KAWASAKI STEEL TECHNICAL REPORT

No.19 (November 1988)

Steel Pipe

Construction and Operation of Dry Type Dust-Removal Equipment for Blast Furnace

Kunihiro Tanaka, Toshiyuki Matsumoto, Teruo Kanetsuna, Katsunori Yoshida, Hideyuki Kamano, Yunosuke Maki

Synopsis :

Dry type dust-removal equipment was installed at Chiba No.6 blast furnace in September 1986, and has been smoothly operating since the start of its operation. The dust-removal equipment uses a bag filter, which is under stable, continuous operation through the use of a unique and highly accurate temperature control system of water spraying. As a result of installing the dry type dust-removal equipment, generating electrical power by the top pressure recovery turbine increased by 4.5 kWh/t (about 11%) and the running cost of the BF gas heater and others has been reduced.

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Construction and Operation of Dry Type Dust-Removal Equipment for Blast Furnace*


Kunihiro Tanaka
Staff Manager, Machine Technology Sec., Equipment Technology Dept., Chiba Works


Toshiyuki Matsumoto
Manager, Ironmaking Sec., Ironmaking Dept., Chiba Works


Teruo Kanetsuna
Staff Manager, Blast Furnace Relining Technology & Planning Sec., Iron- and Steelmaking Technology Dept., Steel Technology Div.


Katsunori Yoshida
Staff Assistant Manager, Energy Technology Sec., Chiba Works


Hideyuki Kamano
Ironmaking Technology Sec., Ironmaking Dept., Chiba Works


Yunosuke Maki
Electrical & Instrumentation Technology Sec., Equipment Technology Dept., Chiba Works

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1 Introduction

In Japan, blast furnaces (BF) are generally equipped with a top-pressure gas turbine (TRT) as an auxiliary facility for the recovery of BF gas pressure energy in the form of electric power. Moreover, the latent heat of the BF gas, after gas-borne dust is removed in the gas cleaning operation, is used as an energy source for the entire steel mill. The efficient use of sensible heat, however, has not been possible because the jumps in gas temperature and changes in gas volume which result from internal fluctuations in the blast furnace and other changes in operating conditions have until recently necessitated use of wet-type dust-removal equipment for gas cleaning.

Use of dry-type gas-cleaning equipment for the recovery of BF gas sensible heat is under study at various steel mills. Equipment to normalize fluctuating gas conditions has already been installed in some steel makers in tandem with dry-type dust-removal equipment as a measure to improve TRT performance.

Dry-type dust-removal equipment using a bag filter was introduced at the Chiba Works No. 6 BF in September 1986 with the aim of improving TRT output and eliminating the need for pre-TRT gas heating, and thereby reducing running costs (**Photo 1**).

This paper describes the dry-type dust-removal equipment and improvements in related auxiliary equipment.

2 Purposes of Equipment and Selection of Equipment Type

2.1 Conventional Process

A process flow chart of gas cleaning equipment and auxiliary facilities at Chiba Works No. 6 BF before modification is shown in **Fig. 1**. Blast furnace gas typically contains about 5 g/Nm^3 dust. In order to recover BF gas pressure energy with a TRT and render the BF gas usable as an energy source, it is necessary to reduce the quantity of dust to below 5 mg/Nm^3. At No. 6 BF, wet-type dust-removal equipment (ring slit washer and

