

## Granulated Exothermic Mold Powder

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### Abstract

It is necessary for mold powder to improve insulation properties in order to improve steel quality. Granulated mold powder is required to maintain a good clean working environment; however, granulated mold powder does not insulate as well as fine mold powder. Granulated exothermic mold powders with metal were developed in order to both improve insulation properties and maintain a good working environment. The new technology of adding metal material to granule mold powders provides sufficient heat to molten steel and is able to improve steel quality.

### 1. Introduction

It is important to produce defect free slabs in the continuous casting process since high quality slabs have been required for cold rolled sheets, especially for automobiles. Inclusion and pinhole defects on the cold rolled sheets are caused by deoxidation products (such as alumina), powder slag, and gas bubbles that float to the surface and become trapped under excess shell that has formed at the meniscus (called hook)<sup>(1,2)</sup> (Fig. 1). This can result in slag spots and slivers on the cold rolled coil. Ultra low carbon steel, in particular, forms the hook easily compared with low carbon and medium carbon steel<sup>(3-5)</sup>. The cause of hook formation is insufficient temperature at the meniscus. Therefore, it is important to maintain

sufficient temperature at the meniscus in order to prevent hook formation. Maintaining sufficient temperature at the meniscus can be achieved by improving the insulation properties of the mold powder providing heat at the meniscus, controlling the molten steel flow with SEN design, using electric magnetic force in the mold, and utilizing argon gas bubbling.

In general, granulated mold powder insulates less than fine mold powder since granule mold powder has more air permeable gaps than fine mold powder<sup>(6,7)</sup>. In fact, in many case, fine mold powder has been reported to have better quality on the slab surface than granulated mold powder.

On the other hand, carbon content of the mold powder for ultra low carbon steel is required to be minimized for preventing carbon pickup. Therefore the mold powder for ultra low carbon steel cannot be expected to provide sufficient heat from the exothermic carbon oxidation reaction<sup>(8)</sup>.

There already is exothermic fine mold powder containing metal instead of carbon, but the technology of adding metal was limited only to fine mold powder. However, granulated mold powder is required for cleaner working environment in spite of inferior in insulation properties. Therefore granulated exothermic mold powder, which satisfies both the working environment and insulation property requirements, has been developed. This report is a review of the use of granulated exothermic mold powder containing metal.

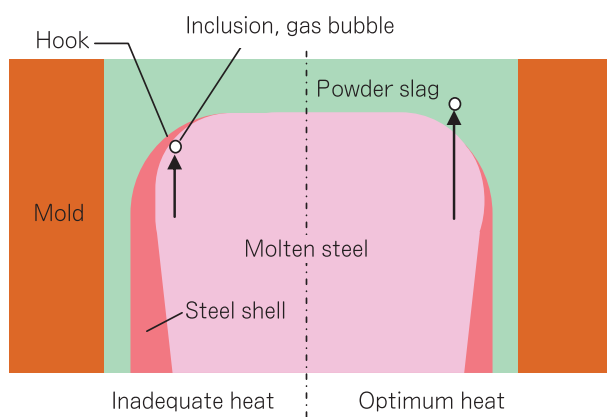


Fig. 1 Image of hook.

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## 2. Exothermic System

There are several technologies that give exothermic properties to mold powder such as carbon, organic substances, or metal. The usage of carbon is limited to the appropriate amount needed to maintain the melting speed of mold powder. In addition, mold powder for ultra low carbon steel is required to minimize the usage of carbon in order to prevent carbon pickup. Organic substance generates steam while being burned, and the steam could possibly cause hydrogen pickup by the molten steel. Metal has good exothermic properties, even in small amounts. In addition, metal will not affect melting speed, carbon pickup and hydrogen pickup.

Therefore, metal would be the optimum choice to add exothermic properties to a mold powder for ultra low carbon steel casting. However, the metal reacts with water during granulating and generates hydrogen with heat. We have successfully made granulated exothermic mold powders containing metal with a new technology that prevents the reaction between metal and water during granulation.

The selection of oxidant is very important for exothermic mold powders to maintain optimum exothermic reaction and good melting property. We developed new granulated exothermic mold powders which contain the optimum oxidant. They were designed to have the appropriate balance between the oxidant and carbon materials in order to maintain good exothermic reaction and melting property.

