Start-up of No.3 Bloom Continuous Caster Operations at Kokura Works

by

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Synopsis

A new two-strand bloom continuous caster (No.3CC) has started operation at Kokura Works in order to meet today's more stringent quality requirements for bar and wire rod products and to increase continuous casting capacity.

This caster is mainly designed with consideration for the quality of special grades of bar and wire rod for the automobile industries, and also for higher productivity. For quality, we introduced a large-volume tundish, an induction tundish heater, a high accuracy steel level control system in the mold, a vertical-bending machine profile, the design of which is based on a newly developed model, and so on. In addition, automation was introduced into many elements of this caster, including, for example, ladle-crane operation and bloom cutting and handling. Consequently, this caster requires only four operators.

Operation of No.3CC started in June 1995, and it has been working well since start-up.

1. Introduction

The new two-strand bloom continuous caster (No. 3 CC) has started up operations at KOKURA works in order to meet today's more stringent quality requirements for bar and wire rod products and to increase continuous casting capacity.

This caster is mainly designed with consideration for the quality of special grades of bar and wire rod for the automobile industries, and also for higher productivity. For quality, we introduced a large-volume tundish, an induction tundish heater, a high accuracy steel level control system in the mold, a vertical-bending machine profile, the design of which is based on a newly developed model, and so on. In addition, automation was introduced into many elements of this caster, including, for example, ladle-crane operation, bloom cutting and handling. Consequently, this caster requires only four operators.

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2. Equipment

Figure 1 shows the layout of No.3 CC in the steelmaking plant at Kokura works. No.3 CC is built alongside the existing No.2 CC, and its casting floor is located 24 m above the ground. The ladles filled with molten steel are transferred to No.3 CC by a ladle traverser, which is rebuilt from a facility for ingot casting, and an automated ladle crane.

Specification of No.3 CC are outlined in **Table 1**. This caster belongs to the category of vertical-bending machines, the design of which is based on a

newly developed model. We call this the SUMITOMO vertical-bending (S-VB) type. It has a vertical strand length of 2.2 m, and a machine length of 36.5 m. The casting speed at its maximum is 1.0 m/min., and monthly production capacity is approximately 50,000 tons.

The schematic view of this caster is shown in **Fig. 2.**

Table 1 Specifications of No.3 CC

Ladle capacity	70t
Machine type	SUMITOMO Vertical-bending
No. of strand	2
Dummy-bar	Top-insert type
Tundish capacity	27t
EMS	Mold-EMS
Bloom width	400mm
Bloom thickness	300mm
Length of vertical strand	2.2m
Curvature radius	110-51-31-21-15.2m
Machine length	36.5m
Casting speed	Maximum 1.0m/min

