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EFFECT OF COAL SIZE SEGREGATION IN COAL BIN ON PUSHING CONDITIONS OF COKE CAKE[1]

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Abstract

It is essential for old coke ovens to avoid pushing trouble because this trouble, which has increased gradually with the aging of coke ovens, negatively affects coke stable production and service life of coke ovens. One of effective approaches to improve pushing conditions is to maintain sufficient clearance between coke cake and oven wall. Especially, clearance near coke side has a critical effect on pushing conditions because the oven wall around there has been most damaged in aging coke ovens. Therefore, the way decreasing the bulk density of coal blend in coke ovens locally was investigated in order to improve the clearance near coke side. In particular, coal size segregation in coal bin, which probably controls bulk density distribution in a chamber, was focused on. At the beginning, the effects of charging conditions on coal size segregation and clearance were investigated by laboratory tests. After then, the segregation test that a charging chute was set in coal bin at Kurashiki No.1 coke oven was carried out. Eventually, it was clarified that controlling coal size segregation conditions in coal bin improved the pushing conditions for the chambers whose pushing load was constantly high.

Key words: Pushing trouble; Coke cake; Clearance; Size segregation.

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1 INTRODUCTION

As coke ovens become older, pushing troubles occure more frequently. Because the troubles decrease the amount of coke production and the service life of coke ovens, it is essential to avoid the troubles at old coke ovens. One of the effective approachs to improve pushing conditions is to keep sufficient clearance between the coke cake and the oven wall. Effects of operational and blending conditions on clearance have been investigated[1-6]. However, it is difficult to change these conditions for controlling clearance because both coke productivity and quality also relate to these conditions.
Meanwhile, there should be a bottleneck of coke cake in oven chamber under discharge because the degree of damages depends on sites of coke ovens. Generally, the oven wall around coke side has been most damaged at old coke ovens. As a result, clearance near coke side should have a critical effect on pushing conditions.
For this reasen, the way to enlarge clearance near coke side locally was investigated. In this paper, we focused on coal size segregation in coal bin as the way to set comparatively fine coal and to decrease the bulk density near coke side. Because clearance is increased as the bulk density of coal blend is decreased. Figure 1 shows the conceptual diagram. As the charging position is shifted toward coke side, the top of the coal pile is also shifted. Fine particles are piled up under the top of pile because of size segregation. Besides, as coal size become small, the bulk density is decreased. We therefore inferred that bulk density near coke side was decreased in a chamber by this way. At the beginning, the effects of charging conditions on coal size segregation and clearance were investigated by laboratory tests. After then, the segregation test that a charging chute was set in coal bin at Kurashiki No.1 coke oven was carried out.

