3A2. Pulverized Coal Injection for Blast Furnaces (PCI)

Research and development: Nippon Steel Corp. and other blast furnace steel makers
Period: Successful introduction of the technology to domestic blast furnaces started in 1981

Technology Overview

1. Background and process overview

The injection of pulverized coal into blast furnaces in Japan began at Nippon Steel Corp.'s Oita No. 1 blast furnace in 1981. Although the main reducing material in blast furnaces is coke, blast furnace operators during and after the 1960s utilized heavy oil as a companion fuel, injecting it through the tuyeres to enhance the productivity, efficiency, and scaling up potential. After the two oil crises, however, the high price of heavy oil forced the producers to switch exclusively to coke, meaning coke was solely relied upon as the reducing material. Nevertheless, there was a desire for an inexpensive heavy-oil-alternative companion fuel to reduce costs and ensure the stable operation of blast furnaces.

To this end, an ARMCO pulverized coal injection system was installed at the Oita No. 1 blast furnace, marking the first introduction of this technology in Japan (Fig. 1). This system featured the following:

1. High-pressure transportation and injection lines with no mechanically rotating components, thereby avoiding wear and tear damage.
2. No recycling of gas, assuring reliable operation.
3. Distribution of pulverized coal fed to individual tuyeres, ensuring uniform distribution utilizing geometrically symmetric flow characteristics of fluid.
4. Drying, pulverizing, and collection of coal conducted in two parallel lines, assuring stable operation of blast furnace.
5. Flow velocity of carrier air and pressure resistance of equipment set in consideration of prevention of fire and explosions.

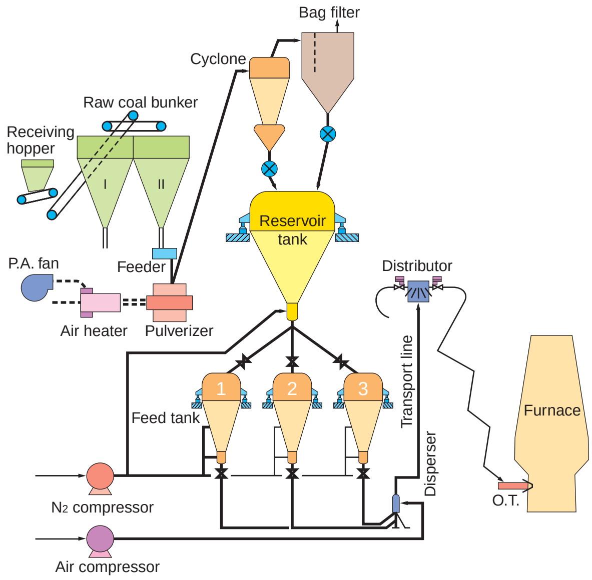

Fig. 1 Process flowchart of pulverized coal injection facility at Oita No. 1 blast furnace

2. Development objectives and technology to be developed

Field tests of the introduced technology had been performed abroad. Considering the differences in facility configurations and scale, as well as operating conditions in Japan versus abroad, a study team conducted tests and investigations, focusing on the following items, and reflected the results in the design.

1. Pulverized coal combustion test: The influence of the grade and size of the pulverized coal, the temperature, pressure, and oxygen rich condition of the air feed, and other variables were evaluated.
2. Model plant test (1 t/hr scale) for coal treatment, transportation, and control.
3. Test to inject coal through a single tuyere into an actual furnace: Combustibility evaluation at the tuyere of an actual furnace, as well as the sampling and evaluation of coke inside the furnace.
4. The distribution of pulverized coal along the circumference: Utilizing a prototype, studies were made to understand the powder flow characteristics and to determine the distribution accuracy.

3. Progress and development results

Considering the heavy oil injection level during an increased production rate period and the experience of long-term results, the capacity of the Oita No. 1 blast furnace was designed for 80 kg/t. Two mill lines, each having 25 t/hr capacity, were installed. After the start of the plant, the equipment operation and injection operation functioned smoothly, establishing a stable production system.