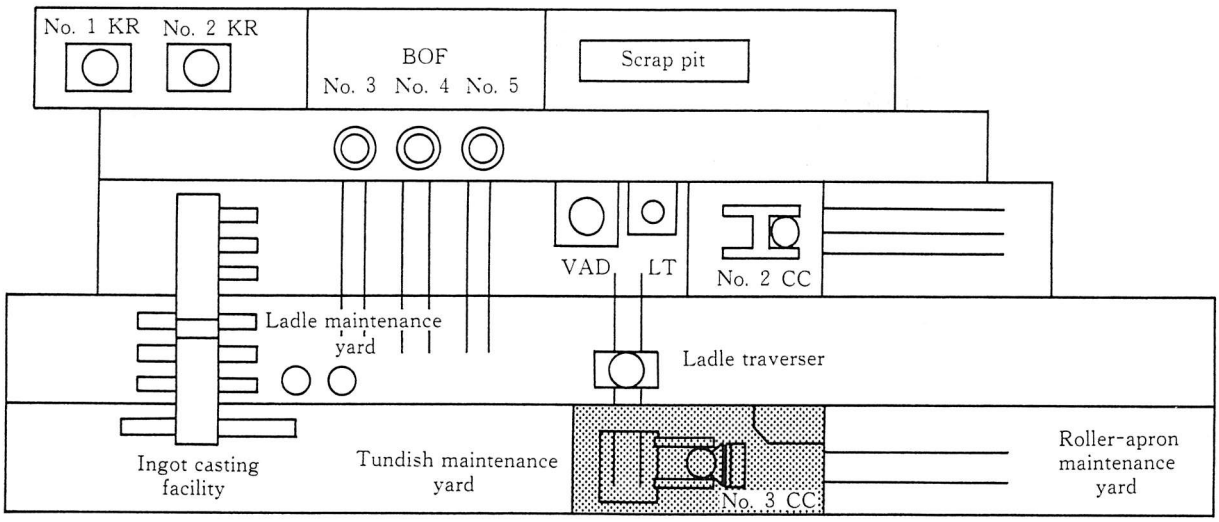


Fig. 1 Layout of No.3CC in steelmaking plant

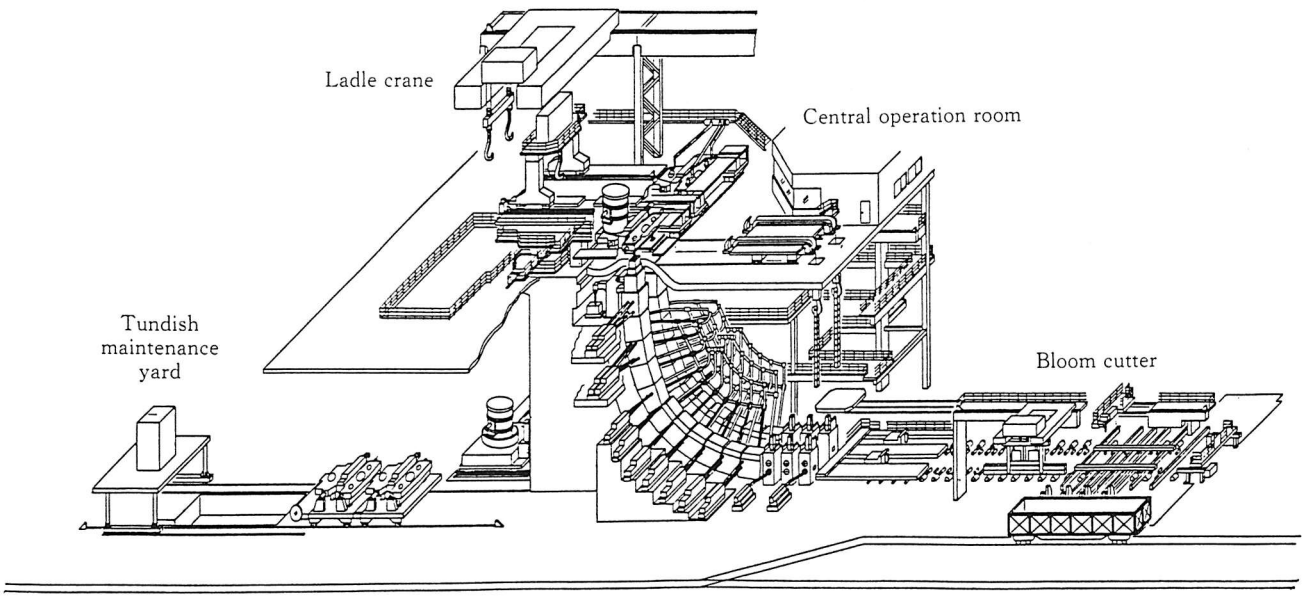


Fig. 2 Schematic view of No.3 CC

3. Special Features of Equipment and Operation

Figure 3 shows the design concept of No.3 CC. Some of the equipment is outlined as follows.

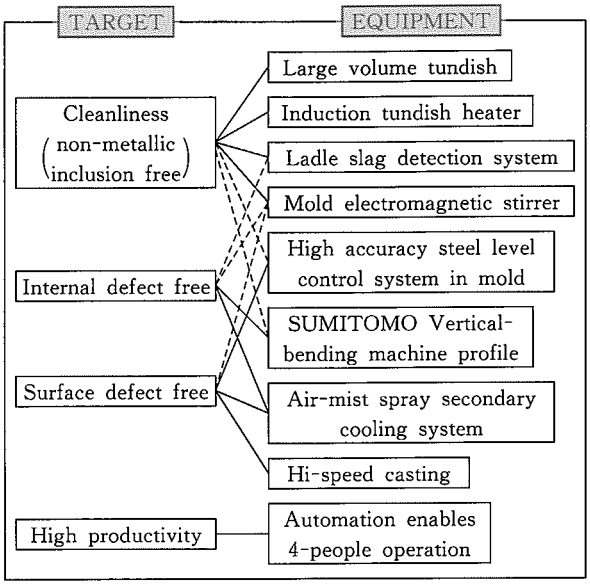


Fig. 3 Concept of No.3CC

3.1 The SUMITOMO Vertical-Bending Profile

In the design of the caster profile, we consider the quality of both non-metallic inclusions and internal cracks inside the blooms.

