Kobe Steel’s Blast Furnace Operation Technology
January 2009 marks the 50th anniversary of Kobe Steel’s blast furnace operations. Since the start of operations, Kobe Steel, the latest Japanese company to commence blast furnace iron-making, has confronted numerous hurdles. Today, we possess the industry’s leading blast furnace operation technology.

The Evolution of Kobe Steel’s Blast Furnace Operations
On January 16, 1959, Kobe Steel, then an open-hearth and electric arc furnace steelmaker, fired up the Kobe Works No. 1 blast furnace for the first time and took its initial step as an integrated blast furnace steelmaker. Later, during Japan’s period of high economic growth, Kobe Steel constructed blast furnaces Nos. 2 and 3 at the Kobe Works and blast furnaces Nos. 1 and 2 at the Kakogawa Works. Kobe Steel has been improving proprietary blast furnace technology ever since. After renovating its blast furnaces and shutting down its smaller furnaces, Kobe Steel currently operates three blast furnaces: the Kakogawa Works No. 2 blast furnace (inner volume: 5,400m³), the Kakogawa Works No. 3 blast furnace (4,500m³), and the Kobe Works No. 3 blast furnace (2,112m³).

The Role of Blast Furnaces
Blast furnaces, which are symbols of the steel industry, are large reaction vessels that produce pig iron by melting and reducing iron ore, which involves the removal of the oxygen from the iron oxide. The process for producing pig iron is:
1. Iron ore and a reductant, such as coke (coal baked in lumps), are alternately fed into the top of the blast furnace.
2. Hot air at approximately 1,200°C and reduction-aiding agents, such as pulverized coal, are fed into the bottom of the blast furnace.
3. The hot air burns the pulverized coal and coke and raises the temperature to more than 2,000°C, which creates carbon monoxide (CO) gas and reduces the coal.
4. The raw material is heated to 1,000°C – 2,000°C in the blast furnace and melts at 1,500°C. It then separates into hot metal (molten pig iron) and slag and accumulates at the bottom of the furnace.

Blast Furnace Operation—Key Points
The key to blast furnace operation lies in how efficiently heat is applied and how efficiently reduction occurs. The best way to raise thermal efficiency and increase the reducibility of iron ore is to evenly distribute the hot air blown in from the bottom of the furnace after it is directed to the center. To achieve this, it is essential that the alternating cohesive layers of iron ore lumps and coke (called the cohesive zone) form an inverted V-shape. Kobe Steel’s unique blast furnace operation technology enables the formation of this ideal inverted V-shaped cohesive zone.
Feature 1  Kobe Steel’s Blast Furnace Operation Technology

Three Unique Technologies

1. Center Coke Charging

Steel raw materials are: lump ore (unprocessed iron ore extracted from mines), sintered ore (iron ore that has been pulverized and hardened at high temperature), and iron ore pellets (a finer grade of iron ore granules that have been pelletized and heated). Kobe Steel, a latecomer to blast furnace ironmaking, uses iron ore pellets extensively. Although relatively inexpensive, because of their round shape, iron ore pellets move to the center of the furnace interior, block the flow of gas, and therefore inhibit the formation of the inverted V-shaped cohesive zone.

To solve this problem, Kobe Steel developed a “center coke charging technology” in 1987. This technology, while also employing the conventional method of alternately charging coke and iron ore, charges small amounts of coke in the center of the furnace, thereby improving the air and liquid permeability of the furnace center and forming an inverted V-shaped cohesive zone. Kobe Steel’s technology, a world first, enables stable blast furnace operation and extends furnace operating life. Having acquired a patent, Kobe Steel is licensing its center coke charging technology to other companies.

Diagram of Center Coke Charging

Center coke charging improves blast furnace operations

Basic principle:
• Coke charged in center of furnace forms core

Application of principle:
• Improves air permeability of furnace center
• Forms inverted V-shape cohesive zone and stabilizes operations
• Inhibits deteriorative reaction of center coke
• Provides sound coke core and improves air and liquid permeability

2. All-Pellet Operation

Thanks to the development of center coke charging, Kobe Steel enjoys an extremely high ratio of pellet use. The ratio per ton of ore for other companies is 20% lump ore to 80% sintered ore. In contrast, the Kobe Works No. 3 blast furnace has a ratio of 30% lump ore to 70% iron ore pellets (called all-pellet operation*), while the Kakogawa Works No. 2 and No. 3 blast furnaces have a ratio of 20% lump ore, 30% iron ore pellets and 50% sintered ore.

However, while extensive use of iron ore pellets contributes to improving cost competitiveness, operational problems do result. Iron ore pellets are by nature difficult to reduce. If the periphery but not the center is reduced, the pellets easily break. The broken pellets descend to the furnace’s interior and fall into the tuyeres, through which hot air is injected, providing a surge of intense heat that damages the tuyeres.

To resolve these problems, Kobe Steel has made a number of improvements to its pellet technology. For instance, dolomite was added to the iron ore pellets, which were called “dolomite pellets,” resulting in a unique technology that is a component design for pellets that do not break.

*All-pellet operation: Of the raw material used in blast furnaces, iron ore that has gone through a pre-firing process, such as iron ore pellets and sintered ore, is called processed iron ore. The term “all-pellet operation” means that all the processed iron ore has been turned into iron ore pellets.

3. Pulverized Coal Injection (PCI)

One characteristic of Kobe Steel is its extensive use of pulverized coal (PC) as a heat source and reductant in blast furnace operations. Pulverized into minute grains with an average particle size of 60 microns, pulverized coal can be purchased for half the price of coke. Kobe Steel procures coke from outside sources and thus has sought to develop a method that would reduce the ratio of coke and increase the ratio of pulverized coal. As a result, of the 500 kg of reductant (total of coke and pulverized coal) required to produce one ton of iron, Kobe Steel was able to lower the coke ratio to under 300 kg—a world first—and thereby achieve the highest pulverized coal ratio in the world.

A high PC ratio is now possible with Kobe Steel’s proprietary PCI technology. Specifically, pulverized coal is fed into the furnace through an injection lance, while hot air is sent to the blast furnace via separate means. Both are ignited and burned within the blast furnace. The distinctive feature of Kobe Steel’s PCI technology is that the furnace interior is the site of ignition.
Companies are now working to develop new ironmaking processes that are not blast furnace-dependent, and at Kobe Steel such processes are now being commercialized. (Please see pages 12 to 15 of this report.) However, since the blast furnace process can mass produce high-grade iron units at low cost, this process is likely to continue to coexist with next-generation ironmaking processes in the years ahead. If that is the case, the biggest issue then facing the blast furnace process is its environmental impact, especially CO₂ emissions. In order to resolve this issue, Kobe Steel will address the problem of lowering the reductant ratio.

In blast furnace operations today, many sensors are used to assess furnace conditions and stabilize operations, but there are still areas that rely on human senses. In terms of passing down specialized knowledge and skills to the next generation, we will continue to work to replace the use of human senses with sensors in order to create an easier operating environment.

**Future Issues**

Moving forward, the steel industry must make the concept of “high added value” its core doctrine with the aim of creating more high-end products. To that end, with its hot metal production system, Kobe Steel can secure iron units to stabilize furnace conditions and support the manufacturing of high-value-added steel products. We will also strive for a low reductant ratio of operation with an eye toward reducing our environmental impact by lowering CO₂ emissions and other measures. In these two areas, Kobe Steel will undertake work on technical development.

**Column**

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