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MODELING OF COKE DISTRIBUTION IN A DRY QUENCHING ZONE

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The coke industry is one of the essential industries and provides coke to ferrous metallurgy and several other sectors. Using coking, the chemical processing of hard coal of different grades and levels of oxidation is carried out [1].

The coke coming out of the furnace is quenched (cooling to 180–250 ºC), because it is in a red-hot state (with a temperature of 950–1000 °C). The method and technique of quenching significantly affect its subsequent strength, and therefore the size of the pieces.

There are two quenching methods: wet and dry [2]. In the wet method, coke is sprayed with a certain amount of water in the quenching tower. The formed water vapor is removed through the exhaust pipe.

During dry quenching, coke is cooled by CO_2 or N_2. In this case, the coke through a special charging facility is fed into the CDQ (coke dry quenching) installation, which consists of a quenching chamber divided into two parts, a cyclone in which dust is separated, a boiler-utilizer and a blower.

Dry quenching has a number of important advantages: absence of pollutant emissions into the atmosphere from the quenching tower; the possibility of providing coke chemical production with steam and electricity due to the utilization of the heat of red-hot coke; minimum coke moisture; obtaining a more homogeneous coke in terms of size; improving the quality of coke due to the absence of rapid cooling; corrosion prevention of metal structures in the area of the quenching tower.

At the same time, certain risks are inherent in CDQ, namely: large capital costs; loss of part of the coke due to gasification in the chambers; increased coke dust; additional pollutant emissions into the atmosphere with excess circulating gas.

Optimization of the CDQ process will allow minimizing the above-mentioned disadvantages. Works on improving the CDQ process are carried out in various directions [3]. One of the directions for such optimization is the technology development for the uniform distribution of coke in the quenching chamber. Therefore, the research purpose described in the article is to find a solution in which each class of coke will be evenly distributed across the section of the quenching chamber.

The research consisted in studying the distribution of coke porosity in the quenching zone and the degree of influence on its various devices involved in loading and was carried out by the method of discrete elements.

Based on the statement that the pressure loss when passing through a layer of coke strongly depends on the size of its particles, it was suggested that the efficiency of coke cooling depends on the gas permeability of the charged coke, which is affected by the porosity (the fraction of free space between the particles). That is, it was necessary to determine what the porosity depends on and how it is distributed in the charged coke.

Practical data obtained at PrJSC "Avdiivka Coke" indicate the porosity dependence on the concentration of the different-size particles. At the same time, changes in porosity are enhanced due to particle size segregation as a result of shrinkage. The greatest compaction is observed in the center of filling coke, and the largest amount of coke material is found (coke, falling from a great height to one-point, self-compacts in this area). That is, the porosity in the quenching zone is affected not only by the size distribution of coke but also by compaction from a great height falling.

That is, by correctly choosing the form of devices and methods of charging/discharging coke, it is possible to achieve the maximum uniform distribution of small and large classes of coke during its dry quenching.

Figure 1 shows the real charging device used in PrJSC "Avdiivka Coke".

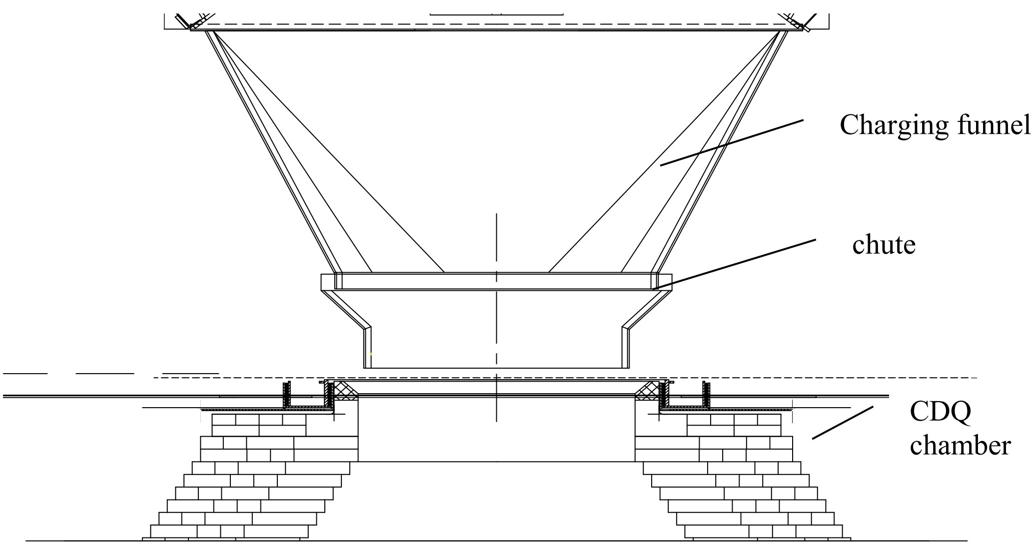

Figure 1. Real coke charging device of PrJSC "Avdiivka Coke"

The process of segregation of blast-furnace coke particles during their fall can be caused by several factors. One of the main factors is gravitational separation. as the coke particles fall, the heavier particles can move closer to the center of mass and the lighter particles move outward. This can lead to the formation of different layers of different sizes and densities. The greatest shrinkage was in the center of the backfill, where the largest amount of coke material was found, that is, falling from a great height to one point, the coke self-compacts in this zone. Thus, porosity in the quenching zone is affected not only by the size distribution of coke but also by compaction from a great height falling. And this has a stronger effect on porosity than segregation.

