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DEVELOPMENT OF MOLD POWDER FOR KAKOGAWA No.4 SLAB CASTER

Seiji Saruhashi , Junji Abu , Katsuyosi Matsuo and Koichi Ebato

Kakogawa Works, Kobe Steel Ltd.
1, Kanazawacho, Kakogawa , Hyogo, Japan

Synopsis:

Middle carbon steel has a high surface crack sensitivity. To prevent surface crack of middle carbon steel, mold powder with higher solidification temperature was developed , which produces a uniform solidified shell. The solidified shell profile is assessed using thermocouples installed in the copper plate. Low carbon steel , which is low crack sensitive , can be cast at higher casting speed. But this steel easily produces surface defects on the final product. To prevent surface defects of low carbon steel , mold powder with higher viscosity was developed. By adjusting the chemical composition of mold powder , a sufficient inflow of molten slag goes into the gap between the solidified shell and the mold. In addition to improvement of mold powder , the proper casting conditions are applied. Controlling the properties of mold powder and the casting conditions , middle carbon steel for plate and for sheet is casted at 1.7 m/min , low carbon steel at 2.0 m/min and good surface quality of continuously cast slab is obtained.

Key words:

Continuous casting , Mold poder , Copper mold temperature , Longitudinal crack , Transverse corner crack , Viscosity , Solidification temperature , Basicity

1. Introduction

In recent years , mold powders have gained a very important place in the continuous casting technology due to the effect on the surface crack and the surface cleanness of continuously cast slab. Because of selection of the optimum mold powder and the casting condition, good surface quality of continuously cast slab and final product is produced at Kakogawa No. 4 slab caster.
This paper introduces the improvements of mold powder and casting condition made at Kakogawa No.4 slab caster.

2. Surface quality improvement for middle carbon steel

Surface crack occurs more often in the carbon range between 0.10 to 0.15 %. This carbon range steel has the shrinkage due to the peritectic reaction[1]. This shrinkage tends to create a nonuniform solidified shell in the mold and easily causes longitudinal crack and transverse coner crack(Fig. 1).

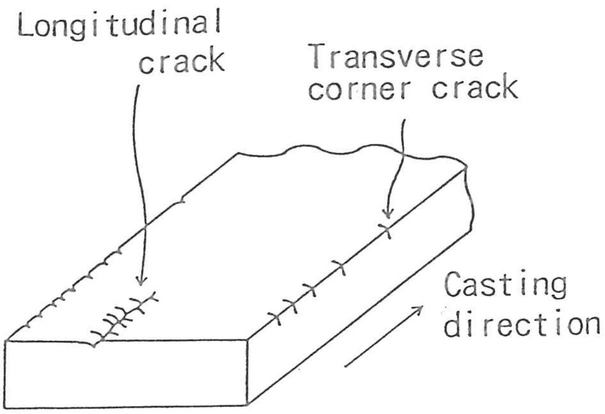

Fig. 1 Surface defects of middle carbon steel

Longitudinal crack is caused by thermal stresses in the steel meniscus resulting from difference in thermal contractions of the δ to γ phases. The best way of minimizing longitudinal crack is to produce a uniform solidified shell by decreasing the heat transfer between the solidified shell and the mold[2]. The decrease of heat transfer is achieved through raising the solidification temperature of mold powder and reducing the flow rate of mold cooling water. High solidification temperature of mold powder allows a solid slag to form between the solidified shell and the mold ; this slag layer acts as a heat transfer barrier. The solidification temperature varies with basicity. Fig. 2 shows the effect of the basicity on the solidification temperature. The solidification temperature is increased by the increase of basicity.

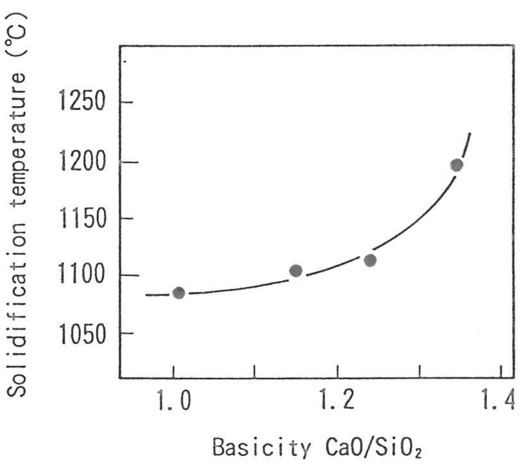

Fig. 2 Effect of basicity on solidification temperature

For the prevention of longitudinal crack , the solidification temperature of mold powder is improved as shown in Table 1 and in addition the flow rate of mold cooling water is changed from 670 m^3/h to 506 m^3/h.