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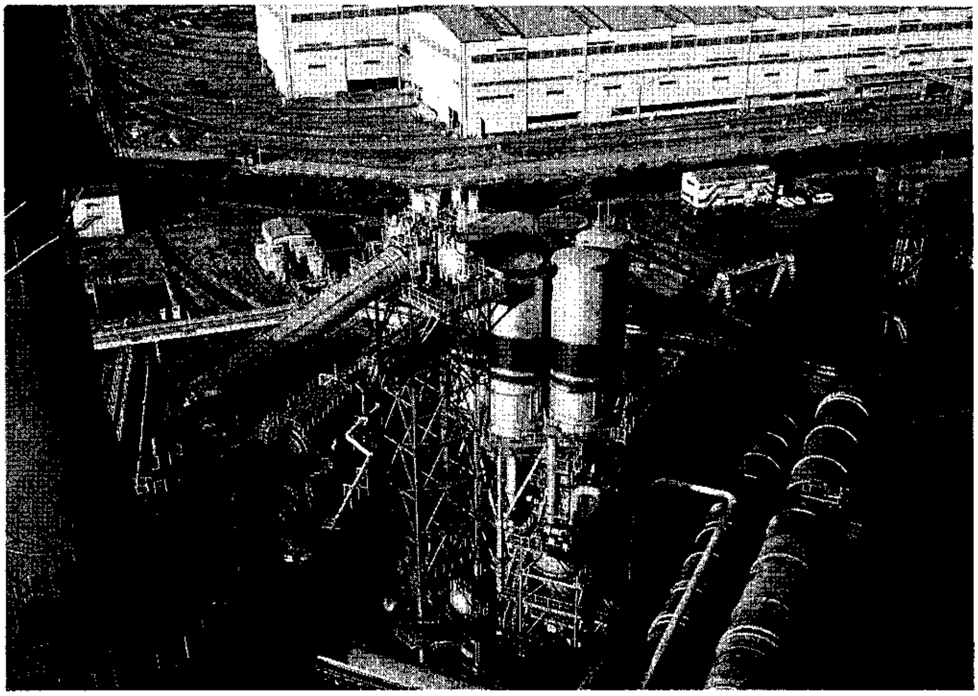


Photo 1 General view of the dry type dust-removal equipment

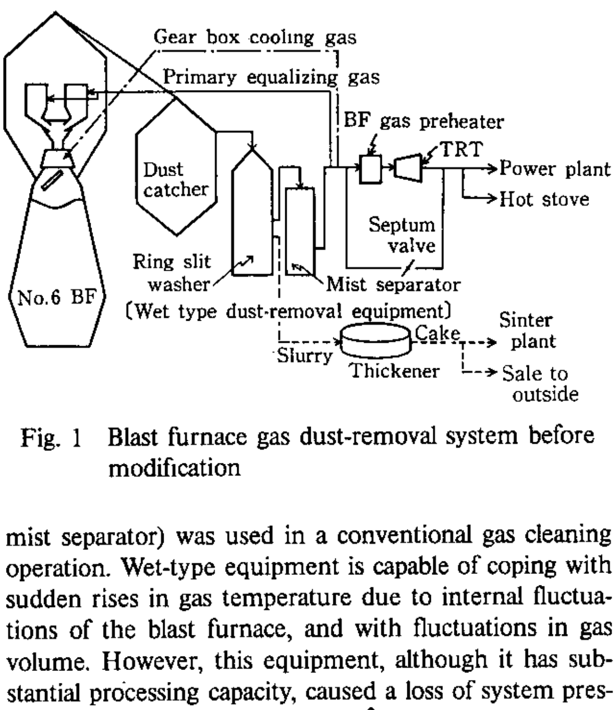


Fig. 1 Blast furnace gas dust-removal system before modification

mist separator) was used in a conventional gas cleaning operation. Wet-type equipment is capable of coping with sudden rises in gas temperature due to internal fluctuations of the blast furnace, and with fluctuations in gas volume. However, this equipment, although it has substantial processing capacity, caused a loss of system pressure on the order of 0.25 kg/cm^2, a serious drawback.

A BF gas preheater was used upstream of the TRT as auxiliary equipment. Since the TRT was of the axial flow type, it was sensitive to both dust and moisture in the gas, and restrictions were imposed on dust and moisture contents. The gas heater, which served to prevent moisture-related problems with the TRT, extracted about 3% of the TRT inlet gas for burning, thereby heating the remaining inlet gas from 50°C to 125°C.[1)]

Another 3% of the clean gas was used for primary pressure equalization in the material feed device at the furnace top and for pressurizing and cooling the interior of the gear box for the bell-less type feed device. Dust caught by the wet-type dust-removal equipment was partly re-used as a sinter raw mix after concentration and dehydration.

In 1986, dry-type gas cleaning equipment was installed with the following aims:

(1) Improvement in TRT output through operation at higher gas temperatures and reduction in the pressure drop in the system
(2) Reduction in running costs through elimination of the need for the gas heater and cooling gas booster.