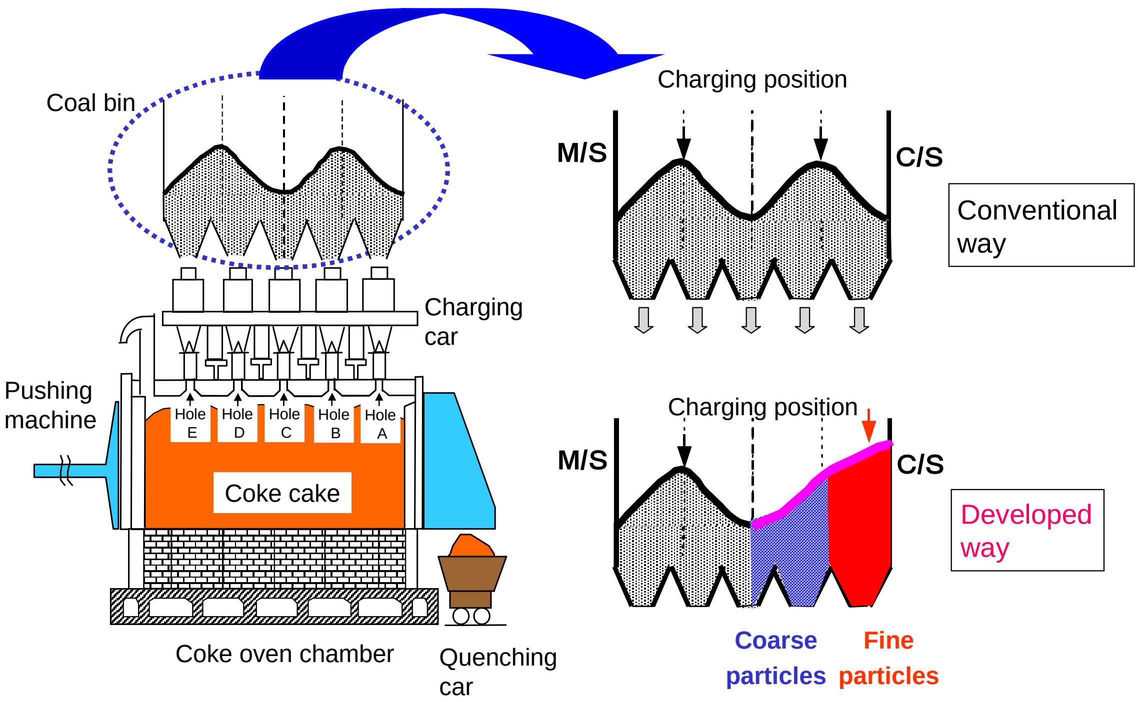

Figure 1. Conceptual diagram of the way to control coal size segregation.

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2 MATERIALS AND METHODS

2.1 Laboratory Tests

For estimating size segregation of coal blend in coal bin, we ran the charging tests and measured the coal size. In addition, the effect of size segregation on the bulk density and clearance were investigated. The sample coal was taken from commercial coal blend of Kurashiki No.3, 4 coke ovens. That characterization data is shown in Table1. The schematic illustration of experimental apparatus is shown in Figure 2. The board was set in order to simulate the slope face of the coal pile in coal bin. Based on the relationship between moisture content and repose angle, the angle between board and ground was set 37.5°. The sample coal was constantly feeded above top of the board from the belt feeder and piled up on the board. The samples for measuring size were taken from the sampling places as shown in Figure 2. The samples taken from the sampling places which were on the same level were regarded as same data. And the total samples taken from sampling place No. 1, 2 and 3 (hereinafter referred to as a "Supposing hole A sample") were supposed the coal discharged from charging hole A which is nearest coke side as shown in Figure 1. And the total samples taken from sampling place No. 4, 5 and 6 (hereinafter referred to as a "Supposing hole B sample") were supposed the coal discharged from charging hole B which is next to the charging hole A. We measured the bulk density and clearance of the sample before charging test (hereinafter referred to as a "Base sample"), supposing hole A and B sample.
The free-fall tests were carried out so as to measure the bulk density. 38 kg of the each sample free-fell from 3 m above into a case (W350×H350×L350 mm). The weight of samples within the case were measured. Then the bulk density of samples were calculated.
In attempts to estimate clearance, the carbonization tests and the measurement of clearance for carbonized coke cake were conducted. The schematic illustration of experimental apparatus is shown in Figure 3. The samples were packed into a case (W190×H120×L114 mm). The bulk density of the samples were set based on the results of the free-fall tests. The 3 same samples were carbonized in laboratory-scale coke oven at 1,050°C for 4h20min. After carbonization, distance between the coke cake and the wall were measured by lazer displacement at 5 mm intervals (H95×L100 mm) per one side of coke cake. If measured distance exceeded 20 mm, the data were ignored as outliner due to cracks of the coke cake. Mean value of those data of one sides of coke cake were calculated. Then total value of the mean value of 2 sides of coke cake were defined as clearance.

