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Application of the forced cooling in the mold for prevention of the occurrences of metal penetration

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Among the steel castings by using the sand mold, particularly of heavy thickness and large mass, *metal penetration* often occurs on the product surface toward the core mold. Generally, in order to prevent the occurrences of *metal penetration*, the thick coating of mold wash (known as *Surfacer*) and/or the high refractory sand has been applied in our foundry shop. But, it is not so effective as an Extra-high temperature portion, so called as *Hot Spot* where a core is surrounded by melted steel, and the occurrence has not been prevented. It takes a large amount of worktime to remove the zone of *metal penetration*, and it makes the productivity stay low.

We'd like to report herein on the prevention of *metal penetration* by using the *forced cooling* at *Hot Spot*.

Keywords: *metal penetration, Hot Spot , Forced Cooling*

1. The occurrences of *metal penetration*

We are manufacturing heavy thickness and Large mass steel castings by using the sand molds. The *metal penetration* often occurs on these large items due to the high pressure head of melted steel. Appearance of *Metal Penetration* occurred in our foundry shop is as shown in Fig.1. This Figure shows the typical *metal penetration*, melted steel Penetrating into the void between sand particles.

It takes a large amount of worktime to remove the zone of *metal penetration*, and it makes the productivity stay low. Therefore, we need a new method to prevent the occurrences of *metal penetration*.

Generally, in order to prevent the occurrence of *metal penetration*, the thick coating of mold wash (known as *Surfacer*) and/or the high refractory sand has been applied in our foundry shop. But, it is not so effective as an Extra-high temperature portion, so called as *Hot Spot* where a core is surrounded by melted steel, and the occurrence has not been prevented.

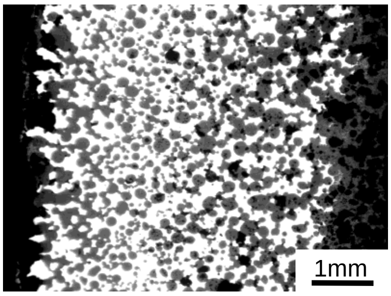

Fig.1 Appearance of *Metal Penetration* (Enlarged)
(The left side is product, The opposite side is Mold)

2. The estimated cause of the *metal penetration*

The *metal penetration* seems to occur on the *Hot spot*, therefore we focused on the strength of the casting mold. The higher the temperature of the mold arises, the extremely lower mold strength becomes, due that the resin (as binding material) will be decomposed or burned. After the pouring into the mold, mold strength becomes lower and cracks will happen on the contact surface. Then, unsolidified melted steel penetrates into the cracks.

We estimated these phenomenon causes the *metal penetration*.

3. Method of prevention of the *metal penetration*

It is supposed that the appropriate cooling will keep the molding temperature lower and it helps to maintain the mold strength. We planned the *forced cooling* method by aeration pipes set in the core mold at expected *Hot Spot*.

4. Test plan

The planned method was applied to the actual production. Aeration pipe was set in the expected *Hot Spot*. The applicable part is as shown in Fig.2. Concept of molding around the applicable part is as shown in Fig.3. As the aeration pipe, stainless steel pipe with 20(mm) of internal diameter was used. Also, 2 Thermo-couples were set to measure the mold temperature. Thermo-couple 1 is to measure the mold temperature distant from the aeration pipe, while thermos-couple 2 is closed to aeration pipe. Compressed air was used for the *forced cooling*. It is supposed to take 6(Hr.) from the end pouring to complete solidification, the planned aeration duration is 6(Hr.).

5. Result

The result of the mold temperature measurement is as shown in Fig. 5. As comparison of Curve 1 and 2, the rising rate closed to aeration pipe is slower than those distant from aeration pipe. The ultimate temperature of Curve 2 is lower than Curve 1. And, the Appearance of the applicable part after Sand Cleaning is as shown in Fig. 4. There was not any *metal penetration*. The result indicates the *forced cooling* of the mold is effective to prevent the occurrences of crack on the mold surface until the complete solidification even where direct contact with melted steel.

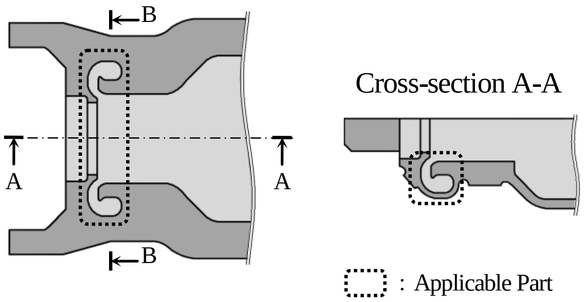

Fig.2 Applicable part of *forced cooling*

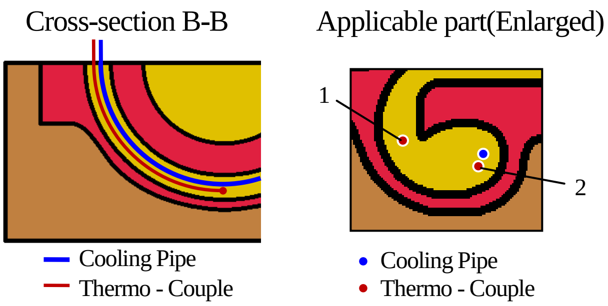

Fig.3 Concept of molding around the applicable part

Fig.4 Appearance of the applicable part after Sand Cleaning (After the shot-blast)

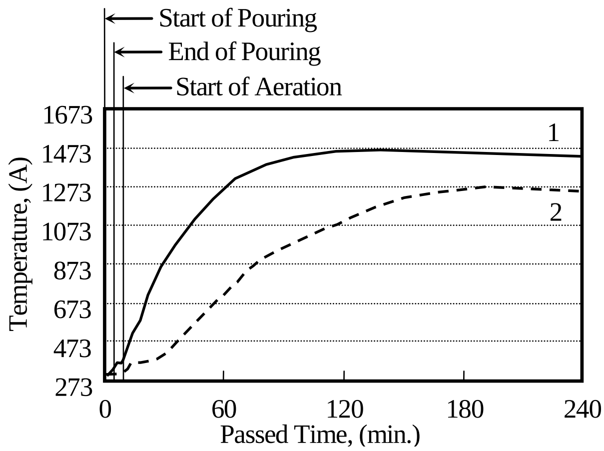

Fig.5 The result of the mold temperature measurement

6. Effect

The effect of prevention of *metal penetration* on *Hot spot* by *forced cooling* is as shown in Table1. Although the setting of aeration pipe is needed in the molding procedure, surface shaping worktime is reduced. We succeeded to improve the total productivity by prevention of the occurrences of *metal penetration* on the *Hot Spot*.

Table1 Effect of *forced cooling* application

process	Effect
Molding	Relaxation of sand grade (High refractory Sand ⇒ Normal Sand)
	Increase of core molding time (＋1.8(%))
Shaping	Reduction of the time to gouging (－95(%))
	Reduction of the time to grinding (－58(%))

7. Summary

(1) By application of *the forced cooling* in the mold the rising rate and the maximum temperature of the mold temperature could be lowered.
The *metal penetration* on the *Hot Spot* which has often occurred this discontinuity Could be prevented.

(2) As a result of the prevention of the occurrences of *metal penetration* on the *Hot Spot*, the total productivity was improved.