New Products & Technologies

Image Fiber Probe for Detection of Furnace Top Burden Particle Size*

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1 Introduction

Burden distribution control plays a significant role in blast furnace operation control. In recent years, improvement in burden distribution control techniques has been achieved through the development of probes to measure the burden surface profile and distribution of gas flow rate. However, increasingly diverse and sophisticated requirements for blast furnace operation, such as use of smaller-particle raw materials and lowering of Si concentration in hot metal, have necessitated more refined, quantitative burden distribution control. In such precise burden distribution control, one of the most important points is an accurate grasp of the radial distribution of furnace top burden particle sizes. Therefore, the authors developed a probe capable of measuring particle sizes at arbitrary positions in the furnace top radial direction during operation, without disturbing burden distribution.

2 Outline of the Probe

2.1 Structure and Specification of the Probe

The structure of the particle size measurement system is shown in **Fig. 1**. The support probe, which is securely attached to the lower support car, is moved in the in-furnace direction, and the car is stopped when it reaches the prescribed position. Next, the flexible probe is lowered until the tip reaches the burden surface, and the image obtained through the optical fiber material is recorded. In this way, the particle size distribution in the blast furnace radial direction can be measured.

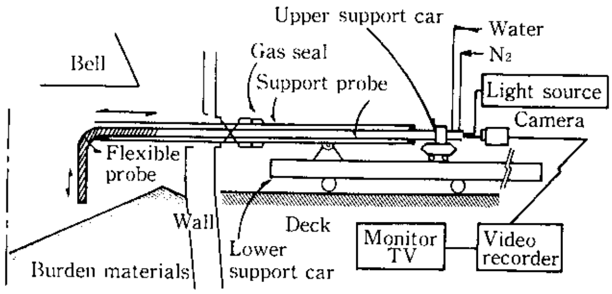

Fig. 1 Schematic representation of particle size measurement system at furnace top

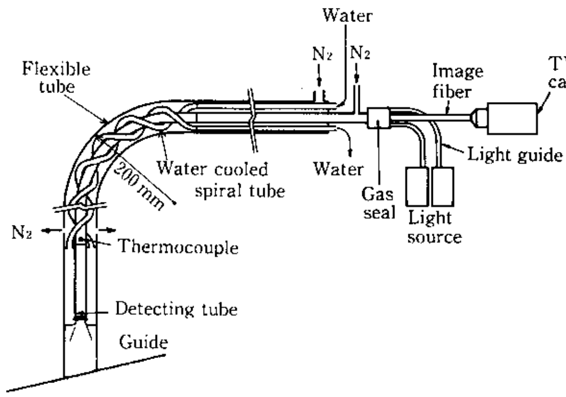

Fig. 2 Structure of particle size measuring zonde

The structure of the image probe is shown in **Fig. 2**. Since the optical fiber must be protected, the flexible probe is cooled by a combined N_2 gas and water system. The flexible portion of the probe is so constructed that four water-cooling pipes are wound around the fiber tube in a spiral configuration, while the N_2 gas coolant flows around the water-cooling pipes. The specifications of the burden image probe are shown in **Table 1**. The features of the probe are given below.

(1) Measurement can be made at an arbitrary point in

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Table 1 Specifications of particle size measuring probe

Item	Specification
Detected part (Image fiber)	
Detector	30 000 element image fiber
Focus system	Automatic adjustment system
Detecting limit	0.8 mm
Vison angle	40°
Curvature radius of flexible tube	≥150 mm
Range of size detected	0.8~75 mm
Cooling system	Water cooling+N_2 gas
Max. temperature	800°C
Diameter of flexible tube	60.5 mm

the furnace radial direction.

(2) Since the probe can be withdrawn from the furnace when not in use, durability is excellent.

(3) The burden distribution is not disturbed by the measurement process.

2.2 Method of Particle Size Measurement

To measure particle sizes, an image (**Photo 1**) recorded by video is analyzed by a LUZEX-500 image analyzer. The diameter d_i of individual particles is obtained as a disc diameter equivalent to the projected area. The mean diameter D_P of particles is calculated using the following equation:

$$D_P = \frac{\Sigma n_i d_i^3}{\Sigma n_i d_i^2} \quad \cdots\cdots (1)$$

where n_i: Number of measured particles
d_i: Individual particle diameter

3 Results of Measurements

3.1 Off-Line Test

A comparison between the particle size of a sample sized by screening and the value obtained by the image fiber is shown in **Fig. 3**. When the particle size is 50 mm or below, the values show good agreement. However, when the particle size is greater than 50 mm, the value measured by the probe is smaller than that indicated by the sieve analysis, because a particle over 50 mm in diameter is bigger than the viewing field of the fiber.

When the coke particle size is large, measurement at an increased distance from the burden surface gives good results. The appropriate distance must be determined on the basis of the particle size range.