First, we calculate the inclusion distribution inside the bloom by computer. The calculation conditions are shown in **Fig. 4. Figure. 5** shows the calculation result, relationships between machine type and accumulation of inclusions inside the bloom. In a curvature type, even large-sized inclusions (for example, 100 mm in diameter), which are considered to be easy to float or eliminate from molten steel, are accumulated in the upper part of the bloom, even if the curvature radius is large. Conversely, in a case of vertical-bending type with 3 m long vertical part at the initial stage of solidification, the accumulation disappeared. Consequently, we chose the vertical-bending type as No.3 CC machine profile.

Next, since the internal cracks at an area near the surface which are caused by bending strain sometimes become a problem, especially in case of bar products, we decided the layout of bending points on the basis of our developed model[1]. This model demonstrates that the internal cracks occur when the accumulated strain in the range between Zero Strength Temperature [ZST] and Zero Ductility Temperature [ZDT] exceed the critical strain for internal cracking.

Therefore, the SUMITOMO vertical-bending type, in this case, has five dispersed bending points. It is a characteristic point of this machine profile that the accumulated strain of bloom at the point of solidification is designed to be maintained below the critical strain for the initiation of cracks, as is shown in **Fig. 6. Figure. 7** shows the macro-etch print of the high-carbon steel bloom in longitudinal section. The effect is that it is free of internal defects in the area near the surface inside a bloom.

Type	① Curvature type	② Curvature type	③ V-B Type
Size	Curvature radius : 13m	Curvature radius : 18m	Vertical length : 2.5m Curvature radius : 15m
Casting speed	①1.2m/min, ②0.9m/min, ③0.7m/min		
Superheat	35℃		
Nozzle depth	250mm		
EMS	Applied		

