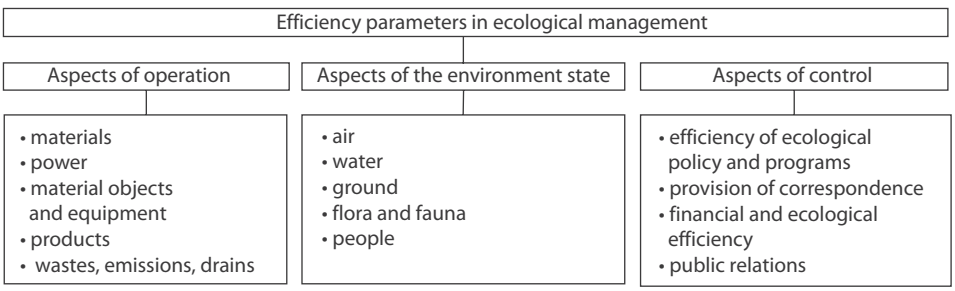

Fig. 4. The system of efficiency parameters in ecological management

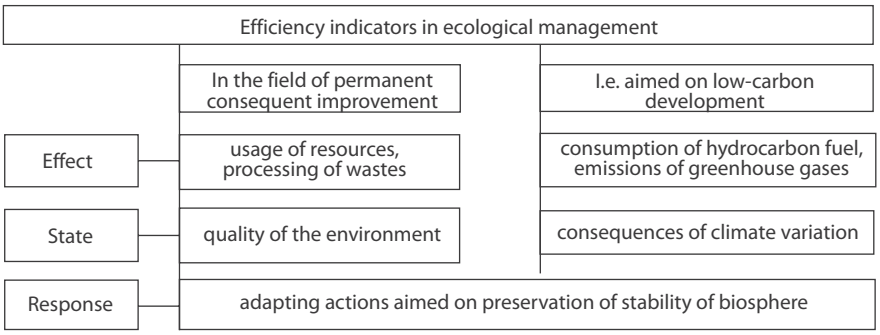

Fig. 5. Distribution according to ecological indicators in the system of ecological management

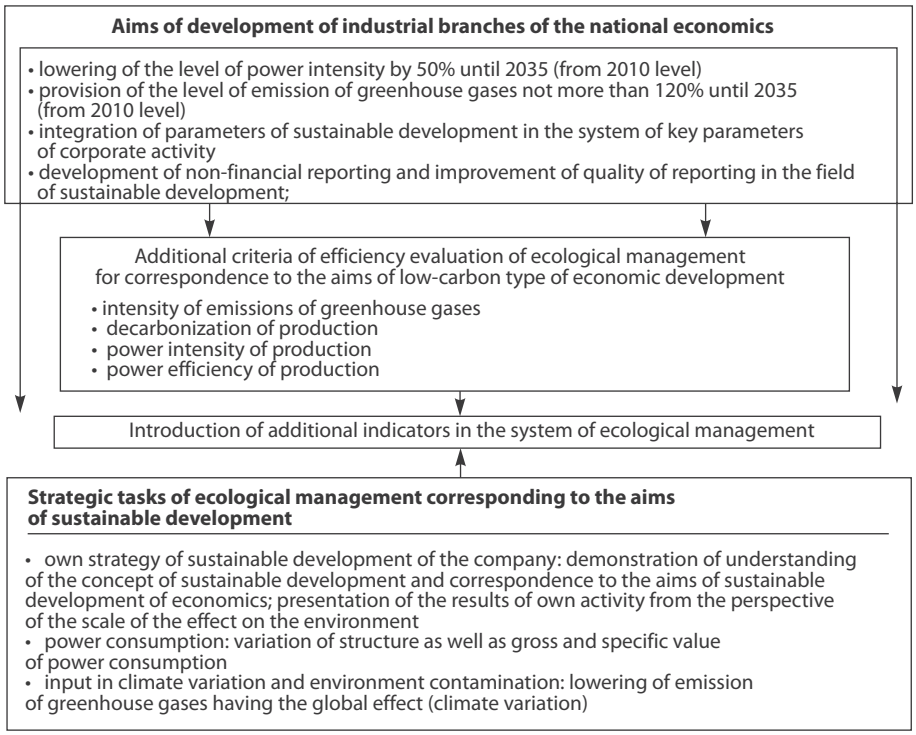

Fig. 6. Criteria of correspondence to the aims of sustainable development

of adding and coordination of parameters of the system of ecological management and non-financial reporting. These parameters connect the aimed parameters of power intensity with the level of emissions of greenhouse gases and reflect present or future input of the company in improvement or degradation of the environment and climate variation.

Realization of the concept of low-carbon development is connected with solving of the complex of mutually related problems directed on rise of power efficiency, change of the structure of power consumption, decrease of emission of greenhouse gases. The concrete aims of development of the industrial branches of national economics until 2035 are noted within the scope of its realization.

Absence of the parameters characterizing efficiency of solving the problems and reflecting the operating results in correspondence with the aims of realization of the concept in the system of ecological management and non-financial reporting for the most of Russian enterprises is noted. It requires introduction of additional criteria and indicators for evaluation on correspondence to ecological and power engineering aims of sustainable development (**fig. 6**).