## 3. Experiments

For evaluating the effect of the exothermic material addition, the differential heat between the granulated mold powder with 1.5% metal addition and the granulated mold powder with no metal were measured while they were rapidly heated to 800°C. These powders were formulated to have the same chemistry after melting. The test result shown in Fig. 2 shows the granulated mold powder with 1.5% metal is able to increase the differential heat over that with no metal.

Then the granulated mold powder with added metal was poured on molten pig iron that was heated at 1500°C by a high frequency furnace in order to evaluate melting property and exothermic reaction. Fig. 3 shows the result. Both granule mold powders melted smoothly with good

melting property; however, the exothermic reaction was not visually observed. No un-reacted metal was visually observed in the powder slag after the test. A chemical analysis was also conducted on the powder slag, and it was confirmed that all metal was oxidized during the test.

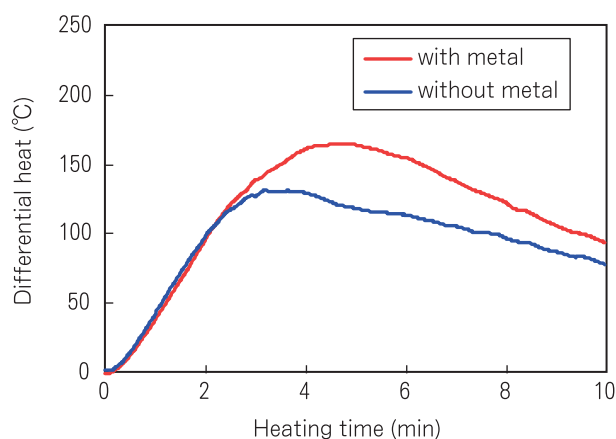


Fig. 2 Effect of metal addition on exothermic reaction.

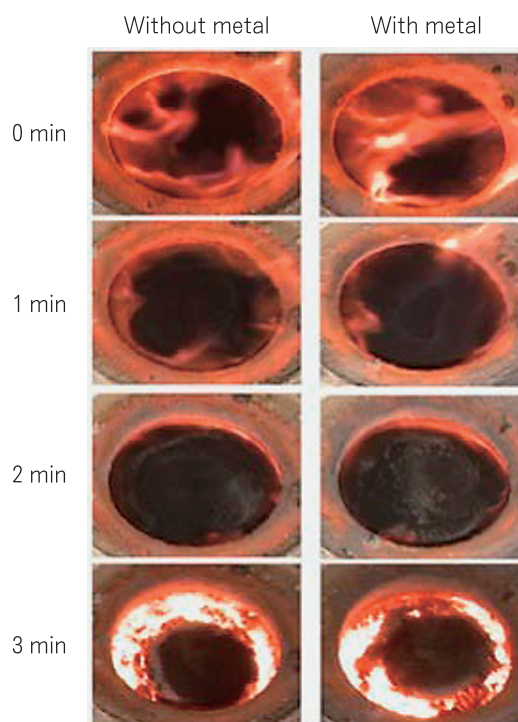


Fig. 3 Melting behavior of granulated exothermic mold powder.

4. Results of Actual Casting

The results from the use of new granulated exothermic mold powder on actual casting are shown below:

4.1 Caster A

Casting condition

- Mold : Slab
- Steel grade : Ultra low carbon steel
- Casting speed : 1.2m/min

Granulated exothermic mold powder was tested at caster A. The granulated exothermic mold powder had a good melting property without roping, maintained appropriate thickness of slag layer and had the same consumption as the conventional non-exothermic mold powder. No issue was observed during the test. Fig. 4 shows the carbon pickup and Fig. 5 shows the steel quality. The granulated exothermic mold powder provided better steel quality than conventional mold powder. The amount of carbon in the mold powder was minimized to prevent carbon pickup; therefore the conventional mold powder was not able to provide sufficient heat at the meniscus.

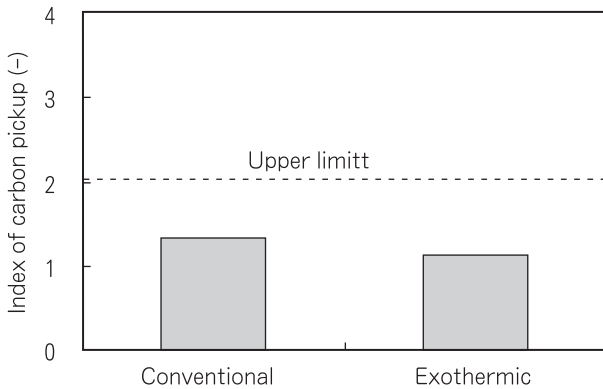


Fig. 4 Carbon pickup at Caster A.