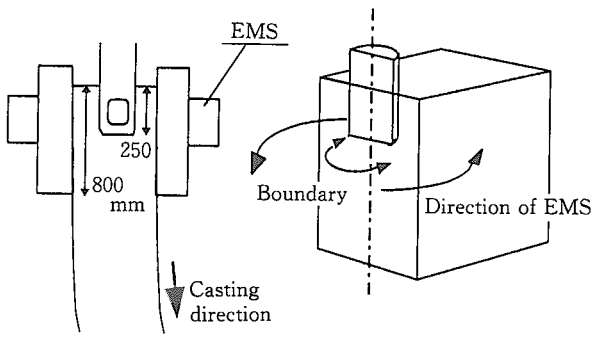


Fig. 4 Calculation condition of inclusions

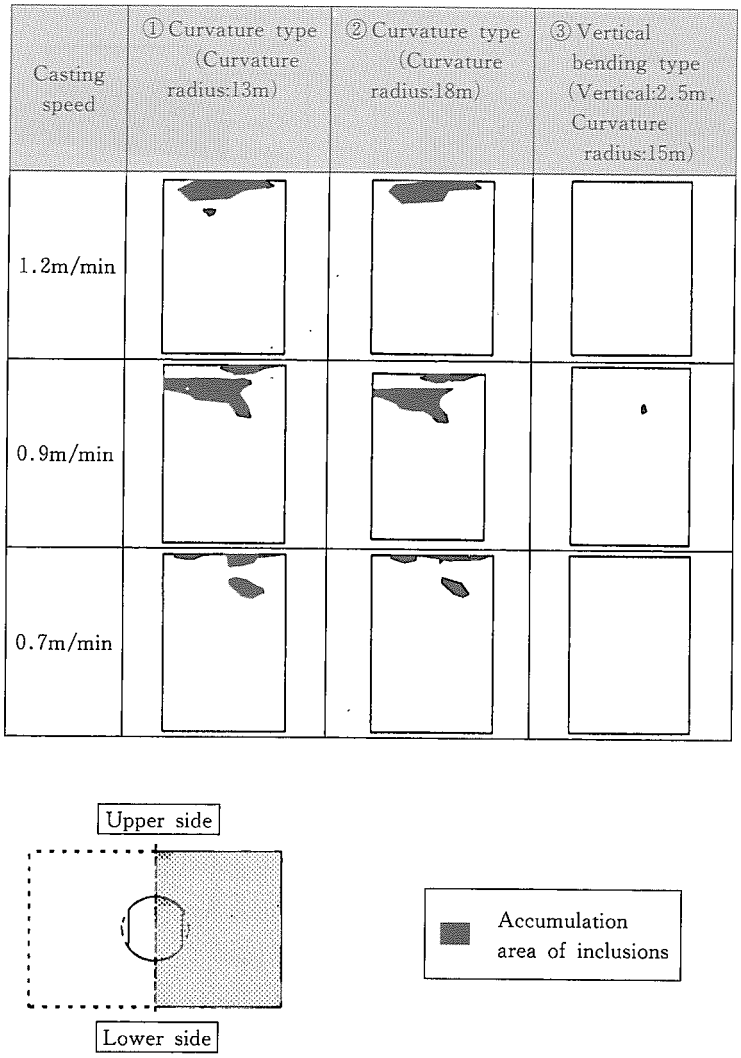


Fig. 5 Accumulation of inclusions in bloom

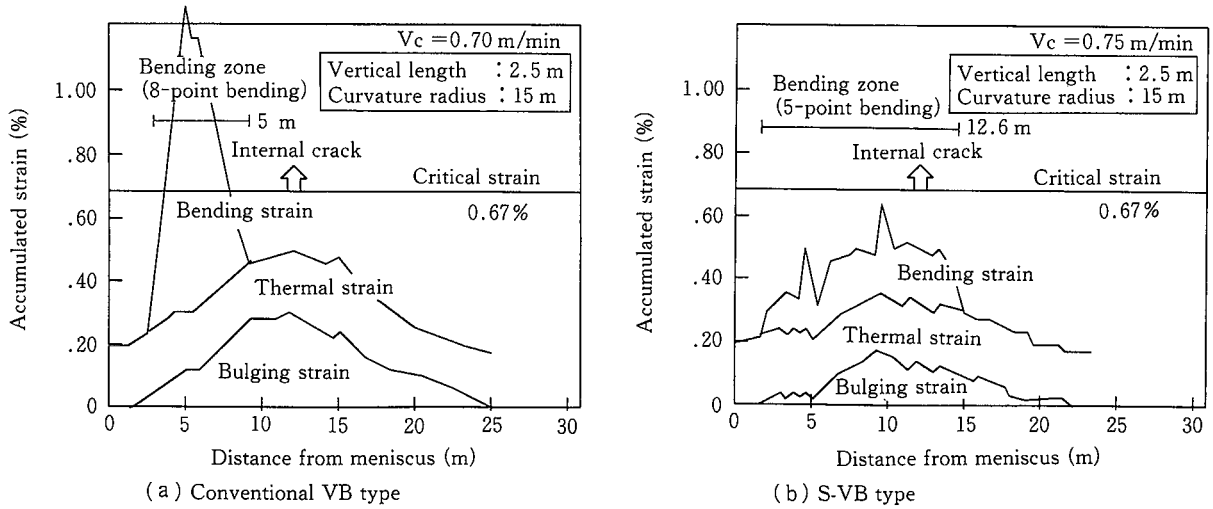
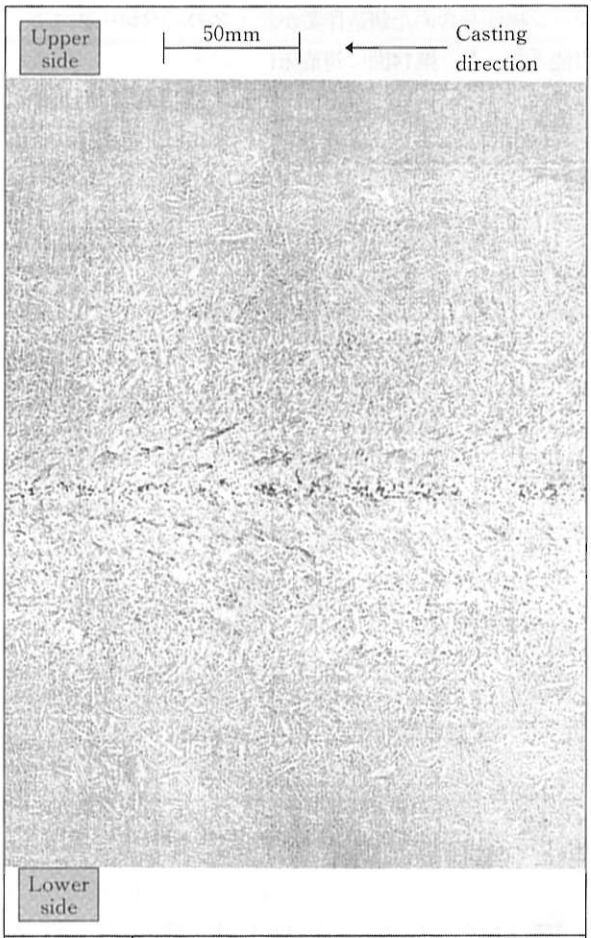