It is suggested on the base of introduced criteria of efficiency evaluation of ecological management to add the existing system of parameters with the following indicators:

- intensity of emissions of greenhouse gases;
- decarbonization of production;
- power intensity of production;
- power efficiency of production.

It allows to correct the strategic tasks of ecological management, while it, in its turn, requires variations in the ecological policy and the system of taking solutions for performance of adapting actions that will eliminate discrepancy between commercial activity and ecological problems.

The suggested additional ecological and power engineering indicators are the base for reliable evaluation of efficiency of the system of ecological management in the conditions of

realization of the concept of low-carbon development. They are also used for ecological and economic substantiation of commercial decisions at different control levels.

Necessity of transition to low-carbon economics requires responsible business practice in the field of efficiency evaluation of use of power resources, effect of the enterprise on the environment and input in climate variation.

Necessity of improvement of the ecological policy and the programs aimed on rise of ecological efficiency is considered as one of the key business obligations fixed in the Business Charter of sustainable development, accepted by the International trade chamber. In this connection, putting into practice, certification and development of the systems of ecological management and opening of ecological aspects of activity in the corporate social reporting are among the corporate priorities for Russian enterprises, in correspondence with the requirement of legislation and volunteer initiatives.

Reporting of Russian enterprises is characterized by transparent information about conventional contaminants: emissions of contaminating substances in the atmosphere, drainage of sewage waters and locating production wastes. The process of accounting and control of direct and indirect emissions of greenhouse gases is not observed in the ecological policy of the most Russian enterprises, as well as the program of their lowering. At the same time, analysis of the dynamics of emission of greenhouse gases for the economic sectors of Russian Federation displays that maximal volume of emission of greenhouse gases in industrial processes is provided by metallurgy having such technological feature as usage of large amount of hydrocarbon fuel (**fig. 7**).

Evaluation of activity of the enterprises from the perspective of low-carbon development (lowering of power capacity and emission of greenhouse gases) meets the actual requirements of the development of corporate ecological management and objective reflection of ecological situation in the subjects of Russian Federation.

Analysis of the effect of anthropogenic activity on state of the environment has shown that the enterprises of processing industry are the first objects of evaluation of efficiency of ecological management. It is caused by their role as the base of production potential, as the largest consumers of raw and technological materials, water, fuel and power resources and as the sources of contaminating substances, wastes and emissions of greenhouse gases.

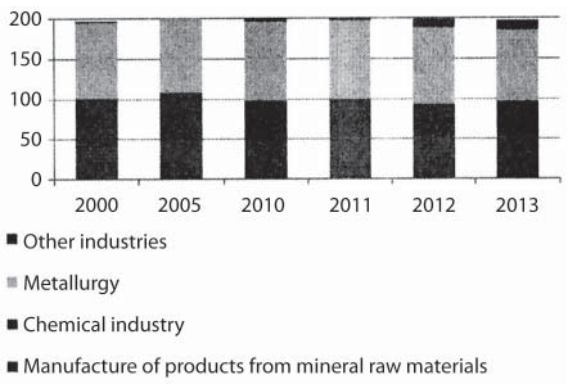

Fig. 7. Emissions of greenhouse gases connected with production processes and usage of commercial products, mln. t of CO_2 equivalent per year

Iron and steel works realize their production activity in correspondence with legislative requirements of Russian Federation in the field of environment protection and international initiatives in the area of ecological management. Analysis of content of reporting on the results of ecological activity allows to reveal that distribution of ecological indicators corresponds in general to the methodical approach to forming of non-financial reporting. This approach has been developed in the framework of the Global reporting initiative (GRI) and recommendations of the Russian Union of Industrialists and Entrepreneurs, but it does not open information about emissions of greenhouse gases and does not demonstrate the effective activity directed on development of low-carbon economics [11, 18].

Taking into account the above-mentioned consideration, the basic ecological parameters have been added by recommended indicators of power capacity, power efficiency, decarbonization of production and intensity of emissions of greenhouse gases (**table 1**).

The aimed parameters of ecological management characterize variation of the structure of power consumption and lowering of emissions of greenhouse gases. Forming of these parameters and introduction of recommended ecologic and power indicators in the corporate non-financial reporting is substantiated based on necessity of the following measured:

- realization of organizing and technological potential of power saving as strategic aim of Russian economic development;
- integration of parameters of low-carbon development in the system of key operating parameters at the corporate level;
- rise of interest of the enterprises in implementation of ecologically important measures;
- development of non-financial reporting and improvement of reporting quality in the field of sustainable development.

Measuring of activity results in the area of control of emissions of greenhouse gases and consumption of hydrocarbon fuel makes it possible not only to evaluate the current situation, but also to determine or work out in details the strategic and tactic ecological aims as well as to develop the efficient managing solutions and to control the process of achieving the results of ecological management.

