AN UPDATE ON FINEX® PLANT OPERATIONS[1]

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Abstract
FINEX® is a new ironmaking process that is based on the direct use of fine ore and non-coking coal. The key technologies involved are the fluidized-bed reduction of fine iron ore, the hot fine DRI(direct-reduced iron) compaction to HCI(hot-compacted iron), the briquetting of fine coal, and the melting of HCI into hot metal. A 1.5 mtpy FINEX® commercial plant has been operating at Posco's Pohang Works since April 2007. The start-up operation was carried out smoothly, and improved gradually over time. Recently, the normal operational performance has been achieved, satisfying target values of production rate, coal consumption, plant availability, and hot-metal quality.
Key words: FINEX®; Posco; Ironmaking; Hot metal.

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1 INTRODUCTION

The blast-furnace ironmaking process, which relies on the coking and sintering processes, has been the dominant hot-metal production technology for over a century due to its high productivity, excellent heat efficiency, and long furnace life. However, complex processing requirements, increasingly scarce high-quality raw materials, and more demanding environmental standards have created an urgent need for an entirely new ironmaking process.

During the past few decades, steelmakers worldwide have pursued development of innovative new ironmaking technologies to take the place of the blast furnace in response to growing economic and environmental imperatives. The common objective of all these new technologies has been to avoid the drawbacks of sintering and cokemaking by producing hot metal through the direct use of fine ore and coal. Although many different projects have been initiated over the years, only a handful of technologies have made it to the demonstration scale phase of development.

Posco is now poised to make a significant contribution to the global steel industry with an innovative ironmaking technology that replaces the conventional blast-furnace process used worldwide for well over a century. FINEX® is a new process for hot-metal production that is based on the direct use of fine ore and non-coking coal, eliminating the need for sintering and cokemaking.

The first commercial FINEX® plant with a capacity of 1.5 mtpy has been constructed and commenced operations in April 2007 at Pohang Works of Posco.

2 PROCESS OVERVIEW

The FINEX® process simplifies ironmaking by eliminating the sintering and coking processes. Its key components include fluidized-bed reactors, a coal briquetter, a hot DRI compactor, and a melter-gasifier. Fluidized-bed reactors are capable of directly reducing iron-ore fines. A coal-briquetting technology allows the use of non-coking coal fines. The separation of the iron-ore reduction and melting processes in the reactors and the melter-gasifier, respectively, makes operational control uncomplicated.

Figure 1 shows the process flow of FINEX® technology. Fine iron ore is charged into the fluidized-bed reactors together with a flux such as limestone or dolomite. As it passes through the four reactors, it is preheated and reduced. The reduced iron ore or hot DRI is transformed into lump form by the hot DRI compactor, and then charged into the melter-gasifier, where it is smelted into hot metal and molten slag. Coal is processed by either the briquetter or the pulverized coal injection (PCI) facilities. Briquetted coal is charged into the dome of the melter-gasifier, while pulverized coal is injected through the tuyeres. The reducing gas generated by coal combustion with pure oxygen in the melter-gasifier is channeled to the fluidized-bed reactors to reduce the iron. A portion of the reactor off-gas is recycled back into the reactors after CO_2 removal to achieve higher gas utilization efficiency.