Fig. 6 Accumulated strain inside bloom
(Steel grade : C1070)



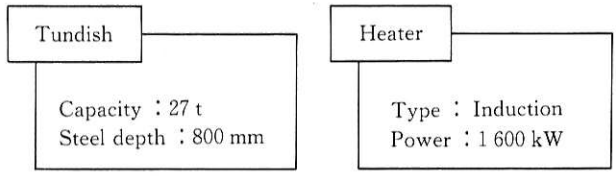
Casting condition	Steel grade : C1070 ([C]=0.72mass%) Casting speed : 0.75m/min. Superheat : 27℃

Fig. 7 Macro-etch print of bloom (Longitudinal section)

3.2 Induction Tundish Heater

An outline of the induction heater is shown in **Fig. 8**. This heater raises and stabilizes the temperature of the molten steel in the tundish to an accuracy of ±3°C, as shown in **Fig. 9.**

As for high cleanliness of products, it can exclude inclusions effectively because a large volume tundish and an induction tundish heater are used. As shown in **Fig. 10**, it is clear that the cleanliness of product was improved by applying the induction tundish heater. It is thought that this is the effect of the raising flow of heated molten steel through the sleeve bricks (**Fig. 11**), and/or the pinch effect in the sleeve bricks caused by the electro-magnetic force (**Fig. 12**)[3].



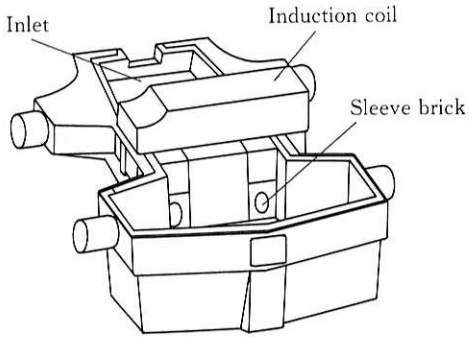


Fig. 8 Outline of induction tundish heater

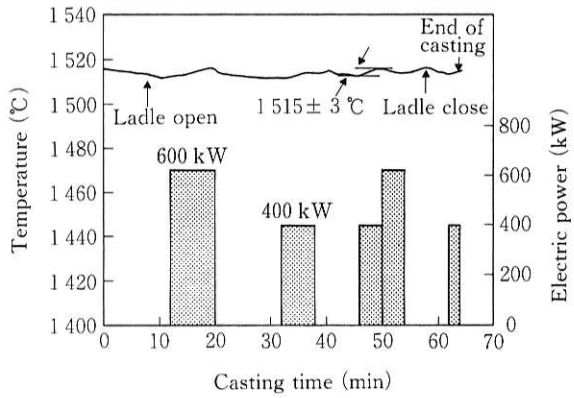


Fig. 9 Change in steel temperature in tundish

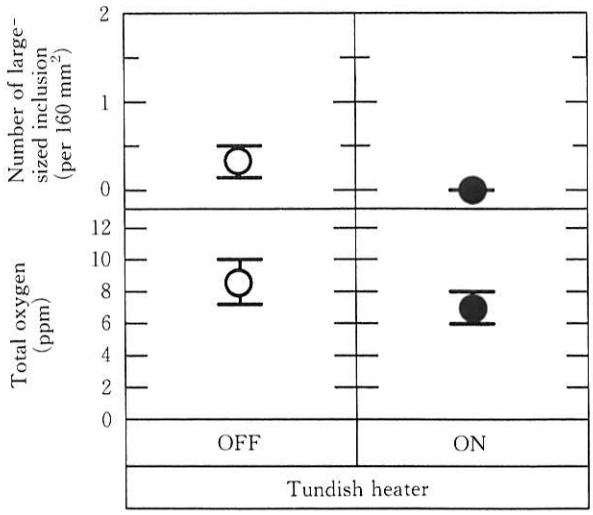


Fig. 10 Cleanliness of product (Silicon-aluminum killed steel)