2.2 Selection of System Type

Dry type dust-removal systems are of two types: the electric precipitator type and bag-filter type. The electric precipitator presents the following problems:

(1) It is difficult to maintain an outlet dust content of 5 mg/Nm^3 or below.
(2) Measures against unusually high gas temperatures are necessary; however, no reliable measures exist for temperature and dust control.
(3) Downtime for the repair or replacement of internal mechanical components is long.
(4) Space requirements are excessive.

On the other hand, the dust removal performance of the bag filter is excellent, and the problems associated with its use can be solved as follows:

(1) The heat resistance characteristics of the filter pose a problem. However, the use of a specially treated heat-resistant nylon in the filter will prevent certain heat-related problems, i.e., the shrinkage, combustion, etc., at normal working temperatures of 204°C or below, as well as at momentary peak temperatures of 370°C.
(2) Unusually high temperatures can be controlled by the vaporization temperature control method using micro-water spray in the preceding stage, thus lowering the gas temperature to within the normal working temperature range.
(3) Sudden increases in dust content due to unseating or outright failure of the filter are a significant danger. A continuous-type dust monitor was installed in the bag filter outlet duct; using this method, it is possible to continue operation while shutting down only the chamber showing poor dust-removal performance.

Based on these consideration, the bag-filter dry-type dust-removal method was adopted.

3 Features of Dry-Type Dust-Removal System

A flow diagram of the dry-type dust-removal system adopted at the No. 6 BF is shown in **Fig. 2**. System features are given below.

(1) Combination use of dry- and wet-type dust-removal lines, and adoption of automatic switching system
(2) Adoption of a water spray gas cooling system
(3) Installation of a cooling device for primary pressure equalization gas
(4) Water-cooling of the gear unit drive for furnace top charging device
(5) Variable control of the TRT static vane
(6) Separation of high zinc-content dust, allowing re-use of low zinc-content dust in the sinter raw mix, is possible with adoption of a dust-size grading system.

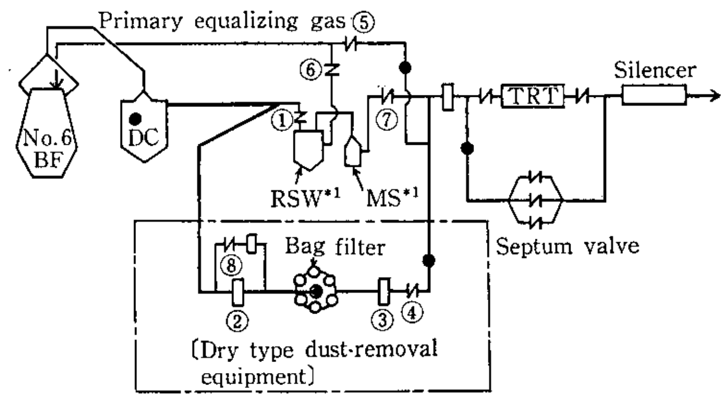
3.1 Dry-Type Dust-Removal Equipment

The specifications of the dry-type dust-removal equipment are shown in **Table 1**, and a schematic drawing of the inner structure of the bag chamber is shown in **Fig. 3**. Features of the facility are given below.

(1) A specially treated heat-resistant nylon filter is used to broaden the normal working temperature range of the gas.
(2) The number of bag chamber divisions is increased to prevent operational fluctuations when dust is cleaned from the filter.
(3) The bottom of the filter is designed to prevent abra-

Table 1 Specifications of dry type dust-removal equipment

Item	Specification
Method	Bag filter
Type	Vertical type, cylindrical mild steel structure, 6 chambers
Gas volume (wet)	725 000 Nm^3/h max.
Dust content	
Inlet	3.6 g/Nm^3 max.
Outlet	5 mg/Nm^3 or under
Filter	Heat resistance nylon with special treatment 306 mmϕ × 10 mL × 648 pcs
Filtering velocity	1.172 m/min



① RSW inlet butterfly valve
② Bag filter inlet goggle valve
③ Bag filter outlet goggle valve
④ Bag filter outlet butterfly valve
⑤ Bag filter outlet butterfly valve for primary equalizing gas
⑥ RSW outlet butterfly valve for primary equalizing gas
⑦ RSW outlet butterfly valve
⑧ Filling pressure butterfly valve
● Installing position of gas cooling device
*1 Wet type dust-removal equipment