Table 1. Coal properties

Proximate analysis (%)		Mean reflectance in oil, Ro (%)	Max. fluidity (ddpm)
Ash (d.b.)	VM (d.b.)		
11.3	28.1	1.08	236

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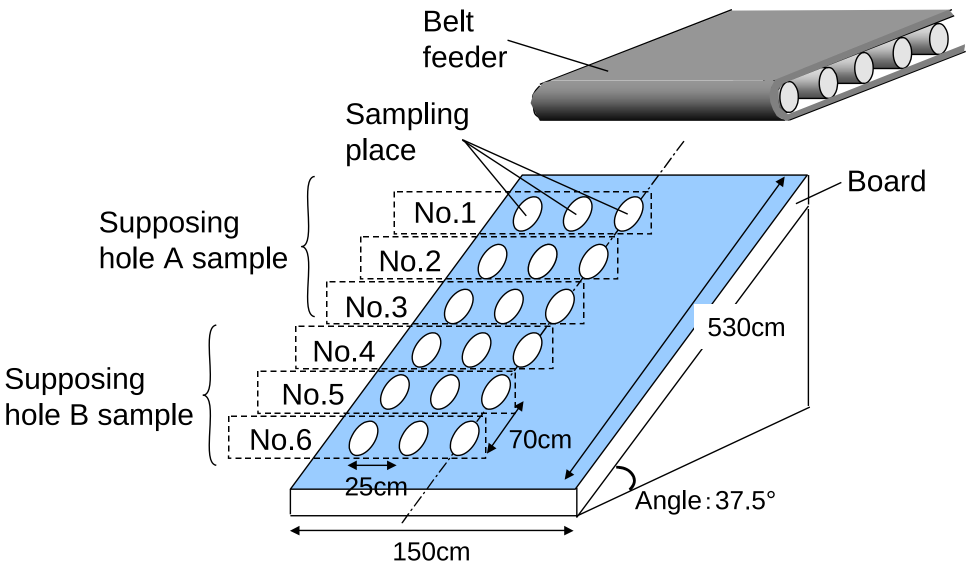

Figure 2. Schematic illustlation of experimental apparatus for charging test.

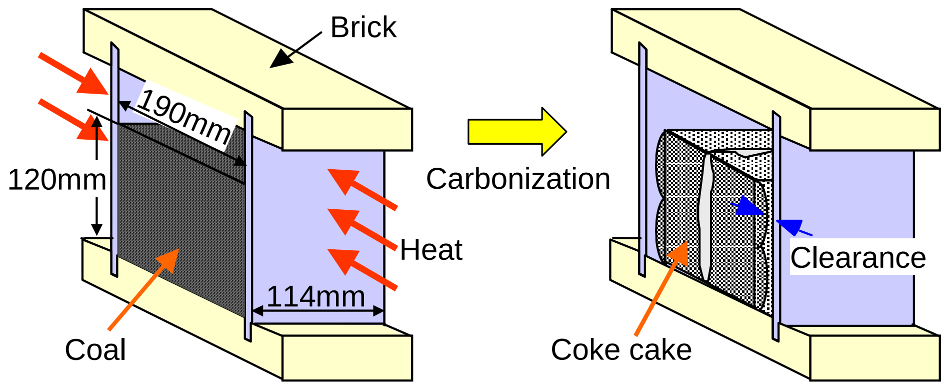

Figure 3. Schematic illustlation of experimental apparatus for measuring clearance.

2.2 Plant Trial

We tried to shift the charging position of coal blend in coal bin and estimate that effect on coal size distribution and pushing conditions. The trial was carried out at Kurashiki No.1 coke oven for 24 days. Basic data about that coke oven at the time are shown in Table 2. The set working rate was kept 92% during trial period. That coke oven has 2 coal bin. The charging position was shifted toward coke side for one coal bin by setting a charging chute (W2.4×L4.3m) as shown in Figure 4. From 7:00 a.m. to 5:00 p.m. during trial period, the coal bin with charging chute was used in order to apply the developed way. The samples for measuring coal size distribution were taken from each hopper of charging car. The maximum power current of pusher with each pushing cycle was evaluated from 20 days before the start of the trial through 16 days after the end of the trial. Where that value has a close relationship to pushing load.