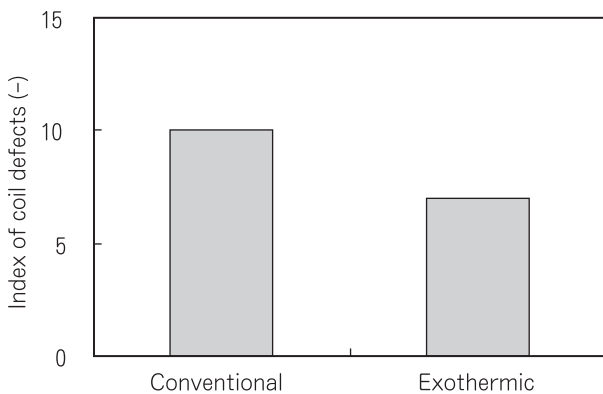


Fig. 5 Coil quality at Caster A.

The granulated exothermic mold powder provided sufficient heat at the meniscus and improved steel quality while maintaining low carbon pickup.

4.2 Caster B

Casting Condition

- Mold : Slab
- Steel grade : Silicon steel
- Casting speed : 1.0-1.4m/min

Conventional powder, which did not contain metal, had powder inclusion issue due to poor insulation. To improve the issue, granulated exothermic mold powder was tested at caster B. As shown in Fig. 6, the granulated exothermic mold powder improved steel quality. While the conventional powder also had an issue with thin slag layer, the granulated exothermic mold powder maintained appropriate thickness of slag layer.

4.3 Caster C

Casting Condition

- Mold : Slab
- Steel grade : Low carbon steel
- Casting speed : 1.2-1.4m/min

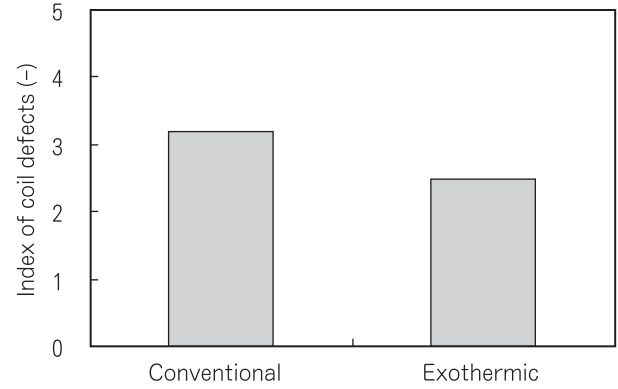


Fig. 6 Coil quality at Caster B.

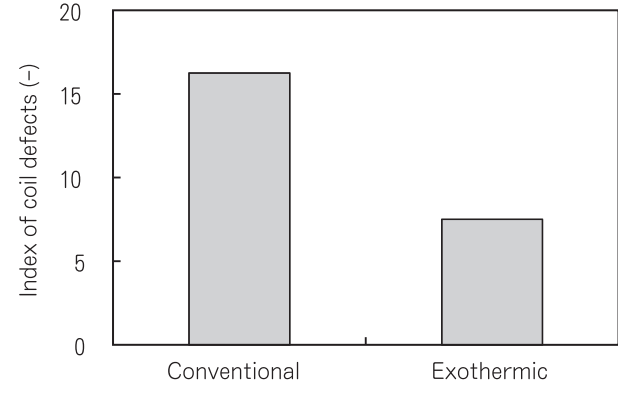


Fig. 7 Coil quality at Caster C.

Granulated exothermic mold powder was tested at caster C. The mold powder also had an increased viscosity over conventional mold powder, which did not contain metal, in order to prevent powder slag inclusion. Fig. 7 shows the coil quality. The granulated exothermic mold powder improved coil quality due to exothermicity and high viscosity.

## 5. Conclusion

Granulated exothermic mold powders containing metal have been developed in order to improve working environment and steel quality. The new powders have provided good working environment with minimal dust, had good melting properties, and improved steel quality over conventional mold powders. The newly developed granulated exothermic mold powders have been used with great success at many casters.

## References

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