Fig. 2 Flow diagram of dry type dust-removal system for blast furnace gas

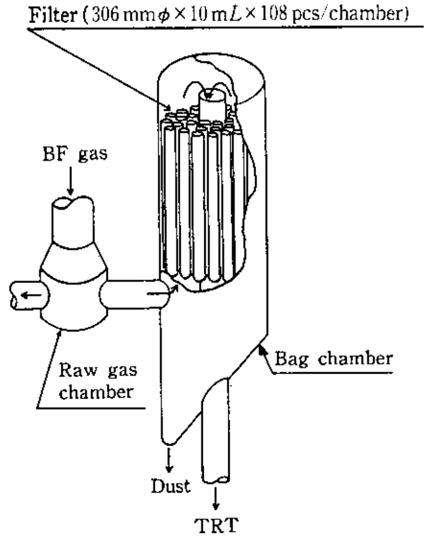


Fig. 3 Schematic drawing of inner structure of bag chamber

sion, taking into consideration the length/diameter ratio of the filter.

(4) The filter tensile range is set so as to prevent unseating or loss of tension.
(5) Level measurement of dust is made with a thermometer.
(6) Dust is floated and fluidizing to ensure smooth discharge.

3.2 Gas Cooling in Dust Catcher

The gas cooling device inside the dust catcher is of a large-capacity, and high-accuracy temperature control type to protect the filter and prevent excess cooling of the gas. The flow and control system configuration of the dust catcher gas cooling device is shown in **Fig. 4**. The features of the system are as follows:

(1) Through the division of the water supply line into several channels and their appropriate use on the basis of nozzle characteristics, wide-range stepless gas temperature control in accordance with the gas temperature and flow rate is possible.
(2) To maximize cooling efficiency in the water spray process, nozzles providing a fine spray were adopted. The mean diameter and range of the water spray was determined on the basis of an examination of the evaporation mechanism to determine the conditions for complete evaporization between the water spray position and the filter.
(3) The spray diameter does not vary with changes in spray volume. To make this possible, a return system was adopted in which the opening of the return line regulating valve is controlled while the water supply volume is held constant.
(4) The spray volume and range of the nozzles were measured, and based on these measurements, the number of nozzles and spray angle with respect to gas flow were determined.
(5) To prevent any backflow of BF gas and possible nozzle clogging due to dust, when the water spray is shut off, a constantly pressurized nitrogen gas jetting purge is used.

An example showing the effectiveness of temperature control with this method is given in **Fig. 5**.

