Experimental Study of Contact Heat Exchange between the Coke and Decaying Technological Material

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Abstract. The article presents the results of an experimental study of the non-stationary process of contact heat transfer between hot coke and siderite ore. To conduct this study, an experimental installation of a cylindrical shape was built. As process of the material used siderite ore (FeMgCO₃) sfericheskoi shape with a diameter of 20 mm. Based on the accepted diameters of siderite ore and coking coal was considered a uniform distribution of process material in the layer of coke, based on the determined quantitative ratio of 1:17. Heat exchange is carried out due to the temperature difference only between the hot spherical pieces of coke and cold spherical piece of ore. High-temperature experimental study of the contact heat transfer process allowed to determine such parameters as: the total heat transfer time, the cooling time of coke, the heating time of siderite ore in the coke layer of spherical shapes, the average mass temperature of coke cooling and heating of siderite ore.

1. Introduction
Due to the increasing scale of coke production in the World and Russia, the world production of which will grow and by 2019 will reach about 800 million tons,[1], the issue of using the heat of hot coke is relevant for coke plants in terms of both energy conservation and environmental protection [2-7].

Dry coke quenching is an energy-saving technology that allows to utilize a significant amount of heat from hot coke. With one ton of coke extinguished utilized 1256,1-1674,8 MJ of heat, which allows to 0.4-0.5 t a pair of high-energy parameters [8].

The conducted studies [9-12] determined that it is advisable to divide the dry coke quenching plant (CDCP) into two zones - high-temperature and low-temperature.

In [13] thermodynamic and exergy analysis proved the feasibility of discharge from the coke cooling circuit low-temperature area in which the most effective is the steam generation medium-energy parameters and the high-temperature region in which it is possible to carry out cooling of coke with different technological materials, as one of such materials is used siderite ore [14-15].

Thus, the objective of the experimental study is to study the non-stationary process of contact heat transfer between hot coke and siderite ore, the purpose of which is to determine the heating time of siderite ore in the coke layer, to confirm the possibility of the proposed process in the high-temperature region.

2. Description of the Pilot Plant
Investigation of the process of contact heat transfer between coke and siderite ore of spherical shapes, 20 mm in diameter was carried out in the installation shown in figure 1. Based on the accepted
dimensions of the materials, the quantitative ratio of spherical pieces of coke to a unit of a spherical piece of ore was determined, which was 17:1, provided a uniform distribution of the ore in the coke layer.

![Figure 1. Photo of the preheating process of spherical coke pieces.](image_url)

The plant is a steel frame, insulated with mineral and kaolin wool, in order to minimize heat losses in the environment, which is pre-laid coke diameter of 20 mm. The next element of the installation is lid, insulated kaolin wool, in which are two holes for the tabulation chromel-aluminiyevh thermocouples operating range from 0 to 1100 °C, to register parameters of the temperature in the center of the spherical pieces of coke and ore siderite, recording and display of which was carried out at the third element of the installation – registered device (computer).

3. The Method of the Experiment
Coke Packed in steel frame installation was placed in a preheated 1150-1100 °C electric furnace where they were heated to the temperature of the surface of coke at 1000 °C. Upon reaching this temperature, the installation of battered metal tongs and placed on a heat insulating surface. Next, fit the technological material in the installation (FeMgCO₃) drawn to him by the thermocouple, the installation is covered with an insulated lid and began registration of the temperature of the center of technological materials, displaying them in the log of observations with an interval time of 1 minute. The experiment was carried out until the temperature difference between the heating and heated materials in 2 °C.

4. Experimental Result
Four series of experiments were carried out, lasting about 80 minutes, in order to obtain the most accurate results, taking into account the error of the experiment.

According to the results of the research, the temperatures of the center of technological materials were obtained over time by the layer height, their processing was performed, the result of which was the construction of a graph of the average mass temperature of coke cooling and heating of siderite ore from time (τ), shown in figure 2.

It follows from the results that the total heat transfer time between coke and siderite ore, namely the heating time of siderite ore in the coke layer is about 18 minutes, where the temperature decomposition sites of iron carbonate (FeCO₃) at 540 °C and magnesium carbonate (MgCO₃) at 680 °C.
5. Summary
Experimental studies have shown that the temperature potential of coke is sufficient to carry out the processes of heating and decomposition of siderite ore. Presented on graph temperature site decomposition of carbonate iron at 540 °C and a carbonate of magnesium at 680 °C. The time of heating siderite ore in the coke bed is 18 minutes, which is within the residence time of coke in the zone of the settling chamber of the coke dry cooling.

Thus, the conducted high-temperature experimental study of contact heat transfer confirms the possibility of the process of firing siderite ore in the high-temperature area of the dry coke quenching plant.

6. References
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Figure 2. Graph of mass-average temperature of the coke cooling and heating of siderite ore from time $\tau$, min.
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