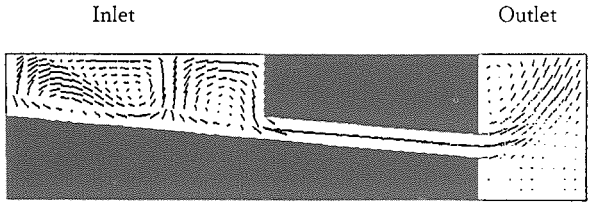


Fig. 11 Schematic steel flow in tundish

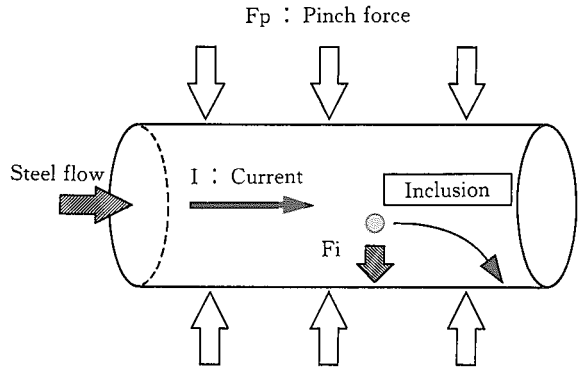


Fig. 12 Concept of pinch force effect

3.3 Operation

Automation is introduced into many pieces of equipment, as shown in **Fig. 13**, and the operator can watch the condition of the work for all the whole continuous casting devices in the central operation room. **Figure 14** shows the disposition of operators. Therefore, it is possible to operate this equipment, including ladle crane operations, with only four operators.

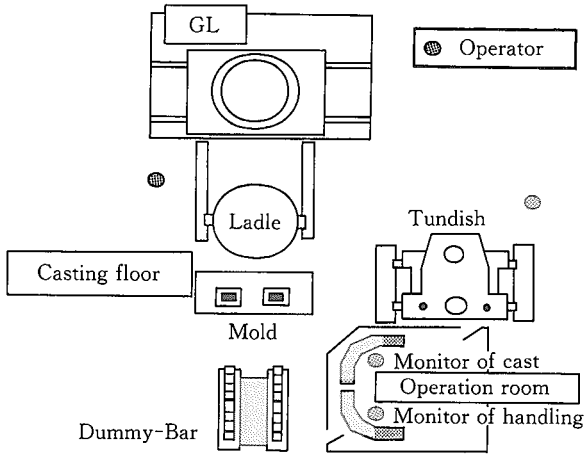


Fig. 14 Disposition of operators

Figure 15 shows the operation process of a heats-connection between the different grades of steel. Also, it is a characteristic of No.3 CC that the temperature of molten steel can be maintained during the process mentioned above by applying the tundish heater.