After the success of the Oita No. 1 blast furnace, Godo Steel, Ltd. began operating an exclusively-developed system in 1982. Following the domestic technology, Kobe Steel, Ltd. introduced the U.S. Petrocarb technology and constructed the Kakogawa No. 2 blast furnace and the Kobe No. 3 blast furnace in 1983, as the "Kobelco system." Following that, ARMCO systems were introduced into Nippon Steel's Nagoya No. 1 blast furnace and Nisshin Steel Kure No. 2 blast furnace, which entered commercial operation in 1984. In 1986, pulverized coal injection equipment for blast furnaces was adopted at 16 sites in Japan, accounting for 50% of the market. The number of blast furnaces employing the technology had increased to 25 in 1996. In 1998, all the operating domestic blast furnaces employed the pulverized coal injection equipment, which increased the average domestic pulverized coal ratio to a 130 kg/t level, (Fig. 2). Table 1 shows the various types of injection for the blast furnace pulverized coal equipment. Table 2 shows the highest level attained in Japan for the typical operational index of blast furnaces utilizing pulverized coal injection technology.

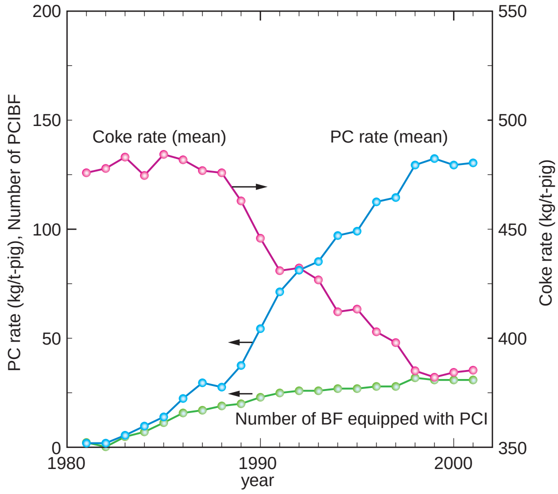

Fig. 2 Increase in installations of pulverized coal injection for blast furnaces technology in Japan

Table 1 Various types of pulverized coal injection equipment for blast furnaces

Process	Type of distribution /transportation	Pneumatic conveying concentration	Velocity	Pipe arrangement/ flow rate control	Users	Investment
Petrocarb	Pneumatic conveying from feed tank directly to each tuyere	Low	High	Carrier gas pressure and flow rate (Downtake)	National Steel, Kobe Steel, JFE (NKK)	Medium
DENKA		Low	High	Same as above, but uptake	JFE (Kawasaki Steel)	Medium
Kuettner		High	Low	Same as above + Flow meter	Thyssen	Large
formerly PW		Medium	Low	Rotary valve	Dunkerque	Medium
Simon Macawber		Low	High	Coal pump	Scunthorpe	Large
ARMCO	Feed tank →Main pipe →Distributor →Tuyere	Low	High	Uniformly distributed to give uniform pressure drop across individual pipes	Nippon Steel Corp., Hoogovens	Small
new PM		High	Low	Uniformly distributed by throttled pipes	Sidmar, Solac Fod	Small
Klockner		High	Low	Same as above	Dunkerque, Taranto	Small
Sumitomo Metal Mining Co., Ltd.		Low	Low	Rotary feeder + uniform pressure drop (one way) distribution	Sumitomo Metal Mining Co., Ltd.	Medium

Table 2 Highest domestic level operational indicies for blast furnaces with pulverized coal injection

	Month and year	Steel works, blast furnace	Coal dust ratio kg/t	Coke ratio kg/t	Reducing material ratio kg/t	Tapping ratio t/d/m^3
Maximum pulverized coal ratio (PCR)	6/98	Fukuyama No. 3 blast furnace	266	289	555	1.84
Minimum coke ratio (CR)	3/99	Kobe No. 3 blast furnace	214	288	502	2.06
Minimum reducing material ratio (RAR)	3/94	Oita No. 1 blast furnace	122	342	464	1.95
Maximum tapping ratio	1/97	Nagoya No. 1 blast furnace	137	350	487	2.63

4. Issues and feasibility of practical application

The average lifespan for domestic coke ovens has reached approximately 30 years, and the importance of pulverized coal injection technology as a companion fuel for blast furnaces increases year by year. Compared with coke, which depends on caking coal, pulverized coal increases the potential for the injection material owing to the adaptability of coal resources. Pulverized coal injection technology has the potential to spur innovations to blast furnaces: recycled materials, such as waste plastics and biomass, as well as recycled ores can be injected with pulverized coal into the furnaces via tuyeres. Thus, the technology is expected to be developed as core blast furnace technology, addressing resource, energy, and carbon dioxide issues.

Reference

Shinjiro Waguri: Ferram, Vol. 8, p. 371, 2003.