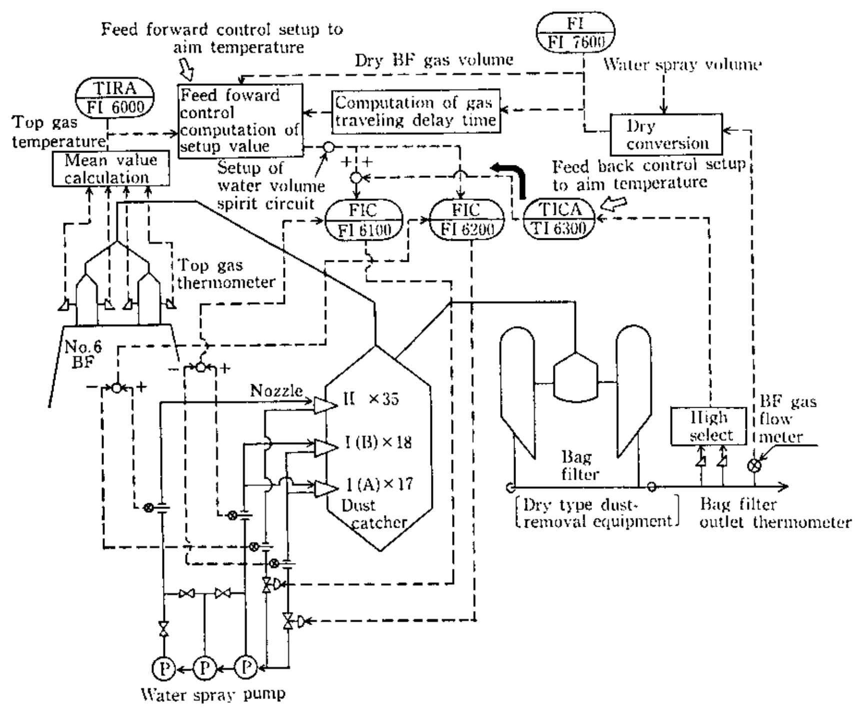


Fig. 4 Flow and control system configuration for dust catcher gas cooling device

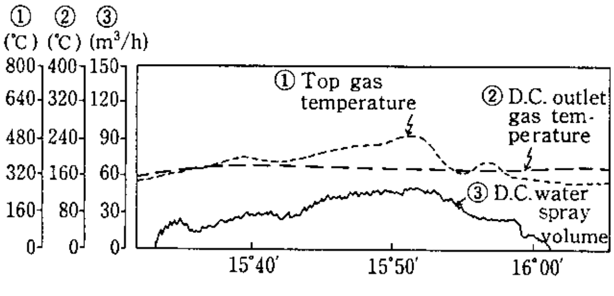


Fig. 5 Results of gas temperature control

Table 2 Example of separated dust component

	Size (μm)	Chemical composition (%)		
		Zn	TFe	C
Oversize dust	44.5	1.17	41.9	27.8
Undersize dust	16.0	4.23	39.8	24.3

3.3 Dust Separation Equipment

A schematic diagram of the dust discharge device and dust separation equipment is shown in **Fig. 6**. Features of the facility are given below.

(1) The grading point can be arbitrarily selected by changing the rotation speed of the separation equipment rotar in accordance with desired dust size characteristics.

(2) The collected and separated dust contains a large quantity of material usable in the sinter raw mix, such as iron and carbon. The dust also contains a considerable quantity of zinc. Because zinc requires upper-limit quantity control when charged into the blast furnace, care must be exercised in formulating a sinter raw mix using recovered dust. It is a peculiarity of this filtration process, however, that as the particle size of the collected dust decreases, the zinc concentration tends to become higher. Consequently, it is possible, by changing the dust size grade point, to control the quantity and zinc concentration of the low zinc-content dust; such dust can then be safely re-used in the sinter raw mix (**Table 2**).

4 Operating Conditions

The dry-type dust-removal system at No. 6 Blast Furnace at Chiba Works was put into operation in September 1986. Operational data for periods before and after the introduction of the equipment are shown in **Fig. 7**. Although no change was observed in top gas volume, the pressure drop in the dust-removal line was reduced to about 0.10 kg/cm^2, and by increasing the TRT inlet gas temperature, TRT output improved by about 11%. The BF gas pre-heater is now used only with the wet-type dust-removal system before and after the shutdown of blast furnace, or when weekday daytime rates for purchased electricity make increased TRT operation economically advantageous. Consequently, consumption of BF gas by the BF gas pre-heater has been greatly reduced.

The dry-type dust-removal system and its auxiliary system are presently in satisfactory operation, and dust-removal performance is excellent, with a dust-removal efficiency of 99.96% and a bag filter outlet dust content of 0.7 mg/Nm^3, as shown in **Table 3**.