Table 1 Properties of mold powder for middle carbon steel

	Conventional	Improved
Solidification temp.	1108 ℃	1200 ℃
Basicity CaO/SiO_2	1.15	1.32
Viscosity at 1300℃	0.45 poise	0.51 poise

The solidified shell profile is assessed using thermocouples installed in the copper plate. Fluctuations of the temperature indicate disturbances in the heat transfer caused by changes in the slag sheet thickness and/or in the solidified shell profile. Fig. 3 shows the mold copper temperature measurement of horizontal direction. The thermocouples are located 250mm from the top of the mold (100 ~150mm below the meniscus level) and 15mm depth from the mold surface. Maximum temperature minus minimum temperature of four thermocouples is the temperature difference. The temperature difference indicates the solidified shell profile. In the case of little temperature difference, the solidified shell is uniform. The improved is applied with the higher solidification temperature and the lower flow rate in comparison with the conventional. The improved shows little temperature difference. The improved encourages the uniform solidified shell.

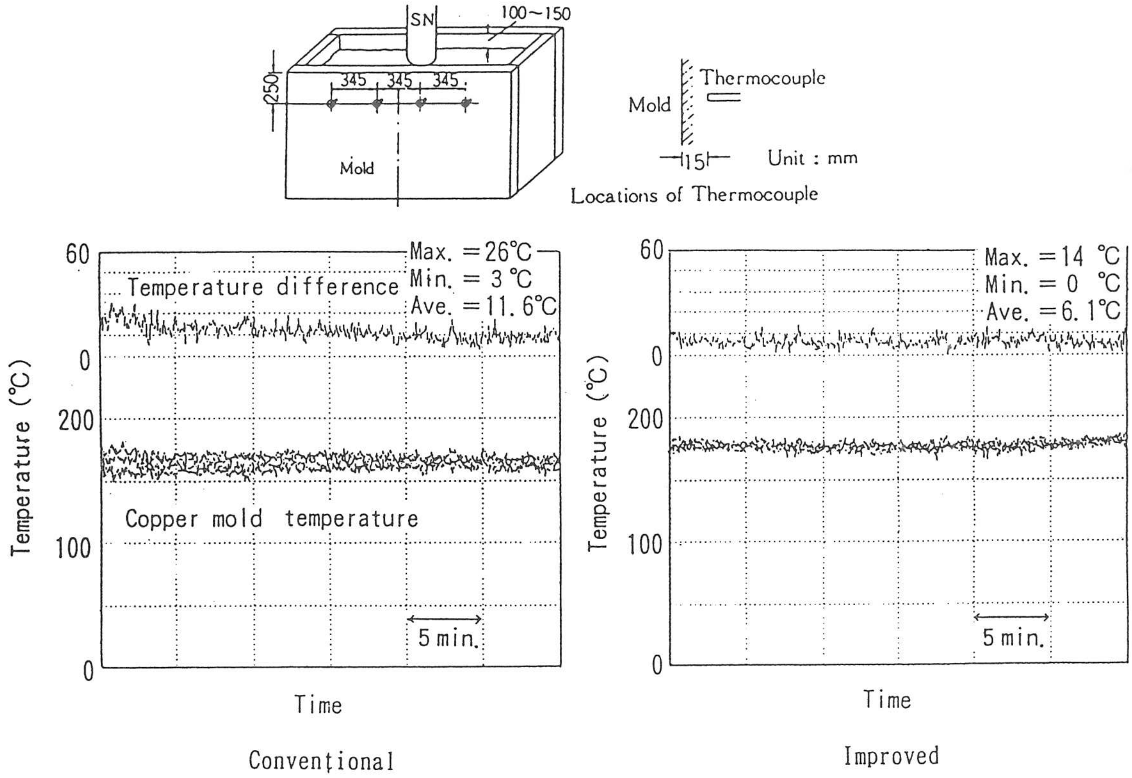

Fig. 3 Effect of powder properties and mold cooling on copper mold temperature for middle carbon steel (C=0.14 %) Casting conditions : Slab size= 230x1770mm , Casting speed= 1.6m/min

With the change of the solidification temperature of mold powder and the flow rate of mold cooling water , longitudinal crack decreases as shown in Fig. 4.