Conclusions

The obtained results allow to make the following conclusions:

1. Rise of power efficiency, usage of renewable power sources, protection and quality improvement of absorbers of greenhouse gases, restriction or cutting of emission, de-

Table 1. **Ecological indicators**	
Indicators relating to the "Power" aspect	
Basic	Usage of power: gross power consumption from all kinds of power carriers, GJ
	Specific power consumption: relation between gross power consumption during the reporting period and the volume of manufactured products during the same period, GJ/unit
Recom-mended	Specific consumption of hydrocarbon fuel: relation between the volume of consumed hydrocarbon fuel during the reporting period and unit of products manufactured during the same period, GJ/unit
	Efficiency of consumption of hydrocarbon fuel: relation between the added value during the reporting period and unit of hydrocarbon fuel consumed during the same period, Rub/GJ
	Efficiency of power consumption: relation between the added value during the reporting period and gross power consumption during the same period, Rub/GJ
Indicators relating to the "Emissions, Drainage, Wastes" aspect	
Basic	Emissions of greenhouse gases: gross volume of emissions of greenhouse gases, t in equivalent of carbon dioxide
Recom-mended	Specific emissions of direct greenhouse gases: Relation between the volume of direct emissions of greenhouse gases during the reporting period and unit of products manufactured during the same period, t in equivalent of carbon dioxide per unit
	Specific emissions of indirect greenhouse gases: Relation between the volume of indirect emissions of greenhouse gases during the reporting period and unit of products manufactured during the same period, t in equivalent of carbon dioxide per unit
	Cutting of emissions of greenhouse gases: cutting of direct emissions of greenhouse gases during the reporting period in relation to the basic period, t in equivalent of carbon dioxide per year
	Removal of greenhouse gases: absorption (conservation) of emissions of greenhouse gases during the reporting period as a result of realization of the measures, t in equivalent of carbon dioxide per year

velopment of absorption technology for greenhouse gases are considered to be the most important problems in the field of realization of the concept of low-carbon development.

2. Investigation of the role and importance of ecological management in solving the problems of sustainable low-carbon development allows to establish the criteria and additional indicators for evaluation of efficiency of ecological management from the perspective of its correspondence to ecologic and power aims, as well as to develop recommendations for their putting into practical system of ecological management at the enterprise.

3. Introduction of additional indicators, reflecting the results of activity of an enterprise in the area of low-carbon development, in the corporate non-financial reporting orients the aimed parameters of ecological management for variation of the structure of power consumption, for lowering of emissions of greenhouse gases, for realization of ecologically important events directed on development of low-carbon economics.

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SIMULATION OF AERODYNAMIC FLOWS OF GAS WITHDRAWAL FROM COKE BATTERIES

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Key words:

coke, coke batteries, simulation, aerodynamics, chimney shafts, calculating hydrodynamics, emissions in the atmosphere

ABSTRACT

The modern level of the development of computer engineering and software allows to simulate the processes with different degree of complication and to solve the problems connected with aerodynamic features of turbulent flows of withdrawn gases both in entrance and exit of coke batteries. The paper presents the results of aerodynamic simulation of gas medium using Ansys program in order to determine the temperature field above the surface of coke battery chimney shaft, as well as the results of registration of speed of withdrawn gases for adjusting the flame level. Realization of operation of continuous monitoring systems directly on chimney shaft makes it possible to control thermal state of a coke battery in general and provides lowering of harmful emissions in the atmosphere.

Solving the ecological problems in the coke-chemical production is one of the main priority tasks for the modern level of technical development. Chimney shafts of coke batteries are the main source of industrial emissions in the atmosphere [1-3]. It is impossible to provide their efficient operation with minimization of harmful effect on the environment and surrounding territories without usage of advanced monitoring remedies, allowing to estimate character and volume of the main emissions withdrawn in the atmosphere with a flow of exhaust gases [4–6]. Realization of continuous monitoring systems with their mounting directly on chimney shafts is considered as one of the possible variants for forming instrumental measurements of harmful emissions in the atmosphere [7, 8]. Correct choice of location places for measuring sensors providing completeness and presentability of a registered parameter or value is the decisive condition of stable operation and receiving of trustworthy information from this monitoring system. Thereby, it is necessary to have information about features of variation of gas flows, both in the body of a coke battery chimney shaft itself and in its exit, in order to ensure rational mounting of the system of control and monitoring of exhaust gases [9].

It seems impossible to register practically and to determine the temperature field in the top part of a chimney shaft, as well as to determine experimentally temperature fields, speeds of flows and distribution of substances in a dynamically varying volume. Thereby, the calculated computer-aided simulation is the only method for examination of aerodynamics.

This article includes description of conducted aerodynamic simulation using Ansys software complex in order to determine the temperature field above the surface of a chimney shaft.

The simulation algorithm consists on the three consequent stages:

1. creation of 3D-model of a gas duct where exhaust gases of preset composition are moving; its geometrical dimensions should correspond to the calculated data;

2. building of the calculating net for solving of Navier-Stokes differential equation and heat conducting equation;

3. choosing and setting the initial and boundary conditions, development of operating algorithm, 3D-solving of differential equations.

Differential equations describing motions of exhaust gases out of chimney shafts are composed along three di-