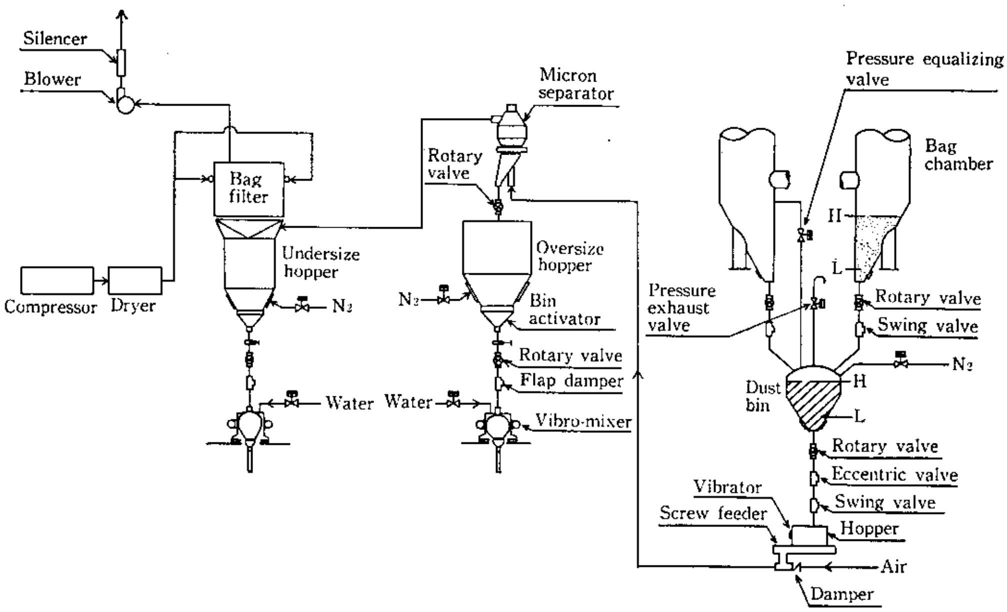


Fig. 6 Schematic diagram of dust discharge device and dust separating equipment

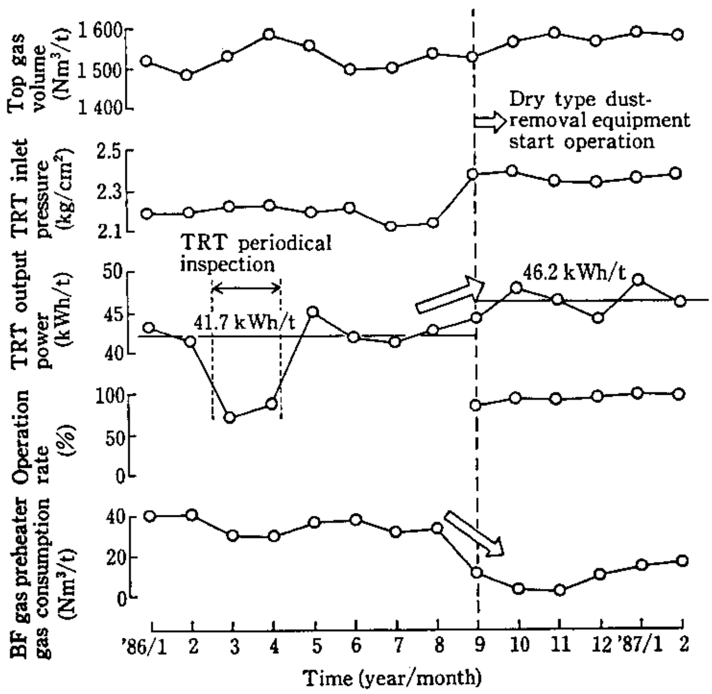


Fig. 7 Transition of operation before and after the start-up of dry type dust-removal equipment

Table 3 Dust-removal conditions of BF gas

Item	Result	Remarks
Dust-removal efficiency	99.96%	At performance test Inlet: 3.98 g/Nm³ Outlet: 1.7 mg/Nm³
Bag-filter outlet dust content	3 mg/Nm³ max 0.7 mg/Nm³ ave	Sept. 1986~Mar. 1987
Dust volume	About 1 200 t/month	Average from Sept. 1986 to Mar. 1987

5 Conclusions

A dry-type dust-removal system of the bag filter type was introduced at Chiba Works No. 6 BF in September 1986. Results to date have been satisfactory.

Water spray cooling protects the filter against unusually high BF gas temperatures, and through use of a unique step-less gas temperature control system, operation at the upper end of the heat-resistance temperature range of the filter has become possible, resulting in increased energy recovery. Since the start-up of the system, TRT output has improved by about 11% due to increased TRT inlet temperatures and reduced pressure drop in the dust-removal line.

The running costs of the auxiliary system have also been significantly reduced through such means as elimination of BF gas heating upstream of the TRT, a practice considered necessary with conventional systems.

Finally, through grading of the dust recovered with this system, dust of high zinc content is separated, making possible increased use of the remaining low-zinc dust as a material for the sinter raw mix.

References

1) T. Nishiyama, and K. Kikuchi: *Kawasaki Steel Giho*, **10**(1978)2 · 3, 47