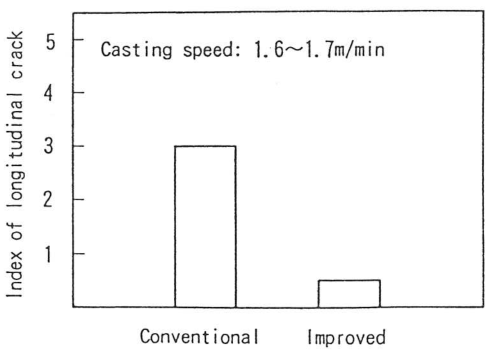

Fig. 4 Improvement of longitudinal crack

Transverse corner crack is associated with the depth of oscillation marks. The depth of the oscillation marks is principally determined by the oscillation conditions and casting[1]. The influence of the mold powder on the depth of the oscillation marks is not large. For the prevention of transverse corner crack , the casting conditions as shown in Table 2 and the mold powder as shown in Table 1 are applied.

Tabel 2 Casting conditions

	Conventional	Improved
Flow rate of mold cooling water	670 m^3/h	362 m^3/h
Narrow face taper	7 mm/m	6 mm/m
Oscillation stroke Oscillation frequency	8 mm 160 cpm	6 mm 180 cpm
Decrease of roll gap	-6.0 mm	-2.0 mm

Transverse corner crack decreases as shown in Fig. 5.

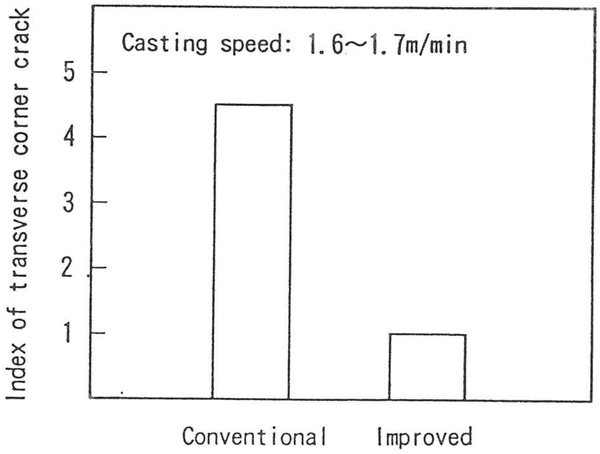

Fig. 5 Improvement of transverse corner crack

3. Surface defect improvement for low carbon steel

Low carbon steel, which is low crack sensitive , can be cast at high casting speed. But this steel easily produces surface defect such as slivers on the final product. Surface defect is due to the entrapment of mold powder in the solidifying menisucus. The control of surface and subsurface quality of continuously cast slabs is of great importance. For the prevention of the entrapment of the mold powder , the viscosity of mold powder is increased. The viscosity varies with the basicity. Fig. 6 shows the effect of the basicity on the viscosity. The viscosity is increased by the decrease of the basicity.

