Improvement of Production Capacity at Steelmaking Plant in West Japan Works (Fukuyama), JFE Steel†

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Abstract:

At JFE Steel West Japan Works (Fukuyama), various technological developments have been carried out with the aims of improving productivity, expanding sales of high quality steel sheets for automobiles, improving slab quality, and reducing costs. To achieve these targets, No. 7 continuous slab caster (7CC) and a new converter were constructed, and the heat size of No. 3 Steelmaking Plant was increased. 7CC has exceeded its planned productivity of 200 kt/month. Productivity was also increased in the refining process by constructing a new converter and increasing the heat size to 348 t/charge, and costs have been reduced and slab quality has been improved by performing dephosphorization pretreatment in the converter by a newly-developed process called the Double-slag Refining Process (DRP™). As a result of these developments, production at No. 3 Steelmaking Plant increased to a record 636.9 kt/month in March 2015.

1. Introduction

At JFE Steel West Japan Works (Fukuyama), a new No. 7 continuous slab caster (7CC) was constructed at No. 3 Steelmaking Plant in April 2010 in order to expand sales of high quality steel sheets, centering on automotive sheets, and improve productivity[1)], and in the refining process, the heat size was expanded to improve productivity. In January 2015, one new converter was constructed with the aims of enhancing the capacity to build quality into products and reducing costs by increasing the tapping capacity of No. 3 Steelmaking Plant and performing dephosphorization pretreatment in the converter, and a new converter-type pretreatment process called the Double-slag Refining Process (DRP®) is now being used.

The above-mentioned equipment has been operating smoothly since startup. This paper reports on the integrated production capacity improvement measures at No. 3 Steelmaking Plant, centering on this construction.

2. Iron and Steel Material Flow at Fukuyama District

Figure 1 shows the flowchart of production at Fukuyama District after the startup of the new converter. Before the startup of 7CC, the production system at No. 3 Steelmaking Plant comprised two converters and two continuous casters, that is, No. 5 continuous slab caster (5CC), which is a 2-strand slab caster, and a 4-strand bloom continuous caster (BLCC). As a result, the continuous casting process was the bottleneck pro-

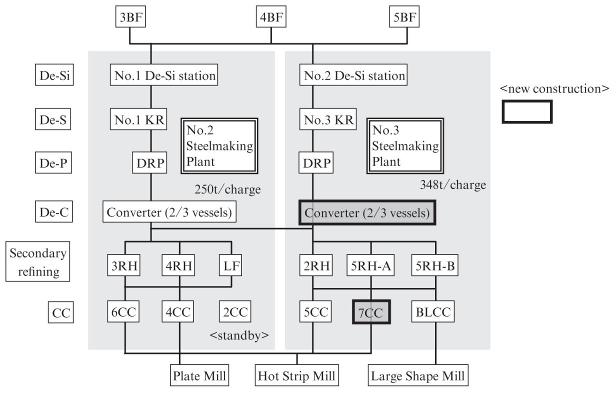

Fig. 1 Production flow at Fukuyama District

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cess for crude steel production capacity at No. 3 Steelmaking Plant. 7CC was constructed to eliminate this problem. After the startup of 7CC, the production system consisted of two converters and three continuous casters, resulting in a margin in continuous caster capacity. Therefore, a new converter was constructed at No. 3 Steelmaking Plant in order to increase production at the plant and perform pretreatment in the converter.

3. Measures for Productivity Improvement

3.1 Measures for Productivity Improvement in Continuous Casting Process

3.1.1 Construction of 7CC

Table 1 shows the main specification of 7CC. 7CC is a vertical-bending single-strand continuous caster based on Fukuyama No. 6 continuous slab caster (6CC).

Planned productivity was 200 kt/month, and the machine length is 44.7 m. To improve the operating rate, a submerged entry nozzle (SEN) quick change system was introduced. This was the first such system at JFE Steel. For control of the molten steel flow in the mold, the Flow Control (FC) Mold was adopted in order to respond to stricter quality requirements for automotive steel products, etc. similar to 5CC[2]. An online mold thickness change system (short side quick change method) was also adopted, making it possible to cast the two slab sizes of 235 mm and 260 mm. **Figure 2** shows the equipment layout of 7CC, and **Fig. 3** shows the product mix.

3.1.2 Measures for improvement of production efficiency

To improve productivity, after the startup of 7CC, efforts were made to achieve high efficiency in unsteady portions of the slab (at start of casting, before/after SEN exchanges).

