Abstract:

Technique for high-ratio coke-mixed-charging was developed and applied at No. 6 blast furnace in JFE Steel's ? l t s s m f Ń

rapidly rising raw material prices, further promotion of low reducing agent ratio (RAR), low coke ratio operation, and an expansion of the degree of freedom in raw material selection by increasing the use ratio of low grade raw materials are important technical issues of blast furnace operation in the future.

Ore-coke mixed charging, in which coke is mixed in the sinter or iron ore raw material and charged into the blast furnace, is known as one technique for achieving these objectives[1,2]. Although this is a technique which improves the permeability and reducibility of the softening and cohesive zone, for various reasons, the mixing ratio in actual furnaces is limited to around 5 wt%. These include the fact that the difference in the

mixing ratio increases shows the same tendency as with small coke. It was found that the size ratio has virtually small effect on reducibility.

From the results of observation of the cross section of samples extracted after interrupting the under-load-reduction experiment, voids were observed at the boundary between the softened raw material and the mixed coke. It is assumed that this was due to local carburization resulting from contact between the reduced and metalized sinter and coke, and melting of the metal in the boundary area, which generated the voids[3]. In other words, it is considered that permeability was secured by the flow of gas in these voids at high temperature, as a result of mixing of coke in the raw material. The reducibility of raw materials with low reducibility, such as lump ore, is presumably improved under a low sinter ratio condition because mixing of coke suppresses the formation of unreduced FeO and promotes reduction of the lump ore.

Based on the experimental results described above, with uniform mixing, it was found that the high temperature properties of the raw material layer are improved by coke mixing ratios up to 10 wt%, even when using a lump coke mixture.

2.2 Effect of High Ratio Coke Mixed Charging on Blast Furnace Operation

2.2.1 Effect on permeability of cohesive [redacted]

If high ratio coke mixed charge is perf[redacted] actual blast furnace, there is concern tha[redacted]ckness of the coke layer (coke slit) charged between the raw material layers may decrease, d[redacted]iorating gas permeability, particularly in the c[redacted]e zone.

On the other han[redacted]der-load-reduction experi-

chute tilting angle of 54.5° is shown in **Fig. 7**. It can be understood that the coke mixing ratio increases with distance from around the mainstream falling point toward the furnace center and the furnace wall.

If a group of particles having a size distribution flows on a sloping surface, percolation occurs, in which the coarse grains tend to segregate toward the lower end of the slope, while the fine grains remain at the upper end. According to Miwa, percolation on a sloping surface has been formulated as shown in Eq. (4) as a function of the distance *L* which the particles flow[6].

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coke was charged simultaneously from a top bunker, and the small coke was mixed with the ore by simultaneous discharge from a bin. The coke mixing ratio was 3.75 wt% in both batches, resulting in a total of 7.5 wt%.

Using the burden distribution model, the charging pattern was set so as to obtain a uniform mixing ratio in the radial direction, and the effect was confirmed by performing a charging experiment. In order to observe the burden cross section, after the charging experiment, a low viscosity resin was poured on the burden surface and allowed to soak into the burden, and a section of the burden was cut after the resin had hardened. The results of mixed charging with the conventional charging pattern and the charging pattern in this experiment are shown in **Fig. 10**. In both cases, the small coke was distributed uniformly on the coke terrace in the 2nd batch of ore. On the other hand, with the conventional method, the lump coke mixed in the 1st batch segregated and flowed to the center, whereas with the new pattern, the lump coke was uniformly distributed in the ore.

3.2.3 Improvement of mixing by FCG dynamic control

In order to minimize the effect of segregation of the mixed layer at the burden surface, the discharge rates of raw material and coke from the bunkers were changed over time. Concretely, the opening of the flow control gates (FCG) was controlled independently so that coke discharge was gradually increased and raw material discharge was gradually decreased during reverse tilting.

In this experiment, the charging model device described previously was used. As combinations of FCG opening patterns, 3 cases were compared, these being case 1, in which only the coke FCG was opened in steps, case 2, in which only the raw material FCG was closed in steps, and case 3, in which the raw material FCG was closed simultaneously with opening of the coke FCG (**Fig. 11**). After this experiment, the cross sections of the burden surface were observed, the mixed coke yield in the ore layer was obtained by image analysis, and the uniformly mixed coke ratio was obtained.

The results are shown in **Fig. 12**. The coke mixing ratio improved approximately 8–10% with FCG dynamic control, and in particular, mixing improved greatly in case 3. This is considered to be because the amount of coke flowing to the furnace center was reduced by initially charging with a low mixed coke ratio and increasing the mixed coke ratio in charging at the periphery.

3.3 Low Sinter