Table 2. Kurashiki No.1 coke oven

Type	Carl Still
Age (year)	42
Total of chambers (-)	78
Dimension (m)	W0.44×H6.71×L14.8

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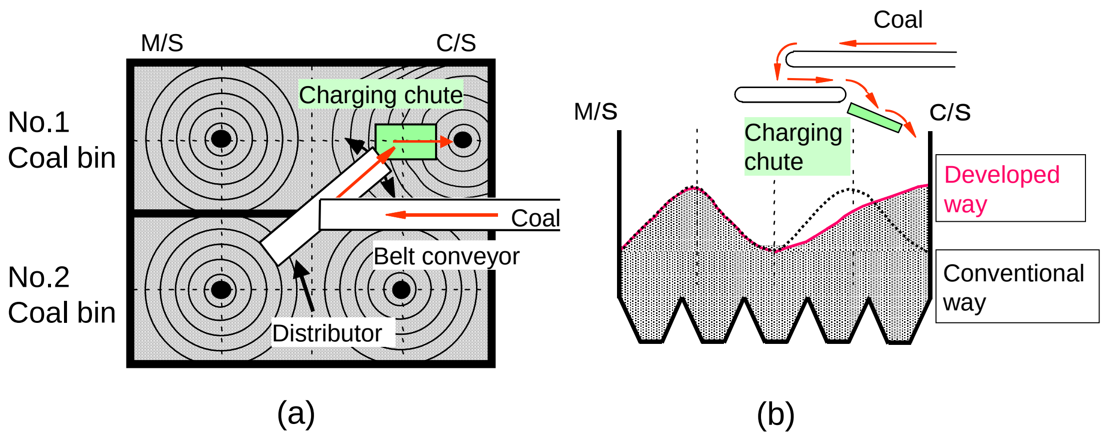

Figure 4. Schematic illustlation of charging chute in coal bin. ((a)Top view (b)Side view).

3 RESULTS AND DISCUSSION

3.1 Effectiveness of Size Segregation for Controlling Clearance

The size of sample coal taken from each sampling place is shown in Figure 5. Fine particles indeed existed on the upper side because of size segregation. The bulk density and clearance of supposing hole A and B samples are shown in Figure 6. In case of supposing hole A sample, the bulk density was 8.5kg/m^3 less than base one. Then the clearance was enlarged 0.3 mm. On the contrary, in case of supposing hole B sample, the bulk density increased 10.2 kg/m^3 and the clearance decreased 0.1 mm. Thus, it was clarified that clearance could be controlled by size segregation. In addition to the effect of bulk density change on clearance, coal size change should directly affect clearance because coal size strongly relate to the generation behavior of cracks in coke cake. And the number of cracks is connected with clearance[6,7].

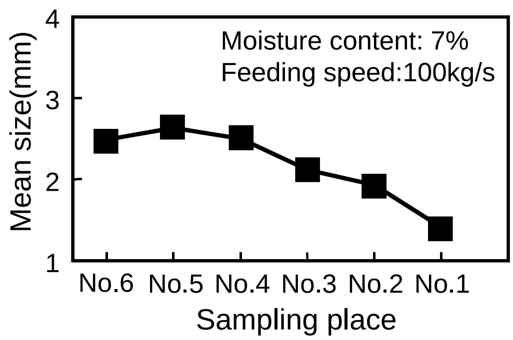

Figure 5. Effect of size segregation on mean size.