Table1 Specification of No. 7 continuous slab caster

	7CC	remarks
Type	Vertical bending/ single strand	shared segments and common spare segmennts with 6CC
Cast grades	sheet	
Slab thickness (mm)	235/260	quick mold thickness change system
Slab width (mm)	750−2100	
Machine length (m)	44.7	
Max. casting speed for low carbon (m/min)	2.6 (235 mm thickness)	
Productivity (kt/month)	200	

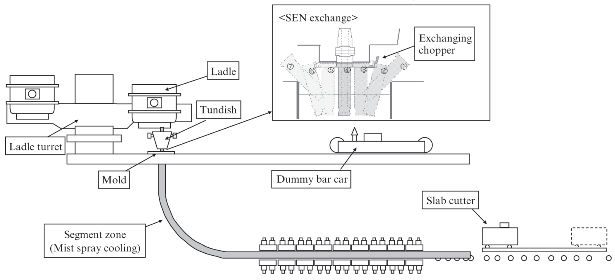

Fig. 2 Facility schematics of No. 7 continuous slab caster

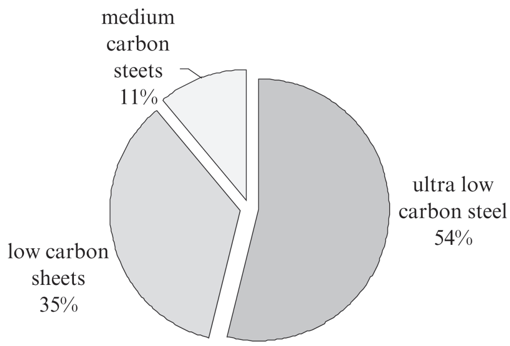

Fig. 3 Product mix of No. 7 continuous slab caster (2014 FY)

At the start of casting, the risks of trouble in separating the slab from head of the dummy bar (DB), and of breakout (BO) due to thinning of the molten mold (MD) powder layer in the initial stage of casting were concerns. As a result, the casting speed acceleration rate was slower than that of the base continuous caster (i.e., 6CC), and during SEN exchanges, changes in the casting speed (acceleration, deceleration) accounted for 85% of the time required for nozzle changes. Therefore, efforts were made to increase the casting speed acceleration and deceleration rates.

To increase acceleration rate at the start of casting, a test was performed under two acceleration conditions; the same acceleration rate as at 6CC was set as Level 1 and a rate 1.5 times faster than that at 6CC was set as Level 2 (**Fig. 4**). In order to evaluate the risk of operational trouble, in this test, (1) the slab shape at the connection with the DB head and (2) the thickness of the molten layer of MD powder in the initial stage of casting were checked, and the effect of increasing the accel-

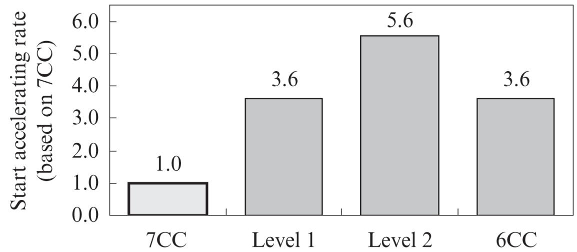

Fig. 4 Comparison of start and submerged entry nozzle exchange accelerating rate

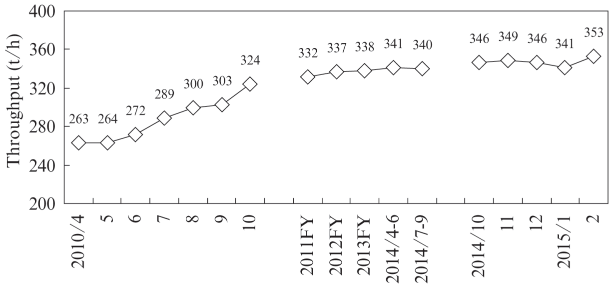

Fig. 5 Throughput transition of No. 7 continuous slab caster

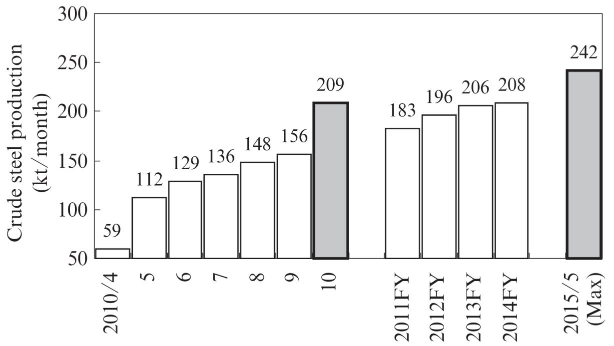

Fig. 6 Transition of production amount at No. 7 continuous slab caster

eration rate on slab quality was evaluated by (3) the surface properties of the slab near the bottom and (4) the defect inclusion ratio at the coil surface. Since satisfactory results equal or superior to those under the conventional conditions were obtained under both acceleration rate levels, Level 2 was adopted as a standard operation procedure.

