The intensification of the solid fuel grate-firing process

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Abstract. The results of a complex fuel additive tests – the intensifier of the combustion process on a coal boiler KV-r-11.63-115 – are presented. An increase in the efficiency of the boiler unit by 5.1% (abs) was recorded with a corresponding reduction in the consumption of conventional fuel for the generation of a unit of thermal energy. Application of the intensifier allowed to solve the problem of cleaning the waterfall tubes from the layer of annular deposits and to change the structure of the slag formed during the combustion of coal, which became more homogeneous and without the center of agglomeration.

1. Introduction

Nowadays, more than a quarter of the world's demand for various types of energy is met by burning fossil fuels. The volumes of coal consumed in various sectors of the world economy are increasing year by year. With an increase in the amount of coal burned, intensive pollution of the environment with environmentally hazardous substances - combustion products - also increases. Obviously, further increase in the energy produced by burning coal and, consequently, the development of energy, is impossible without the development and implementation of effective ways to reduce the negative impact on nature. One such method is the combustion of coal fuel with added additives. However, their wide application is limited today by the lack of sufficient and reliable information [1-5].

Fuel additives are substances introduced directly into combustible fuels in order to improve its properties, realized both during storage and during use for its intended purpose. Fuel additives can affect both on one property of fuel, and on a number of its properties, and in this case the additive is called complex [1].

As a result of the additive action, the conditions and the mechanism of the course of all physical and chemical, including oxidation-reduction reactions, change the temperature gradient throughout the combustion volume, reduce the need for atmospheric air necessary for burning fuel, reduce the number of products of incomplete combustion and several the quantity of products of complete combustion increases. As a result, the qualitative and quantitative composition changes, and the temperature of the exhaust gases emitted into the atmosphere decreases [5-8].

CJSC SPE "Sibecotechnika" has carried out industrial tests of additives of foreign manufacture (3H Korea Co.Ltd) at one of Novokuznetsk coal-fired boilers.

2. Materials, equipment and test methods

Industrial tests of the fuel additive were carried out on a coal hot water boiler KV-r-11,63-115. The hourly consumption of Kuznetsk coal with a density of ≈ 1500 kg / m3, a moisture content of 22.5% and a net calorific value of 22 283 kJ / kg per one coal-fired boiler KV-r-11,63-115 at the nominal mode is 223 tons / hour. The fuel mixture supplied for combustion consisted of 99% coal and 1% additive. Calculations show that the use of 1-1.1% additive for such a boiler allows you to save on a nominal mode up to 20-25 tons / hour of coal, which is about 10% of fuel consumption per boiler.

Combustion of coal in the boiler is layered using a reverse-flow furnace of the TChMZ type. Pre- crushed coal cl. 0-20 mm from the hopper enters the feeder of pneumomechanical type and is thrown on the grate. Burning on the grate occurs in a thin layer, the thickness of which is set depending on the required heat output of the boiler. Fine coal from the grate is removed continuously while moving the grate blade towards the front of the boiler [9-10].

As a fuel additive, the complex liquid additive Aid-Clean Force catalyzing and modifying action was used, consisting of nano-oxide aluminium (Al2O3), nano-hydrotalcite (Mg6Al2(Co3)(OH) 16.4HO), hydrogen peroxide (H2O2), etc. The physical properties of the additive are shown in Table 1.

Table 1. Characteristics of the additive

Indicator name	Value
Particle size of the disperse phase	10-50
Specific surface area, m^2/ml	200
Relative weight, kg/m^3	1.14
pH	6-8
Frost resistance, °C	-20

The additive was introduced into the fuel in a dosed manner, which allows it to be used more rationally for its intended purpose. The technological process of preparation of the additive was determined by its aggregate state and consisted in imparting a finely dispersed state, in an even distribution of the additive throughout the fuel volume in order to increase the total area of contact with the chemical elements, compounds and substances participating in the oxidation reaction. To enter the additive, it is advisable to have a special system in the boiler plant that allows its preparation, dosage and even distribution throughout the fuel volume.

The concentrated additive solution was diluted with water to a ratio of 1:10 (solution: water) and thoroughly mixed until a homogeneous mass was obtained. The resulting solution was filtered and the dispersing pump was fed through a nozzle onto the crushed coal conveyed by the belt conveyor into the coal bunker in front of the boiler during its loading. Consumption of fuel additive was 10 ÷ 11 kg of ready solution per 1 ton of coal. Irrigation of the coal loaded into the bunker was carried out periodically in accordance with the schedule of filling the hoppers in the boiler room. The effectiveness of the action of the fuel additive was evaluated by comparing a number of parameters of the balance tests of the boiler before the introduction of the additive and after at various capacities with the subsequent calculation of the main technical and economic indicators by the inverse balance method.

In the process of testing, samples of coal, slag, and fly ash were sampled and analyzed, and the flue gas composition was measured using the Testo-3000 gas analyzer. In addition, before and after the tests, the state of the heating surfaces of the boiler in the vicinity of the furnace space was recorded, namely, the degree of their contamination and the structure of the annulus deposits were estimated.

3. Analysis of the test results

The results of the boiler operation using an additive and without an additive at different capacities are presented in Table 2.

Table 2. Indicators of the efficiency of coal combustion without additive and with an additive when the boiler is operating at different capacities.

Heating capacity, Gcal / h	Content operation parameters (with / without addictive)			
	Losses in combustible losses, %	Content of flammable, %		Efficiency, gross weight %
		In the slag	In fly ash	
2-3	10.7 / 20.8	31.4 / 46.2	49.9 / 60.1	63.0 / 60.0
3-4	9.6 / 18.6	30.2 / 44.6	45.2 / 60.0	61.8 / 60.0
4-5	5.9 / 8.6	18.2 / 24.4	43.5 / 53.4	68.8 / 68.1
5-6	7.0 / 9.0	18.8 / 25.3	46.1 / 53.5	71.4 / 69.1
6-8	6.8 / 10.1	17.8 / 29.0	47.1 / 51.2	75.2 / 70.1

The analysis of the obtained data showed that the application of the additive resulted in an increase in the efficiency of the boiler is up to 75.2%, which is 10.8% higher than the value on the parameter table. At the same time, the value of the efficiency coefficient was continuously increased during the testing (both with additive and without additive). This can be explained by an improvement in the state of the screen heating surfaces due to the action of the fuel additive (Figure 1). A decrease in combustible substances in both slag and fly ash under the action of an additive was noted, which led to a decrease in heat losses with combustible losses. At the same time, the reduction in the consumption of conventional fuel for the production of 1 Gcal of thermal energy when using the additive was 30 kg.

a) b)

Figure 1. The view of surface of screen tubes: a) before the application of additive; b) after the application of the additive

It should be noted that the use of a fuel additive affected the structure of the slag formed during coal combustion, which became more friable and homogeneous.

Also noted the increased efficiency of the boiler after the end of the additive tests, which may be a consequence of maintaining the effect of clean heating surfaces.

4. Conclusions

• It was found that when the boiler was used with the additive, the efficiency was 75.2%, which is 10.8% higher than in the operating chart of the boiler (64.4%).
• The application of the additive provided a reduction in the content of combustibles in slag and fly ash, which, respectively, reduced heat losses with combustible losses by 29-50%.
• It is noted that the application of the additive has led to a change in the structure of the slag, namely, the reduction in the number of large agglomerates and, correspondingly, the increase in the fraction of small classes.
• It has been established that the application of the additive has led to the cleaning of the boiler screen tubes from the existing deposits and to the further maintenance of the heating surfaces in the operationally clean state.

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