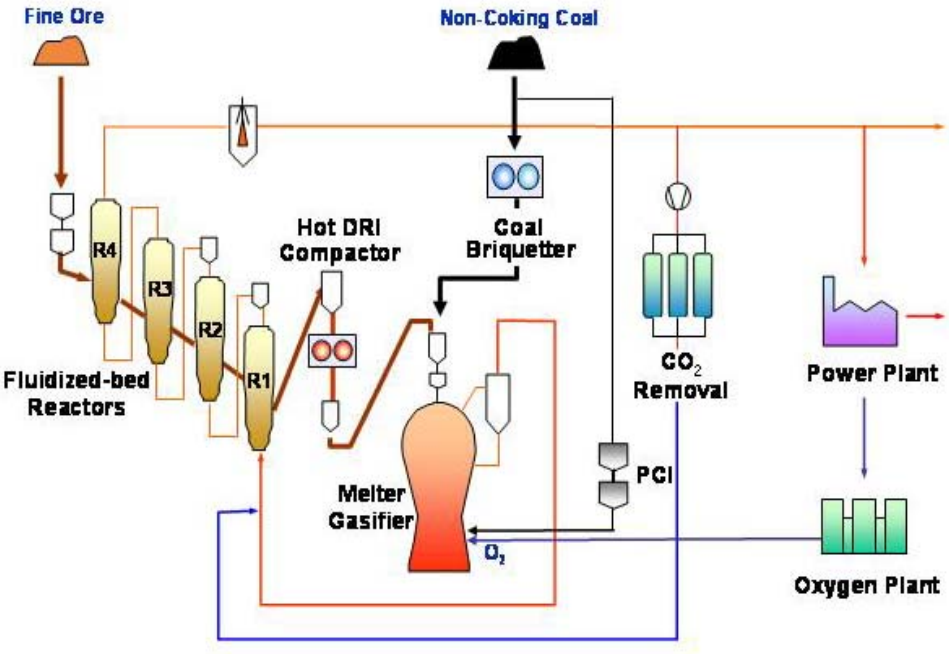

Figure 1: The FINEX® Process Flow

3 FINEX® PLANT OPERATION

Figure 2 shows the 1.5 M t/y FINEX plant built at the Pohang Works. The construction started in August 2004, and the operation started on April 10th of 2007.

The start-up of the1.5-mtpy FINEX® at Pohang works has been successfully performed. As shown in figure 3, the productivity has been increased and reached the target value of daily 4,300 ton in May of 2008. With the operation optimization and facility stabilization, the coal consumption rate is decreased down to 700 kg/t_{HM} and high plant availability is achieved at present.

Figure 2: FINEX® 1.5 MTPY Plant at the Pohang Works

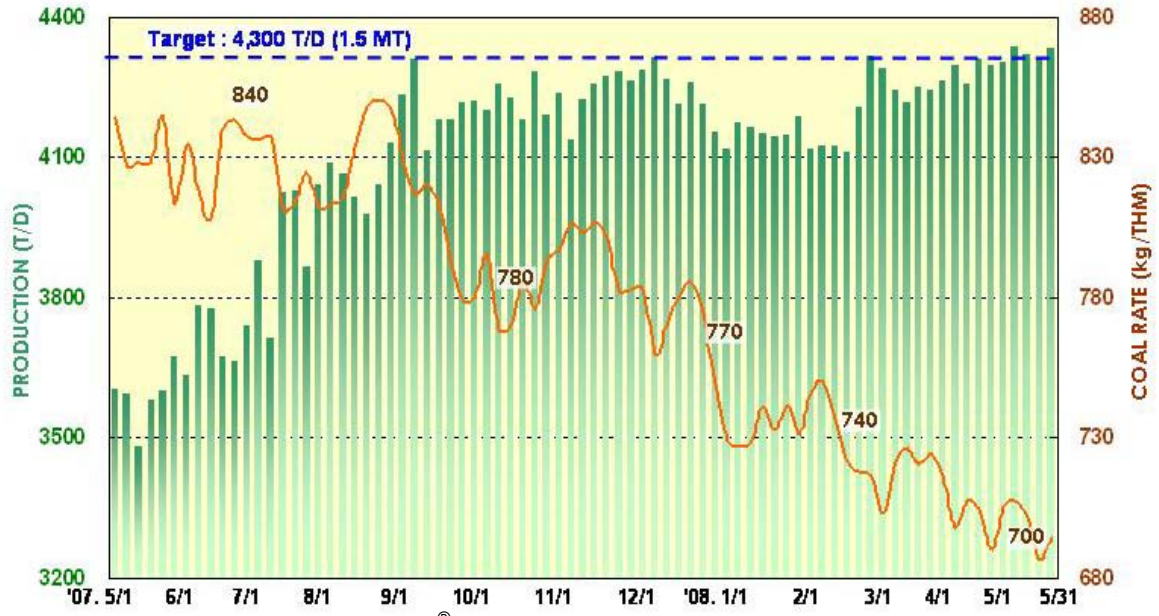

Figure 3: FINEX® 1.5 MTPY Plant Operation Performance

Operational stability in the fluidized-bed reactors is the key to achieving high plant availability in the FINEX® process. In the initial stage of demonstration plant operations, frequent sticking and blocking prevented smooth operation of the fluidized-bed reactor system. Over time, the reactor maintenance interval has steadily been extended by improvements in equipment and operational skills. At present, 300 days of continuous operation is achieved without plant stoppage for maintenance, putting availability on par with conventional blast furnaces

Significant effort has been paid to reducing the coal rate, the primary indicator of process heat efficiency. Carbon dioxide removal and the pulverized coal injection processes majorly contribute to a coal-rate reduction down to 700 kg level. Almost half of fluidized-bed reactor off-gas is recycled to the reactors through the carbon dioxide removal process. This removal process provides 30 % of the total reducing gas needed by the reactors for fluidization, resulting in a coal-rate reduction. Currently, pulverized coal is injected into the melter-gasifier system at the rate of 150 kg/t_{HM}. This is equivalent to around 20 % of the total amount of coal used in FINEX. Similar to blast furnace operation, PCI increases the burden retention time in the melter-gasifier and completes the decomposition of volatiles, consequently improving heat exchange efficiency in the melter-gasifier bed.

