New type Gas Cleaning Plant at Blast Furnace / Dry type Multi Vessel Electrostatic Precipitator system

1 Introduction

The ironmaking process in a blast furnace results in large amounts of gas being emitted from the top of the furnace (in the order of tens of thousands of Nm^3 per hour from each furnace). This byproduct gas is then used to supply energy needs in the wider steel plant.

As this blast furnace gas also contains particulate matter made up of iron and coke dust, it needs to be cleaned in a gas cleaning plant before it can be used as fuel.

Blast furnace gas cleaning plants can remove more than 99.9% of this particulate matter, with the coarse dust being removed by a primary dust collector that works by gravitational precipitation (dust catcher) or cyclonic separation (cyclone) and the fine dust being removed by a secondary dust collector in the form of a wet scrubber (wet type gas cleaning plant) or dry bag filter.

The gas at the top of the blast furnace also has pressure and thermal energy, with a pressure of about 0.15 to 0.25 MPa(G) and a temperature of about 100 to 150°C. The gas cleaning plant uses some of this pressure energy for dust collection, with the remainder of the pressure and thermal energy being recovered as electric power by the furnace-top pressure recovery generator at the downstream end.

The more stringent environmental protection and energy efficiency requirements of recent years have led to increasing demand for secondary dust collectors that use dry collection. The reasons for this are as follows.

[1] Smaller pressure and temperature drops mean more electric power is generated

[2] Dry collection uses much less water

Nippon Steel & Sumikin Engineering has developed a compact high-performance dry electrostatic precipitator for blast furnaces by combining core technologies from its many years of operational experience with dry bag filters and wet electrostatic precipitators for blast furnaces and dry electrostatic precipitators for sintering. This article describes Nippon Steel & Sumikin Engineering's proprietary system for dry multi-vessel electrostatic precipitation, including its features and testing.

2 Overview of Dry Multi-Vessel Electrostatic Precipitator System

Electrostatic precipitators work by applying a high voltage to discharge electrodes (wires), causing the particulate matter to become negatively charged and attracted to the dust collection plate that serves as the positive electrode, in accordance with Coulomb's law. Taking advantage of the features of electrostatic precipitators — including being compact but capable of collecting large amounts of dust, being easy to maintain, imposing less of a pressure and temperature drop, and being able to operate over a wide temperature range (making the equipment highly durable) — the steel industry makes wide use of them for applications such as sintering dust collection, secondary dust collection for blast furnace gas, dust collection for the converter gas treatment process, and dust collection for the coke oven gas treatment process. In the case of secondary dust collectors for blast furnace gas, these features of electrostatic precipitators make them highly fit for the purpose.

The dry electrostatic precipitators for blast furnaces made by Nippon Steel & Sumikin Engineering have the following features.

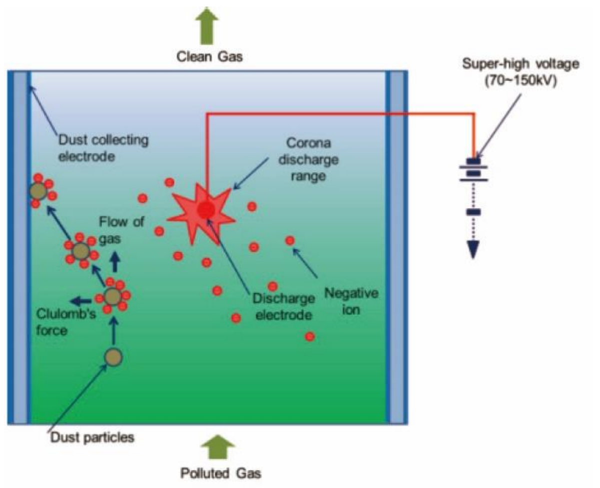


Figure 1 Principle of operation of electrostatic precipitator

[1] The dust that accumulates on the dust collection plates is dislodged by mechanical hammering and carried to the dust hopper by the flow of blast furnace gas.

[2] The dust collection vessels are aligned in parallel. When dislodging dust, the inlet valve for each vessel is closed and hammering is performed one vessel at a time with the system fully offline. This prevents the increase of the concentration of particulate matter in the discharged gas caused by the recovered dust that is raised by hammering.

[3] As the collectors are made entirely of metal, the system can operate at the same temperature as a gravitational precipitator (dust catcher).

[4] The concentration of particulate matter in the discharged gas is less than 5 mg/Nm^3, similar to previous methods.