3.2 Actual Furnace Measurement

Figure 4 shows the mean particle size distribution in the radial direction obtained with the burden image probe installed at the top of the Chiba Works No. 5 blast furnace, which is equipped with a charging device of the movable armor type. Coke is charged in one

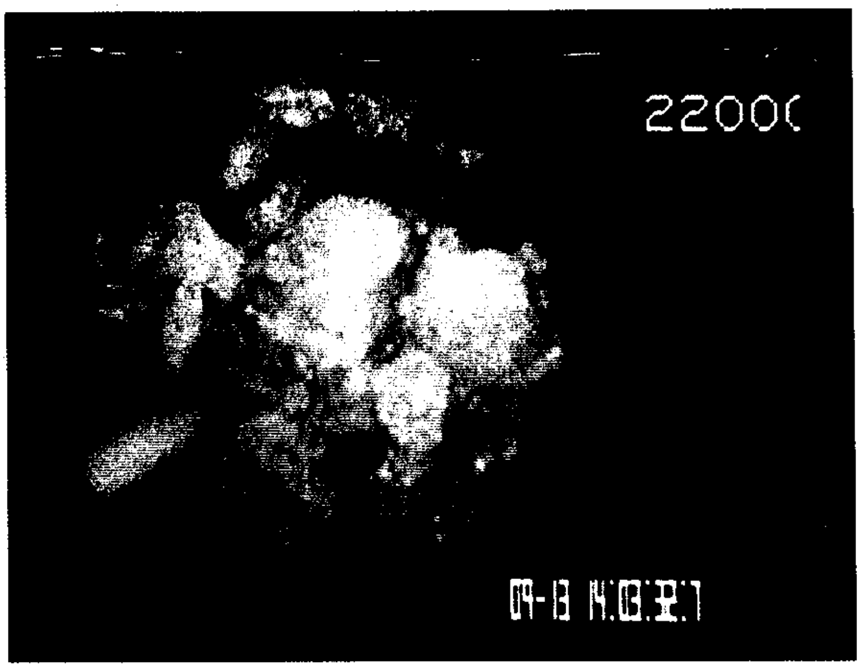

Photo 1 Particle size of coke detected by image fiber probe

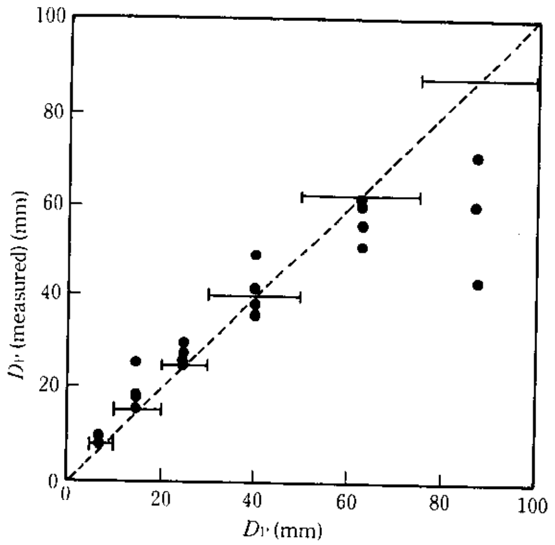

Fig. 3 Comparison of particle size measured by image fiber with actual particle size

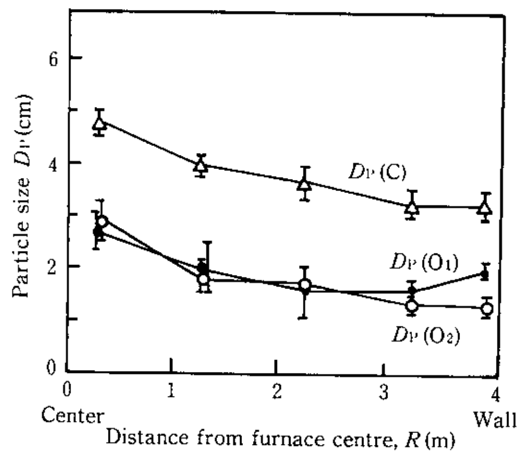

Fig. 4 Radial particle size distribution of burden at furnace top measured by image fiber probe

batch, and sinter is charged in two batches (C ↓ O_1 ↓ O_2 ↓). The mean particle diameter D_P of the coke increases toward the furnace center, and segregation at the time of charging is significant. The mean particle diameter D_P (O_1) of the first-batch sinter shows a larger particle diameter only within 1 m of the furnace center. This is presumed to result from the mixing together of coke lumps in the center area on impact at the time of charging, and from ordinary segregation due to sizing at the time of sinter charging. The second-batch sinter (O_2) consists of small particles and is charged near the furnace wall. Thus there are many fine particles near the furnace wall, and only a small amount of second-batch sinter is delivered to the furnace center. This was clearly shown in the mean particles diameter D_P (O_2) distribution of the second-batch sinter. In this way, it has become possible to quantitatively evaluate burden distribution control efficiency on the basis of measured particle sizes using this fiber probe.

4 Other Measurement Functions

(1) Measurement of burden surface profile: Since the image probe detects burden positions, it also functions as a burden profile meter, if it is known when the burden image probe tip reaches the burden surface.
(2) Detection of fluidization of burden
(3) Detection of burden rush toward furnace center
(4) Monitoring of the red-hot zone of coke at furnace center

Items (1) to (4) are examples of the use of the image probe as an in-furnace monitoring probe equipped with optical fiber.

5 Concluding Remarks

Through the use of the burden image probe, it has become possible to quantify particle size distribution as it corresponds to the charging action, facilitating burden distribution control. Further, the probe also functions as an in-furnace monitoring probe, making a variety of useful information available.