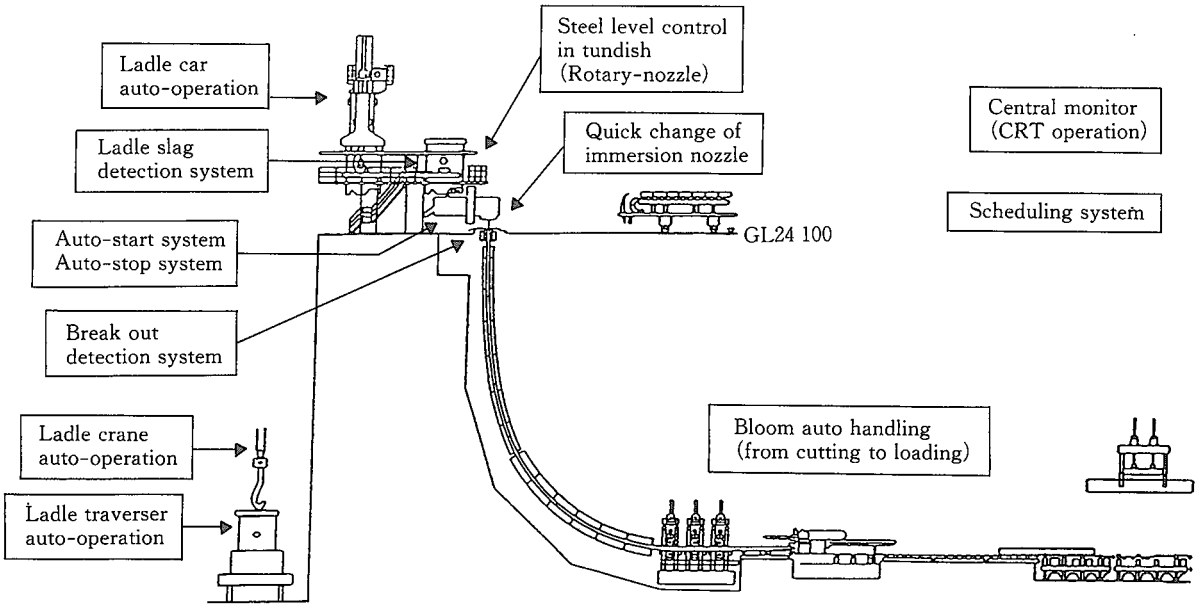


Fig. 13 Automatic equipment in No.3 CC

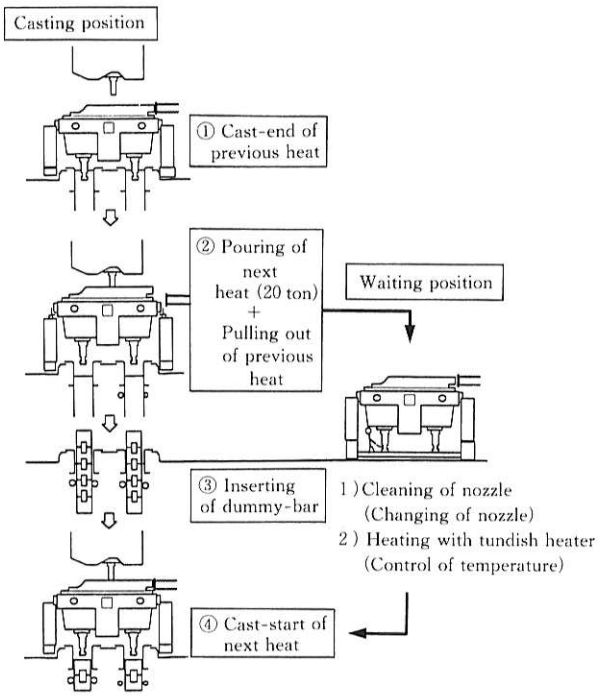


Fig. 15 Operation process of heats-connection between different grades of steel (KDC)

4. Production

Figure 16 shows the change in caster production at the Kokura steelmaking plant. The amount of production has been increasing since the plant started using one tundish many times for several different grades of steel. The continuous casting production reached 97 % of the whole steelmaking plant production as of March 1996.

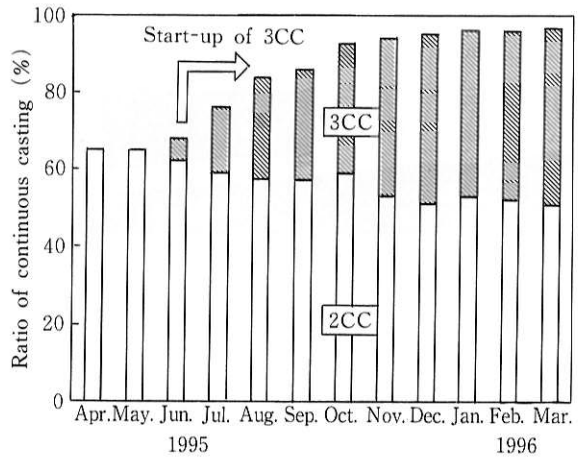


Fig. 16 Change in caster production

5. Conclusion

The new two-strand bloom continuous caster (No.3 CC) has started up operations at Kokura works in June, 1995. It has been working well and the amount of production has been increasing since its start-up.

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References

1) A. Yamanaka et al., la Revue de Metallurgy-CIT, p.623, 6, 1992
2) A. Yamanaka, CAMP-ISIJ, Vol.7, 1994, p.186
3) S. Taniguchi et al., Tetsu-to-Hagane, Vol.80, 1994, p.24