[5] An additional backup dust collection vessel is included that can be activated immediately in the event that electrical charging halts, thereby avoiding a blast furnace shutdown.

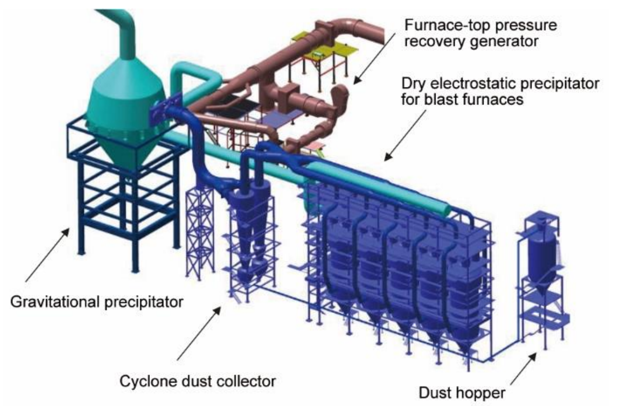


Figure 2 3D drawing (for a large blast furnace in the 5,000 m^3 class)

3 Features

The dry electrostatic precipitators for blast furnaces made by Nippon Steel & Sumikin Engineering have the following features.

1) Better equipment reliability

Nippon Steel & Sumikin Engineering developed technology for dry electrostatic precipitators for sintering in the early 1970s, and has continued to develop electrostatic precipitator technology ever since. The technology was subsequently applied to blast furnaces, with a wet electrostatic precipitator for blast furnaces being commercialized in the late 1980s in the form of a wet secondary dust collector designed to use less pressure energy than previous techniques. The system is still in operation at three large blast furnaces in Japan.

Table 1 Wet electrostatic precipitators supplied to blast furnaces

Customers for wet electrostatic precipitators for blast furnaces		Year delivered	Quantity	Furnace capacity (m^3)	Remarks
Kimitsu Steel Works, Nippon Steel & Sumitomo Metal	No. 3 blast furnace	1985	1 system	4822	Shutdown in 2016 due to idling of blast furnace
Yawata Steel Works, Nippon Steel & Sumitomo Metal	No. 1 blast furnace	1985	1 system	4407	Shutdown in 1998 due to idling of blast furnace
Nagoya Steel Works, Nippon Steel & Sumitomo Metal	No. 3 blast furnace	1986	1 system	4300	
Kimitsu Steel Works, Nippon Steel & Sumitomo Metal	No. 4 blast furnace	2003	1 system	5555	
Kimitsu Steel Works, Nippon Steel & Sumitomo Metal	No. 2 blast furnace	2012	1 system	4500	

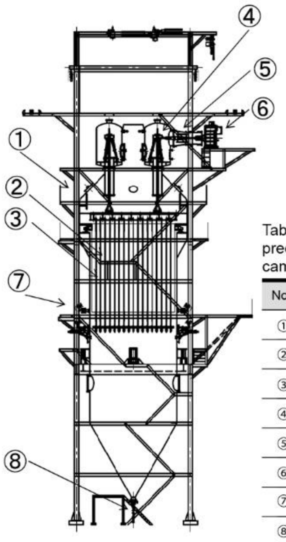
In the late 1980s, Nippon Steel & Sumikin Engineering developed its own dry bag filter for blast furnaces with the aim of further reducing the use of pressure energy and the loss of thermal energy. The dry bag filter was commercialized as a dry secondary dust collector. The system is still in operation at four large blast furnaces in Japan and one in China.

Table 2 Dry bag filters supplied for blast furnaces

Customers for dry bag filters for blast furnaces		Year delivered	Quantity	Furnace capacity (m^3)	Remarks
Oita Steel Works, Nippon Steel & Sumitomo Metal	No. 2 blast furnace	1989	1 system	5245	
Nagoya Steel Works, Nippon Steel & Sumitomo Metal	No. 1 blast furnace	1992	1 system	4650	
Oita Steel Works, Nippon Steel & Sumitomo Metal	No. 1 blast furnace	1993	1 system	4884	
Kure Works, Nisshin Steel	No. 1 blast furnace	1998	1 system	2650	
Oita Steel Works, Nippon Steel & Sumitomo Metal	No. 2 blast furnace	2004	1 vessel	5775	Capacity increased as part of a blast furnace upgrade
Nagoya Steel Works, Nippon Steel & Sumitomo Metal	No. 1 blast furnace	2007	1 vessel	5443	Capacity increased as part of a blast furnace upgrade
Oita Steel Works, Nippon Steel & Sumitomo Metal	No. 1 blast furnace	2009	1 vessel	5775	Capacity increased as part of a blast furnace upgrade
TISCO steel works (China)	No. 5 blast furnace	2009	1 system	4350	

Note: “1 vessel” means that an additional vessel was installed as part of a blast furnace upgrade

Nippon Steel & Sumikin Engineering’s dry electrostatic precipitator for blast furnaces achieves high reliability by combining these proven equipment designs.



