

Possibilities of increasing coal charge density by adding fuel oil

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Abstract

The requirement of all coke-making facilities is to achieve the highest possible production of high quality coke from a chamber. It can be achieved by filling the effective capacity of the chamber with the highest possible amount of coal. One of the possibilities of meeting this requirement is to increase the charge density in the coke chamber. In case of a coke battery operating on bulk coal there are many methods to increase the charge density including the use of wetting agents in the charge. This article presents the results of the laboratory experiments aiming at the increase of the charge density using fuel oil as a wetting agent. The experiments were carried out by means of the Pitin's device using 3 coal charges with various granularity composition and moisture content of 7, 8, 9 and 10 %.

Keywords: Coal charge, increase of dry bulk density, addition of fuel oil, increase of coke production

1. Introduction

One of the possibilities to reduce costs in the production of high quality metallurgical coke is to increase the coal charge density in coke chambers. The arrangement of grains in the coke chamber determines their mutual interaction during the carbonization, thus affecting the structure of the formed coke. A higher thickness of the charge participates in the increase of its quality, which is manifested by the increase of its solidity and the decrease of its reactivity as well as by the changes of the

medium grain size and the evenness of the coke properties in the chamber section. The use of higher quality coke in a furnace subsequently results in the decrease of its specific consumption. With a higher density of the coal charge it is possible to cut the costs of coke production while maintaining its quality by expanding the raw material basis to include worse grades of both coking and non-coking coal. A higher content of the coal charge in the chamber affects the battery capacity, thus influencing the profit rate.

The charge density is influenced by three basic factors, namely size of coal, its moisture content and the effect of

external mechanical forces. The highest charge density in coke chambers is achieved by the ramming of coal in plants which use the rammed charge. In batteries using a bulk charge the charge density in the chamber is influenced by the size and moisture content of coal, chamber dimensions, number of filling holes and the mode of the chamber occupancy. As the charge density can be affected to the maximum extent during its preparation, a large number of technologies have been developed all around the world, the use of which subsequently increases the charge density in coke chambers. These are the technologies

- that ensure the optimum charge size, and are aimed at the prevention of regrinding the coal components by extending the charge preparation and including wet coal sorters with subsequent changes in the technology of coal grinding;
- with the thermal pretreatment of charge in order to decrease or remove the moisture content from coal, or with its pre-heating, which requires the extension of the charge preparation and the inclusion of coal heating equipment as well as changes in the heated charge transport and storage technologies;
- with a partially briquetted charge, where due to the use of mechanical forces the part of the charge is compressed; it requires changes in the coal storage and grinding technologies as well as the briquetting of a part of charge in special equipment and subsequent mixing with the ground coal charge;
- with a partially granulated charge, which involve the granulation of the dust components of coal and their subsequent mixing with the charge; it requires pelletization equipment, transport equipment and the mixing of pellets with the charge;
- using wetting agents, which eliminate the effect of the water surface tension on the charge density, and thus increase sliding properties of coal grains when pouring the coal into the chambers; the technology requires the extension the charge preparation and the inclusion of the storage and transport of wetting agents.

All mentioned charge preparation technologies are used not only to increase the charge density, but also to use lower quality grades of coal in the charge.

Thus the charge density in the coke chamber represents one of the major parameters, which, in addition to the quality of coal used in charge, influence the carbonization process in the coke chamber and affect the coke yield and quality.

2. Determination of charge density in the coke chamber with bulk

When pouring the charge into the coke chamber, the charge is distributed unevenly in the chamber due to the formation of pouring cones under the filling holes, segregation of grains according to their size, pouring height, chamber temperature, etc. The subsequent leveling of charge causes its compression in top layers of the poured coal. It results in the unevenness of the

charge density in the coke chamber section, and it is not possible to measure it under operational conditions.

The charge density in the chamber can be calculated from the weight of the poured coal and the filled chamber volume. The result gives the average charge density in the chamber, which is expressed in kg.m^{-3} in practice.

According to ECC [1] the calculated average values of the charge density in coke batteries operating on bulk coal and using the traditional preparation of charge in the European Union were within the range between 688 and 735 kg.m^{-3} last year; as for our cokery, they reached the value of 702 kg.m^{-3} in the both coke batteries.

To assess the effect of various factors on the charge density, either laboratory or operational measurements of the charge bulk density are used in practice to determine its value; and the determination differences are applied under the coke chamber conditions.

3. Laboratory experiments of charge density changes caused by the addition of fuel oil

The work was focused on the verification of possibilities to increase the density of coal charges, which under operational conditions vary from each other in their size composition and water content. The research focusing on the effect of the addition of a wetting agent on the change of the charge density was carried out using laboratory equipment of the Department of Ferrous Metallurgy and Foundry of the Faculty of Metallurgy TU in Košice. The coal charge sampled during the common charge preparation was used for the experiment.

Due to the fact that the charge density is affected to the maximum extent by the charge size composition and moisture content, the granulometric analysis of the delivered coal was carried out primarily. According to the results the charge contained 82.9 % of grains under 3 mm, while 23.2 % of fine charge components belonged to the grade under 0.2 mm. The evaluation of the charge size composition according to RRSB and Birstlein diagrams shows that the charge contains the excess amount of fine components. According to our results [2], this size composition has a significant effect on the charge density, especially in case of moisture content values of the prepared charge in the plant.