The Table 1 summarizes a recent monthly operational performance for the 1.5 M t/y plant with the Pohang No. 4 blast furnace. The plant availability and hot metal quality is comparable to the conventional large blast furnace. The alumina in FINEX® slag is in 17~18% range, higher than a normal blast-furnace slag.

Table 1. Summary of FINEX® 1.5 MTPY Performance with Blast Furnace (May, 2008)

		Pohang BF4	FINEX 1.5M
Daily Production (ton)		**8,851**	**4,305**
Plant Availability (%)		**98**	**95**
Hot Metal	**Temp (℃)**	**1,514**	**1,530**
	[C] (%)	**4.5**	**4.5**
	[Si] (%)	**0.53**	**0.85**
	[S] (%)	**0.027**	**0.027**
Slag	**Basicity**	**1.21**	**1.21**
	(Al_2O_3) (%)	**15.62**	**18.03**
	Volume (kg/thm)	**298**	**271**

4 RAW MATERIALS

One of important feature of FINEX® is that it covers wide range of fine iron ores in the size distribution and composition. For instance, the low grade ore of high alumina content which is restricted in the blast furnace is available. Currently, the Australian ore of 2.5% alumina content is mostly used in 1.5 mtpy FINEX® plant operation. With that ore, the stable operation is proven both in fluidized bed reactors and the melter-gasifiers. The Indian ore of higher alumina content up to 3% has been also tested, and proven to be available in FINEX® process.

Coal briquetting technology enables FINEX® to use non-coking coal as it can artificially adjust the composition and the quality by blending coal species. Due to the superior quality of coal briquette than lumpy coal, it plays an important role for the stable operation in the melter-gasifier slimilar to coke in the blast furnace. For the pulverized coal injection, the mixture of semi-anthracite and steaming coal is used analogous to the blast furnace.

5 ENVIRONMENT

The environmentally friendly nature of the FINEX® process ensures it will be even more competitive in the future. At process emission level, FINEX® SO_x, NO_x, and dust emissions are a mere 3%, 1%, and 28%, respectively, of those generated by the blast furnace process. Even comparing to the BF route with environmental best available technology, FINEX® still show the much lower emission. This enables FINEX® to easily comply with strict environmental standards and legal regulations.

Due to the elimination of coke oven and sinter plants, the FINEX® process inherently prevents pollution from being generated. Most of sulfur contained in coal and ore reacts with limestone into CaS in the reactors, and then smelts into slag. NO_x emissions are naturally very limited because reactions take place in a reducing atmosphere in the melter-gasifier of FINEX®. Dust emissions are low as well, due to simplified processing. It has also been verified that no dioxins are generated in the FINEX® process.

Due to the lower coal consumption rate, currently, the CO_2 emission of FINEX® is 96% of world averaged blast furnace emission amount, and expected additionally

down to 94% by process optimization in the near future. Because FINEX uses pure oxygen for coal gasification and possesses an in-situ CO_2 removal system, CO_2 can be rather easily separated for the storage. Subsequently, FINEX® is highly feasible to apply CO_2 sequestration, and the CO_2 emission can be even reduced to 56% of world averaged blast furnace emission amount with the sequestration.

6 ENERGY

In FINEX®, with parallel to the reduction of oxygen and electricity consumption rate, the high energy efficient route for producing oxygen and electricity is important. The conventional route is electicity generation using FINEX® export gas , and the oxygen production using the electricity.

For the energy and operational cost savings, the 1.5-mtpy FINEX® at Pohang Works is currently combined with newly installed energy efficient oxygen pant and combine cycle power plant using FINEX® export gas. The oxygen and power plant are under the stable operation with satisfactory performance.

For the further energy saving, the integrated configuration of oxygen, power, and a FINEX® plant is under investigation. The above integration is being evaluated as the key measure to enhance the energy efficiency of FINEX® process higher than the blast furnce.

7 CONCLUSION

The simple nature of the FINEX® process and its ability to use low-cost raw materials means that both capital investment and production costs are lower than the blast furnace route.

Posco's 1.5 mtpy FINEX® plant is operating over a year since April, 2007. The annual production capacity has reached the aimed value of 1.5 million tones. The current coal consumption rate is around 700 kg/t_{HM} level, and the operation cost is evaluated lower than to the large blast furnace of 3.0 mtpy in Pohang Works.

Posco will pay furthur effort for the higher energy efficiency and the precise control of hot metal qulity in FINEX® process. Also, Posco plans a scaled-up FINEX® plant up to 2.0 mtpy in order to cope with the current extended blast furn