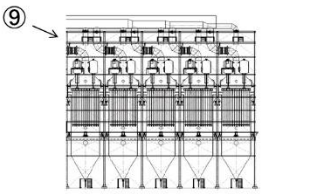


Table 3 Technologies used in dry electrostatic precipitator for blast furnaces and where they came from

No.	Name	Source	Distinctive technology
①	Pressure vessel	Dry bag	Pressure vessel
②	Dust collection plate	New	Optimization of dust collection chamber
③	Discharge electrode	Wet electrostatic	More stable discharge
④	Insulator chamber	Wet electrostatic	Insulator able to hold high charge
⑤	Insulator	New	Voltage insulator
⑥	Charging system	Wet electrostatic	Charge voltage control
⑦	Hammer system	Sintering electrostatic	Mechanical hammering
⑧	Gas flow transportation	Dry bag	Carried by blast furnace gas
⑨	Multi-vessel configuration	Dry bag	Immediate switching between vessels

Figure 3 Where in the system each technology is used

2) Higher dry utilization

As blast furnaces are subject to sudden increases in gas temperature, protection of the dry dust collector and downstream equipment is vital. Whereas the dry bag filters used in the past were also equipped with a wet dust collector (wet type gas cleaning plant) for equipment protection (to protect the filter), the electrostatic precipitator enables operation to be entirely dry, improving utilization.

3) Easier to maintain

The dry bag filters required replacement of the several thousand filters once every few years (replacement with new filters). Electrostatic precipitators, in contrast, are easier to maintain because they do not require replacement of the electrodes and dust collection plates.

4) More compact

The dust collection performance of the dry electrostatic precipitator for blast furnaces made by Nippon Steel & Sumikin Engineering has been significantly improved by the use of a honeycomb of hexagonal dust collection plates. The means that many fewer dust collection vessels are needed and therefore that the system takes up less space. This expands potential uses of the system to blast furnaces where the adoption of a dry process has been constrained in the past by lack of space.

5) Low cost

Another benefit of requiring fewer dust collection vessels through the use of a hexagonal honeycomb is lower capital costs. The lower number of units also reduces utility usage (including nitrogen and pressurized air).

4 Results of Trials at Pilot Plant

During development, Nippon Steel & Sumikin Engineering conducted its own laboratory testing, testing using actual blast furnace gas, and offline scale model testing (using a one-third scale model).

1) Testing using actual blast furnace gas (2011)

These tests involved a pair of dust collection plates and used actual blast furnace gas. The results demonstrated that the target of less than 5 mg/Nm^3 of particulate matter in the discharged gas could be achieved. It also provided data for determining design parameters for the full-scale implementation, including the gas residence time, voltage, and optimal separation between the

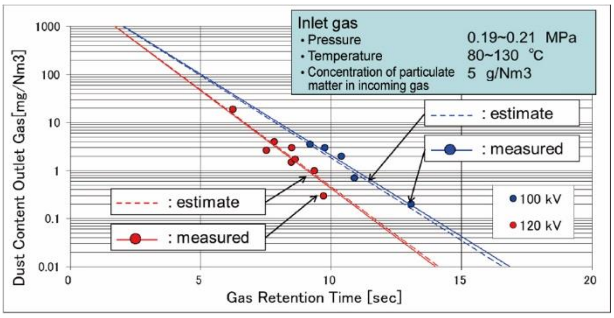


Figure 4 Relationship between amount of particulate matter in the discharged gas and gas residence time

discharge electrodes and dust collection plate.

2) Offline scale model testing (2014)

These tests scaled the system up to have a number of dust collection plates. In addition to demonstrating that the performance target could be achieved, the testing was used to determine the optimal shape for the dust collection plates and the overall equipment design.

5 Future Plans

Nippon Steel & Sumikin Engineering has contributed to creating an energy-efficient low-carbon society by combining technologies that have been in use for many years to supply highly reliable dry multi-vessel electrostatic precipitator systems.

For more information, contact:
Iron Making – Engineering & Development
Steel Plant Engineering Department - I
Plant & Machinery Division
Telephone: +81-(93)-588-7022