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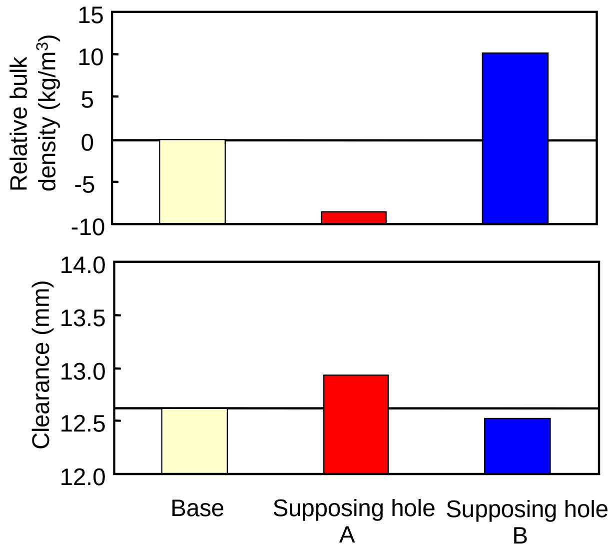

Figure 6. Effect of size segregation on bulk density and clearance.

3.2 Improvement Effect of the Developed Way at Actual Plant

Comparison of mean size of charging hole A and B samples between conventional and developed way is shown in Figure 7. Where the vertical axis is relative mean size change with respect to the mean size of coal blend before piling in coal bin. In case of conventional way, mean size of charging hole A sample was comparatively big because that sample mainly contained the coal which existed at skirt of coal pile in coal bin. Applied developed way, mean size of charging hole A sample became smaller.

The effect of the developed way on the maximum power current of pusher is shown in Figure 8. Where vertical axis is relative value change with respect to the mean of maximum power current of pusher for the each case of conventional way. The value became approximately 5% lower by applying developed way. This trend was obviously observed in chambers whose pushing load were constantly high. In those chambers, the wall near coke side was seriously damaged. Therefore, it was clarified that the developed way was more effective for those chambers.

However, the developed way by setting charging chute was not implemented as routine operation because the charging chute limited coal level in coal bin and the working rate. In the future, feed speed of the distributor is planned to be changed for shifting the charging position.

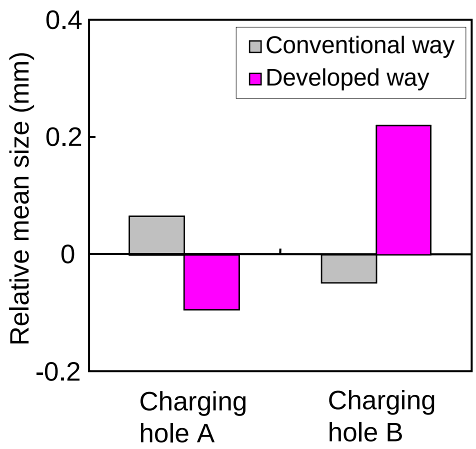

Figure 7. Comparison of mean size of samples between conventional and developed way.

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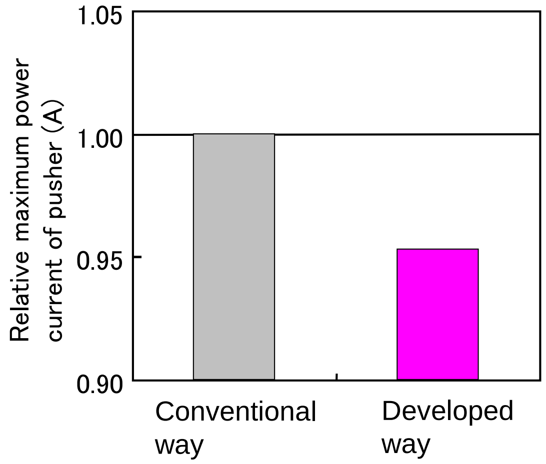

Figure 8. Effect of developed way on pushing load.

4 CONCLUSIONS

- Through fundamental study at laboratory, it was found that size segregation of coal blend affect the bulk density and clearance.
- The new way to set comparatively fine coal and to decrease the bulk density near coke side has been developed. As the results of plant trial, it was clarified that the pushing conditions were improved by the application of the developed way. In particular, the developed way was more effective for chambers whose pushing load were constantly high.

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