Regarding the increase in the deceleration/acceleration rates before/after SEN exchanges, because the tests and quality effect evaluation were completed up to Level 1 at the start of casting, and an improvement in the quality of slabs and coils was confirmed, this was adopted as a standard operation procedure. As a result, the time required for nozzle changes could be shortened to half of the conventional time.

3.1.3 Transition of throughput and production amount

Figure 5 shows the transition of throughput after startup, and **Fig. 6** shows the transition of the production amount. Although throughput of 342 t/h was specified in the construction plan, a new throughput record of 353 t/h was achieved in February 2015 by the above-mentioned improvements, etc. As a result, after startup in April 2010, the planned production amount of 200 kt/month was achieved in the 7th month of operation (October 2010). Following this, production capacity exceeded the planned 200 kt/month on a year-round basis, and a new production record of 241.8 kt/month was achieved in May 2015. Thus, both the throughput and the production amount of 7CC have improved, and greatly exceeded the plan at the time of construction.

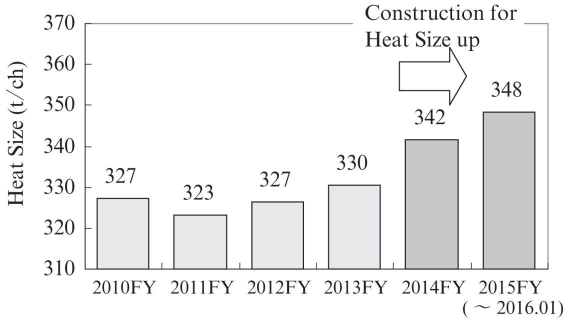

Fig. 7 Change of heat size

3.2 Measures for Productivity Improvement in Refining Process

3.2.1 Expansion of heat size

At No. 3 Steelmaking Plant, the heat size was expanded in 2014, as shown in **Fig. 7**. The ladle capacity was increased by +17.5 t/charge by an increase in the height of the ladle volume, improvements to upgrade the crane, and improvement of transfer cars. As a result of this work as well as various measures to improve yield, the heat size of No. 3 Steelmaking Plant, which was formerly 330 t/charge, was recently expanded to 348 t/charge.

3.2.2 Construction of new converter

3.2.2.1 Purpose of construction of new converter

At Fukuyama No. 2 Steelmaking Plant, JFE Steel developed DRP™ (Double-slag Refining Process), in which dephosphorization blowing is performed after desiliconization blowing and discharge of the resulting high SiO_2 slag out of the system, while also melting scrap by using the sensible heat of the hot metal, and established this technology at East Japan Works (Keihin). Fukuyama is promoting application of DRP to increase the capacity to build quality into products in the