The reason for the decrease of the charge density caused by the charge moisture content is the influence of the surface tension of water on the surface contacts of coal grains, where the formation of agglomerates prevents the charge from a higher thickening [3]. This effect increases with the grinding fineness [2]. The decrease of the effect of the surface tension of water can be achieved by means of wetting agents, which ensure the increase of the mutual sliding of coal grains. In the coke production substances resulting from the distillation of tar or fuel oil are preferably used as wetting agents in the amounts of 1 to 5 kg per ton of the charge [4]. In this work diesel fuel was used to determine the possibilities to increase the charge density.

The determination of bulk density was carried out in the laboratory scale by means of the Pitin's device. At first the bulk density of the charge with a certain size and moisture content was determined, followed by the determination of the bulk density after gradual adding of fuel oil in the amount of 0.10, 0.15, 0.20, 0.25 and 0.40 % of the charge weight. To assess the effect of adding fuel oil to charges with various size the following charges were used:

- with the original size of coal, i.e. 82.9 % under 3 mm,
- with size of coal adjusted to 95 % under 3 mm,
- with the size of coal adjusted to 75 % under 3 mm,

while charges with the moisture content of W_t^r 7, 8, 9 and 10 % were used with the stated size. Each experiment was repeated 3 times and the calculated average values of bulk density were graphically processed.

The effect of adding various quantities of fuel oil to increase the charge density in the original size with various moisture content values is graphically shown in Fig.1.

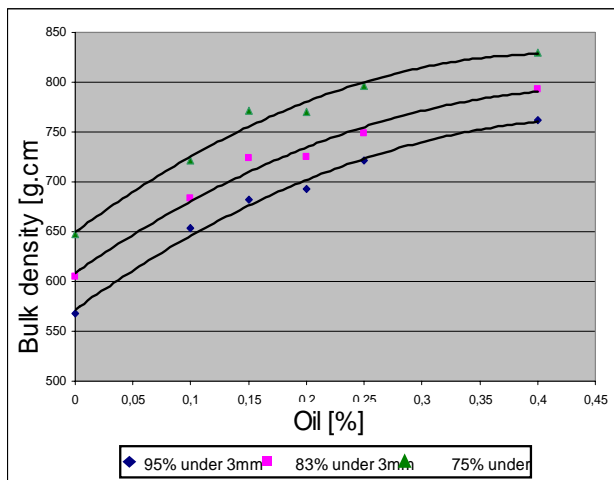


Fig. 1. Effect of fuel oil addition on the bulk density charge (2,9 % under 3 mm)

It is obvious that in all experiments the bulk density values kept increasing with the increasing amount of added fuel oil. The maximum weight increase was reached after adding 0.1 % of fuel oil. With the decrease of the coal moisture content the effect of fuel oil increased slightly. In case of 7 % coal moisture content the increase of the bulk density was uniform up to the value of 0.15 % fuel oil, and after adding 0.2% of fuel oil practically no weight increase occurred either. A similar character of hindering the effect of the increased addition of fuel oil was displayed in all performed experiments; with the increasing moisture content a shift to lower values of the added fuel oil quantities was observed. After another increase of the added fuel oil the bulk density increased again, however, gradually its effect kept decreasing. After adding a higher amount of fuel oil (0.6% - not shown in Fig.) the bulk density value remained almost the same as in case of adding 0.4 %.

A similar effect of adding fuel oil to the charge on the bulk density of the charge was demonstrated when using charges with various size,

The figure displays the increasing bulk density values of charges in case of 7 % moisture content of charges. When increasing the moisture content of charges the decrease of bulk density occurred similarly to the values in Fig. 2; the character of the bulk density dependency on the addition of fuel oil was similar. With regard to the bulk density of the charge with size of coal 75 % under 3 mm the additions of fuel oil showed a higher efficiency than in the previous case, whereas charges with the size of coal 95 % under 3 mm showed a lower efficiency.

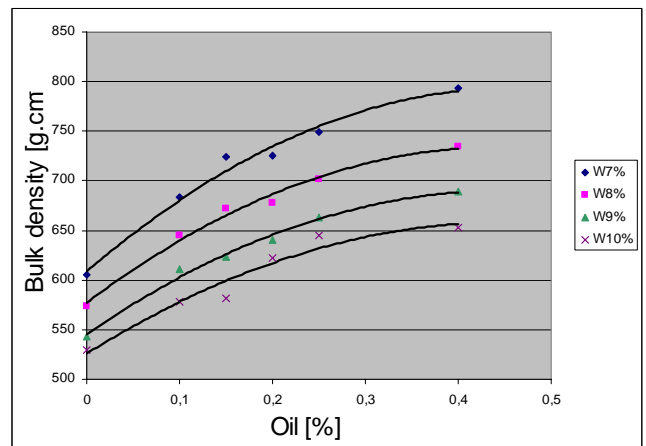


Fig. 2 Effect of fuel oil on the bulk density charges with various size of coal

4. Conclusion

By adding a small amount of fuel oil to the charge the decrease of the surface tension of water is reached, which causes the spontaneous charge thickening during pouring. The effect of the addition on the charge thickening decreases with the increasing moisture content of charge and the increasing grinding grade.

In experiments carried out under the given conditions of the size composition and moisture content of charges the average charge weight of 70.1 g. cm^{-3} was achieved after adding fuel oil in the amount of 0.1 %, which corresponds to the average thickening of charges by 12.3%. It can be assumed that in coke chambers the average thickening of charge by more than 86.3 kg. m^{-3} could be achieved after adding 0.1 % of fuel oil.

The results can also be used to determine the amount of fuel oil needed to achieve the required density of the charge.

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