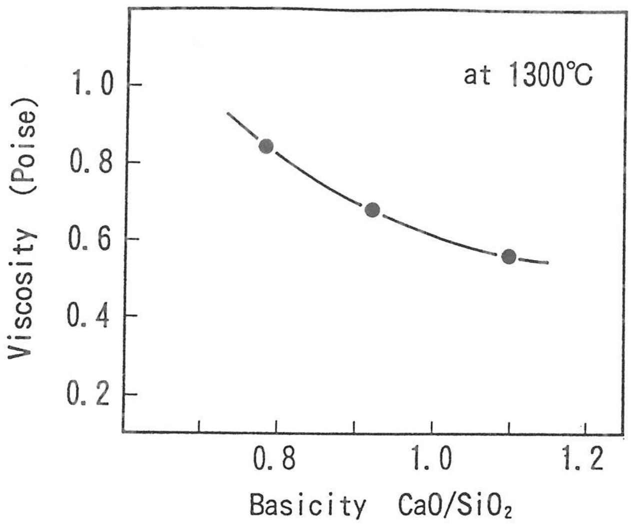

Fig. 6 Effect of basicity on viscosity

However , mold powder with high viscocity may lead to a leak of molten steel at the mold. For the prevention of a leak of molten steel, the inflow of molten slag into the gap between the solidified shell and the mold is considered. Alkali metal Li can control the properties of mold powder.
The effect of Li_2O on the inflow of molten slag is examined. Fig. 7 shows the effect of Li_2O on the index of the inflow of molten slag. In Fig. 7, index of inflow is expressed the length of the solid slag poured on the carbon trough under the constant condition. The increase of Li_2O content increases the index of the inflow of molten slag.
Li_2O is added into mold powder in order to secure satisfactory inflow of molten slag.

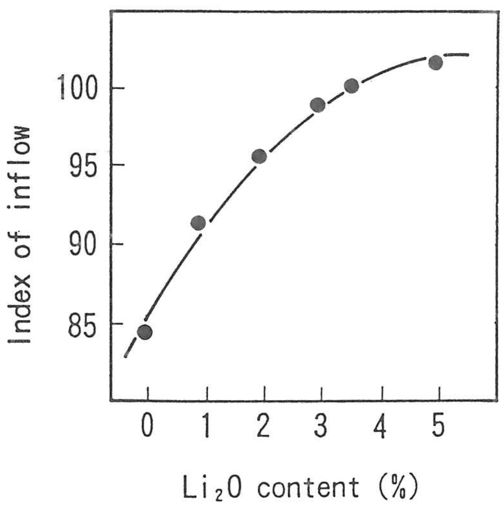

Fig. 7 Effect of Li_2O on inflow of molten slag

The properties of improved mold powder is determined as shown in Table 3.

Tabel 3 Properties of mold powder for low carbon steel

	Conventional	Improved
Viscosity at 1300℃	0.68 poise	0.84 poise
Basicity CaO/SiO_2	0.92	0.78
Solidification temp.	1062 ℃	1045 ℃

In addition to the improvement of mold powder , and in order to prevent the growth of the solidified hook , the oscillation stroke is changed from 8mm to 6mm.

With the change of the viscocity of mold powder and the oscillation stroke , surface defect decreases as shown in Fig. 8. It proves that the improved decreases the entrapment of mold powder in the solidifying menisucus and ensures the inflow of molten slag.

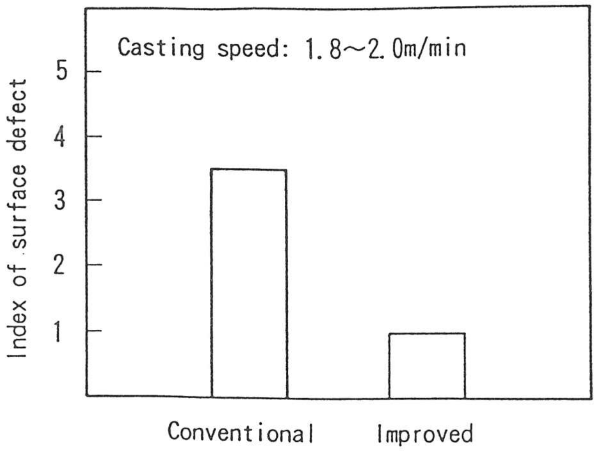

Fig. 8 Surface defect after cold rolling of slab

4. Conclution

Improvement of the mold powder is carried out to prevent the surface crack and the surface defect. In fact , the improvement of the mold powder alone, will not result in good quality of the continuously cast slab and the final product. But, in addition to the improvement of the mold powder, it is necessary to select the optimum casting condition. At present , the mold powder and the casting condition, as described above , are used as usual operations. Middle carbon steel for plate and sheet is casted at 1.7 m/min , low carbon steel at 2.0 m/min and good surface quality of continuously cast slab is obtained.

5. Reference

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