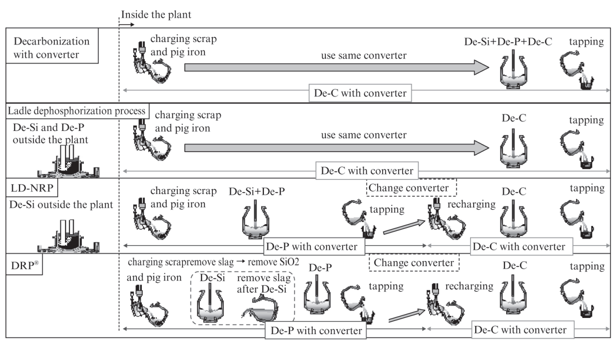

Fig. 8 Types of converter process

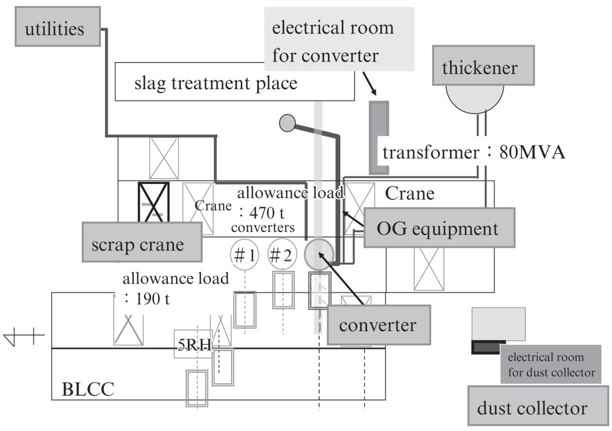

Fig. 9 Equipment which have constructed at the same time as converter

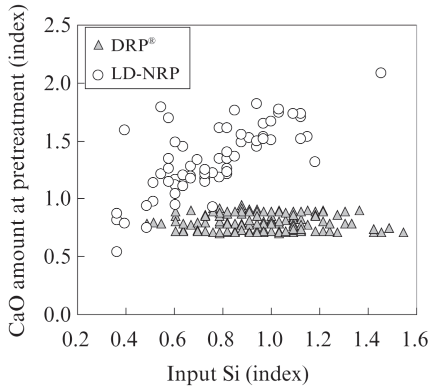

Fig. 10 Relationship between input Si and CaO amount at pretreatment

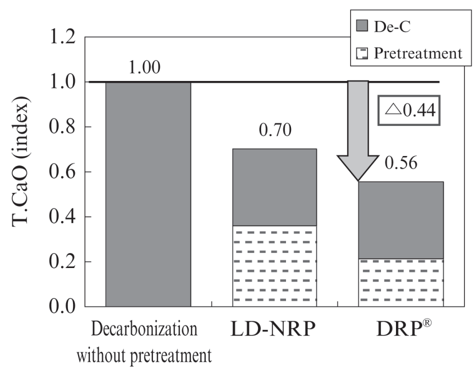

Fig. 11 Effect of DRP on reducing T.CaO

production process and reduce production costs. **Figure 8** shows a comparison of various converter processes, including DRP. Because Fukuyama has implemented priority production at No. 3 Steelmaking Plant, No. 3 Steelmaking Plant had formerly carried out decarburization operation with two converters to secure the necessary production amount. Therefore, in the project reported here, one new converter was constructed at No. 3 Steelmaking Plant in order to increase the production capacity of the plant and perform DRP.

3.2.2.2 Equipment composition

Figure 9 shows the layout of No. 3 Steelmaking Plant and the composition of the main equipment that was constructed simultaneously with the new converter. The flue gas treatment equipment adopted for the new converter was the Oxygen Converter Gas Recovery System (OG), which is the same as the existing equipment. The utilities and water treatment equipment were expanded to meet the needs of the three-converter production system, and a new scrap crane and additional dust collector were installed.

3.2.2.3 Effects of new converter-type pretreatment process

Figure 10 shows a comparison of the total CaO content (T. CaO) charged into the converter in converter pretreatment by the LD-New Refining Process (LD-NRP), which is the conventional converter-type pretreatment method, and DRP™, which is the new converter-type pretreatment method. In LD-NRP, T. CaO increases accompanying increased charging of Si in the converter, whereas in DRP, there is no change in T. CaO, in spite of increased Si charged into the converter, because dephosphorization blowing is performed after discharging the high SiO_2 slag out of the system by intermediate deslagging.

After DRP treatment, the phosphorus level is similar to that in the conventional LD-NRP method. A comparison of T. CaO including the decarburization furnace is shown in **Fig. 11**. Compared to conventional blowing, T. CaO can be reduced by 44% by DRP.

3.3 Transition of Production Amount at No. 3 Steelmaking Plant

Figure 12 shows the transition of the production amount at No. 3 Steelmaking Plant since 2009. The crude steel production capacity of No. 3 Steelmaking Plant has increased as a result of the startup of 7CC, expansion of the heat size, and startup of the new converter, and production of 636.9 kt/month was achieved in March 2015, setting a new production record.

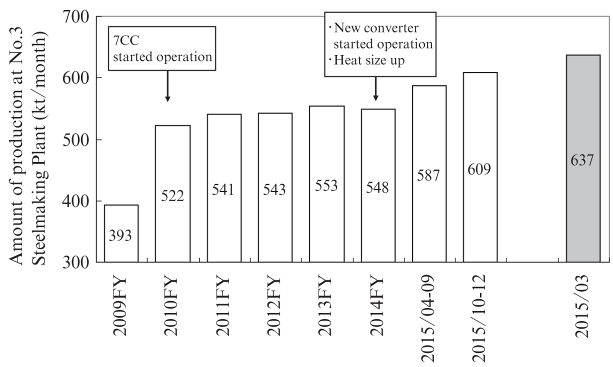

Fig. 12 Amount of production at No. 3 steelmaking plant

4. Conclusion

At JFE Steel West Japan Works (Fukuyama), a technological development and plant expansion project was carried out with the aims expanding sales of high quality steel sheets, centering on automotive sheets, improving productivity, increasing the capacity to build quality into products, and reducing production costs. To achieve these goals, 7CC was constructed, the heat size was expanded, and a new converter was constructed at No. 3 Steelmaking Plant. As a result, the following were achieved.

(1) 7CC, which is a single-strand continuous casting machine, is operating smoothly. A new production record of 241.8 kt/month was achieved in May 2015, and a new throughput record of 353 t/h was achieved in February 2015.

(2) The heat size was expanded in 2014 from the conventional 330 t/charge to a recent value of 348 t/charge.

(3) In comparison with conventional blowing, T. CaO was reduced by 44% by performing the new converter-type pretreatment process (DRP™) in the newly-constructed converter.

(4) As a result of integrated measures to improve the production capacity of No. 3 Steelmaking Plant, centering on various construction projects, the plant achieved a new production record of 636.9 kt/month in March 2015.

References

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2) Hasunuma, J. et al. CAMP-ISIJ. 1996, vol. 9, p. 618.