The first proposed alternative bell-shaped coke distributor had a diameter of 800 mm and a surface angle of 75° (Fig. 2).

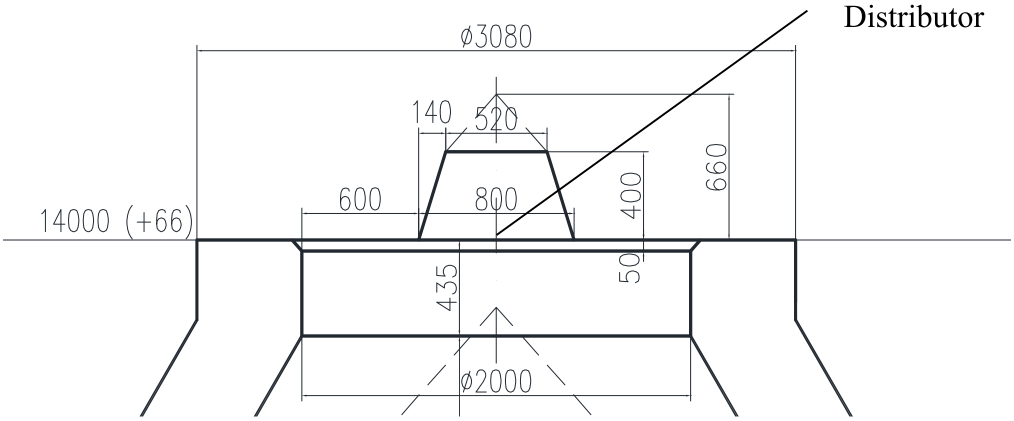

Figure 2. The first design of the coke distributor in the funnel of the loadin hole

The selected 800 mm diameter and shape distributor did not create a sufficient size funnel within the backfill (Fig. 2) to eliminate residual segregation. It also had little effect on the distribution uniformity of small and large classes to the coking chamber location.

As a result of a series of experiments, the second alternative form of the distributor and outlet of the funnel gap was selected (Fig. 3).

The main criteria for choosing the design of the distributor and funnel gap:

– particle distribution diameter (must be large enough that large particles can roll to the funnel center);

– coke descent time from the funnel (should not increase).

The emptying time of the old design discharging funnel of PrJSC "Avdiivka Coke" was 12.8 s (average consumption 744.6 kg/s). The emptying time of the new design funnel was 13.5 s (average consumption 592.6 kg/s).

Thus, the selected shape and dimensions of the distributor and the loading funnel, shown in Figure 3, ensure the scattering of particles with their subsequent stacking in the form of a gap inside the chamber. The gap ensures the dispersion of particles and their gradual movement toward the central axis during the loading.

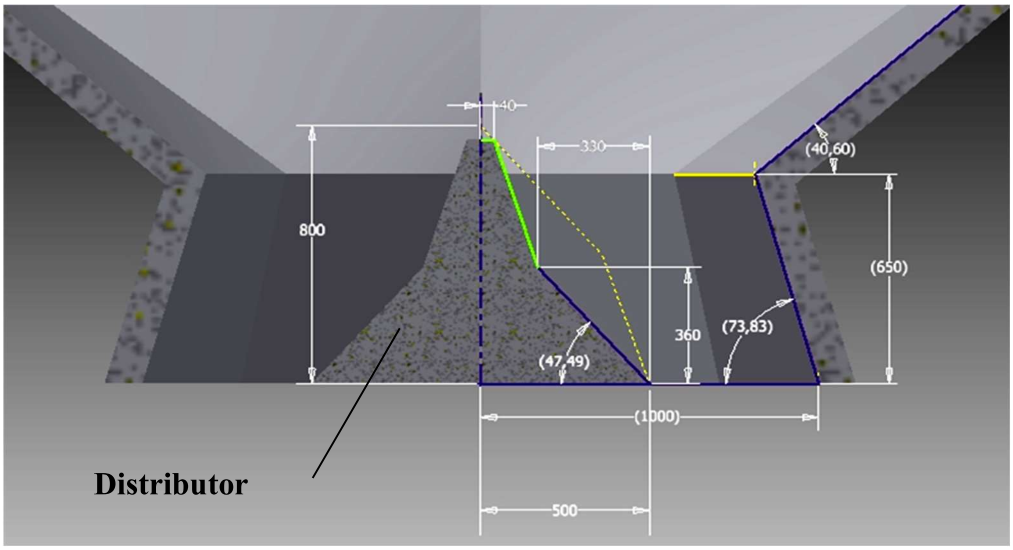

Figure 3. Changed coke distributor and funnel hole

The following aspects affecting the efficiency of coke quenching were established, namely: the probability of coke under-quenching when it passes through the distributor; dynamic compaction of coke due to the fall of a large mass on the same area from a great height; segregation effect (difference in the rate of coke rising opposite the distributor due to different concentrations of small and large particles with different momentum in different parts of the chamber), as a result of the uneven distribution of equivalent diameters of coke particles in different areas of the chamber.

The use of a coke distributor in the form of a bell in the loading funnel allows dispersing of small classes in the form of a ring near the walls, which contributes to the acceleration of the rise of coke in these areas and the slowdown in the center.

The selected shape and dimensions of the distributor in the form of a modified bell (special-shaped gaps) ensure the scattering of particles with their subsequent stacking in the form of a gap inside the chamber. The gap ensures the dispersion of particles and their gradual movement toward the central axis during the loading.

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