Increase an Efficiency of Boilers with Liquid Removal of Slag at Combustion with the Donetsk Anthracites, Including for Recycling Units

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Abstract. There are questions of increase in fusibility of slag in coppers with liquid removal of slag by additives on the basis of alkaline-earth metals are considered in the article. The optimum modes of additives dispensing by their giving in a zone of burning and a supply line of crude coal are under production conditions defined. Optimum doses of additives when burning the Donetsk anthracite are revealed. Methods of IR spectrums and the X-ray phase analysis investigated changes in structure of the studied slag samples at various modes of additives dispensing. The described methods can be also applied to units for recycling.

1. Introduction
Continuous decline in quality of thermal power plants’s coals is caused by considerable development of the operating coal fields and transition to layers with the worsened characteristics. It leads to complications in operation of coppers with liquid removal of slag as there is a decrease in reliability of evacuation of liquid slag from fire chambers of package boilers. Increase in ash-content of solid fuel, quantitative and high-quality changes of structure of its mineral part lead to increase in temperature of a fluid state. Heat of combustion of the burned fuel decreases and is insufficient for achievement of optimum temperature at the exit from a zone of active burning.

At many coal-dust stations, including, on the Novocherkassk state district power plant, there are regularly problems with an exit of liquid slag. Problems are an increase in percent of slagging of openings up to their full closing that leads to long stops of boilers. An improvement of melting characteristics of a mineral part an initial fuel of poor quality can be one of options the additives reducing temperature of fusibility of slag.

The researchers conducted on the example of the Donetsk anthracite included determination the optimum composition a solution of salts an alkaline metal. These structures provided decrease in temperature of melting, and, respectively, a stable exit of slag through openings at combustion of low-grade coals in boilers with liquid removal of slag.

2. Results of an experiment
It is known that applying various additives as a part of the activating agents, it is possible to affect molecular structure of coals at their oxidation. The major characteristics defining features of
molecular structure of coals are types an interatomic communication. It is known that carbon atoms in wild spirits have an electronic configuration \(1S^22S^22P^3\). It provides existence of three types of hybrid communications -SP\(^3\), SP\(^2\) и SP. Energetically, proceeding from sizes of energy and lengths of communications between carbon atoms, communications in alkanes are the most favorable (SP\(^3\) - SP\(^3\)), between atoms of an alkyl carbon and an aromatic kernel (SP\(^3\) - SP\(^2\)) and in an aromatic kernel (SP\(^2\) - SP\(^2\) + π).

The carbon atoms participating in the chemical reactions corresponding to metamorphism process have most often three most favorable communications. The carbon atoms SP\(^3\) и SP\(^2\) - hybridizations of valent electrons are distributed as follows: not aromatic hydrogen is completely connected with saturated atoms of carbon, and aromatic atoms of carbon form a nuclear part. It is confirmed by comparison of the thermodynamic functions and molecular constants characterizing relative stability of model hydrocarbons with various types of carbon communications and data of microscopic methods [1 - 5].

It is proved that at mixture of fine carboniferous material with a potassium carbonate in concentration of 0.1-5% of the mass of dry initial material, potassium takes root between the planes of a crystal carbon lattice. At the same time, it increases distances between them from 0.34 to 0.38 mm, making them more available to oxidation process. Use of a sodium carbonate it’s also leads to receiving the carboniferous material containing chemically connected sodium. It causes the changes of electronic structure the material favorable for implementation of reactions with oxygen participation. It is revealed that at concentration of 2% the distance between the concentrated aromatic layers reaches a maximum and at further increase in concentration of additives does not change. The similar effect gives use of salts of alkaline and alkaline-earth metals, chlorides, sulfides, sulfites, acetates, carbonates and some acids, compounds of iron, manganese and aluminum [6, 7].

Studying of the main characteristics of the Donetsk anthracite included definition of some indicators given in the table. Researches were conducted according to the techniques stated in [8].

**Table 1.** Indicators of the studied material.

| Indicators                              | The studied material |
|----------------------------------------|----------------------|
| Gain of the dry rest, mg/l             | 1.36 – 1.41          |
| Gain of oxidability (permanganate), mgO/l | 5.1 – 5.3            |
| pH water extract                       | 7 – 8                |
| Total maintenance of phenolic and carboxyl hydroxyls, mg-ekv/g | 2.47                 |
| Maintenance of phenolic hydroxyls, mg-ekv/g | 1.21                 |
| Sorption activity on iodine, %         | 19 – 23              |
| Sorption activity on methylene blue, mg/g | 34                  |
| Sorption activity on acetic acid, mmol/g | 0.023               |

For the choice of the additives dosed for improvement of melting characteristics the nature of porous structure the Donetsk anthracite samples and existence and the structure of superficial functional groups were previously investigated.
The research of porous structure of the Donetsk anthracite samples showed that the prevalence of a time, with an effective radius is characteristic of them less $\lg r = 1.2$. Total volume meso- and macrotime of the studied samples is rather small and is approximately $0.30 \text{ cm}^3/\text{g}$.

**Figure 1.** Dependence of the average size of the prevailing time on concentration of additive in slag.

In addition samples of carboniferous material investigated by method of the X-ray phase analysis by means of the x-ray powder diffractometer ARL X"TRA. X-ray ranges are given on figures 2, 3.

**Figure 2.** A x-ray range of the studied sample without additive (a control sample).
The analysis of figures 2 and 3 shows that at increase in percent of content of additive from 0 to 3% the content of such connections decreases, as SiO$_2$ and Li$_2$FeTi(PO$_4$)$_3$. However, in the same samples growth of connections is observed (Mg Al FeO). And in a sample with the maximum additive of additive - 3% the maintenance of this complex is expressed most brightly.

Taking into account earlier conducted researches [10-12] it is possible to claim that the volume of the carried-out laboratory researches is sufficient for reliable interpretation of the received results.

Results of laboratory researches were confirmed with industrial tests: solution of additive had moved in an air part of a hearth torch with an expense according to the program of tests. Further it was observed the mode of removal of slag on a condition of an opening. Besides, parallel sampling of slag from an opening in which additive, and the next opening of the same boiler (control test) was dosed was made. Also, the measurement of a slag temperature by means of the infrared thermometer Fluke was made. Results of industrial tests are given on figure 4.

Figure 3. A x-ray range of the studied slag sample from 3% of additive.

Figure 4. Schedules of change of disclosure of an opening, %, doses of the brought additive, l/h, and sizes of temperature, °C, from time.
3. Conclusions
Results of laboratory researches and industrial tests showed that addition of solutions of alkaline metals has a considerable impact on structure of carbon material. Also, it positively affects process of liquid removal of slag. And it was established that the greatest effect is rendered by additive solution supply directly in an opening through a hearth torch. At introduction of dry additive to a supply line of crude coal the effect was considerably smaller, however, considerable decrease combustible in ablations was registered. Results will also be useful at design of complexes on recycling, including at electrolysis of liquid slag [15]. It is possible to use technology of slag fusion on power complexes on processing of waste, including for carrying out electrolysis. In the course of electrolysis it is possible to receive useful raw materials, for example, to emit non-ferrous metals.

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Acknowledgments
Article is executed with assistance of a grant of the Russian Federation President to the young scientist and graduate students who are carrying out perspective research and development in the priority directions of modernization of the Russian economy for 2018-2020 (Project No. SP-459.2018.1).