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NUMERICAL SIMULATION RESEARCH ON THE INFLUENCE OF STEEL INGOT OF 76 TONS AND 8 CORNERS WITH HOLLOW RISER

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The effect of a hollow riser on the upper heat dissipation of 76 tons and 8 corners ingots is studied by numerical simulation in this paper. Through the simulation of the heat transfer of the traditional riser, the 1 gap riser and the 2 gaps riser ingot, this paper draws a conclusion that the solidification time of the riser part of the riser is the longest in the 2 gaps scheme, and the solidification time of the central molten steel is 31417s, which is far higher than the other two schemes. The heat flux in the riser of the 2 gaps scheme is obviously larger than the other two schemes, which slows down the advance of the solidification front. The 2 gaps scheme is stronger than the other two schemes for reducing the cooling speed of the riser line center and the shoulder joint. It is particularly significant to reduce the cooling rate of the shoulder joints, which is more conducive to expanding the angle of the solidification front and fully filling.

Key words: steel ingot; solidification; numerical simulation; riser; gap

INTRODUCTION

Riser is an important technological measure to prevent casting defects and obtain high quality castings[1]. The effect of the riser on the casting shrinkage mainly depends on the temperature gradient in the casting direction, the temperature gradient in the direction of the riser increases, the expansion angle increases, and the opening of the riser opens, thus the casting sequence is solidified[2]. That is to say, the heat transfer characteristic of riser determines the feeding effect of castings, and then determines the quality and yield of castings to a great extent. Generally speaking, the riser heat preservation effect is good, so does the shrinkage effect[3, 4]. In this paper, hollow structure is adopted to improve the heat insulation performance of risers, and the influence of hollow structure on heat dissipation of ingot is studied.

CALCULATION MODEL ESTABLISHMENT

Geometric model and grid partition

It is simulated that solidification process of 76 ton 8 corners ingot. The schematic diagram of the geometric model is shown in Figure 1.

The model grid partition is shown in schematic Figure 2. The number of grid nodes is 94 131 and the number of tetrahedron elements is 445 733.

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The heat transfer control equation[5]:

$$\rho c\frac{\partial T}{\partial t}=\frac{\partial}{\partial x}\left(\lambda\frac{\partial T}{\partial x}\right)+\frac{\partial}{\partial y}\left(\lambda\frac{\partial T}{\partial y}\right)+\frac{\partial}{\partial z}\left(\lambda\frac{\partial T}{\partial z}\right) \quad (1)$$

Where T is temperature / °C, ρ is steel density / kg/m^3, λ is thermal conductivity / W/m/°C, c is specific heat / J/kg/K.

SIMULATION CONDITION SETTING

Chemical composition of simulated steel is shown in Table 1.

Assuming that the thermal conductivity of molten steel is isotropic, the thermo physical parameters of steel are only a function of temperature. The initial tem-

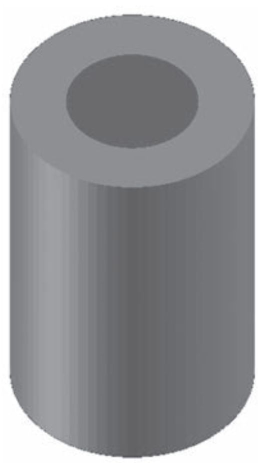

Figure 1 Schematic diagram of geometric model

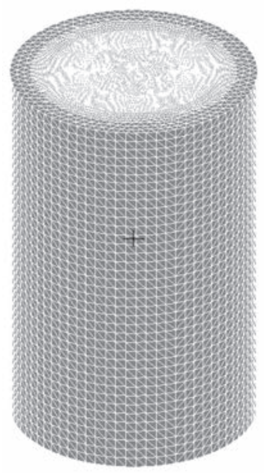

Figure 2 Schematic diagram of model grid partition

Table 1 **Chemical composition / wt. %**

C	Si	Mn	P	S
0,15	0,32	1,6	0,03	0,03

perature of molten steel is 1 560 / °C and the mold temperature is 100 / °C. The heat flow of the ingot mold surface adopts the Newton cooling formula.

$$q = h \times (Td - Tq)$$

where:

q is the heat flux on the surface of the ingot mold, / W/m^2

Td is the surface temperature of the ingot mold, / °C

Tq is ambient temperature, / °C

h is the coefficient of heat transfer, / $W/m^2/°C$

The simulation schemes are traditional riser, 1gap hollow riser and 2gaps hollow riser respectively.

SIMULATION RESULTS AND ANALYSIS

Figure 3 is the solidification time diagram of ingot section under each scheme. The results show that the solidification time of riser center is 180 345 / s for traditional riser, 24 315 / s for 1 gap riser and 31 417 / s for

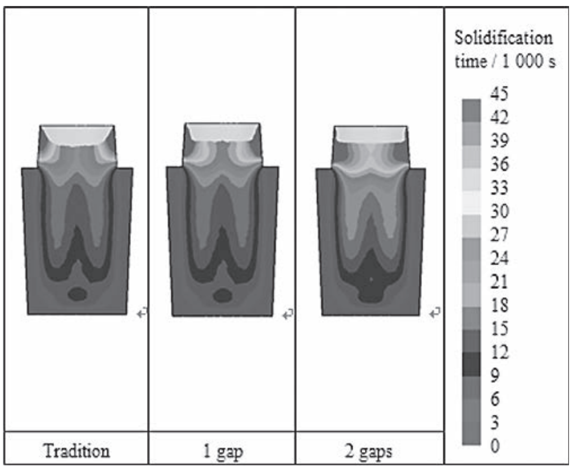

Figure 3 Solidification time of cross section of ingot under various schemes

2 gaps riser respectively. It can be seen from the diagram that the solidification time of the riser part of the 2 gaps scheme is obviously longer than that of the other two schemes. Moreover, due to the long time liquid in the riser, the solidification time of the ingot part in the lower part of the riser is also prolonged.

Figure 4 is the upper heat flow state of the ingot at the moment of 30 000 s. It can be seen from the diagram that the heat flow at the riser in the 2gaps scheme is obviously more dense, which hinders the advancing of the solidification front from the extrovert, which makes the part of the ingot body heat dissipated slowly and is beneficial to the molten steel filling.

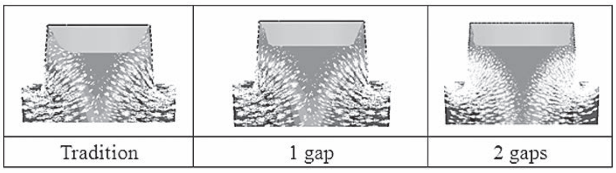

Figure 4 The heat flow in the upper part of the ingot at the time of 30 000 / s

Figure 5 is a comparison of temperature curves of riser joints of ingot section. It can be seen from the diagram that the temperature of the central node of the riser line in each scheme is slower before about 30 000 / s, and the cooling speed is approximately the same, about 0,0016 / °C/s, The cooling rate is faster in the vicinity of 30 000 / s. It is known that the 2gaps scheme has the slowest cooling rate, about 0,0102 °C/s,, 1gap about 0,0128 / °C/s, and tradition about 0,0162 °C/s,. Therefore, 2 gaps riser can delay the cooling rate of central molten steel.

Figure 6 is the temperature curve of shoulder joint of ingot riser line. It can be seen from the diagram that the temperature of the ingot mold begins to decrease obviously at the beginning of the calculation because it is

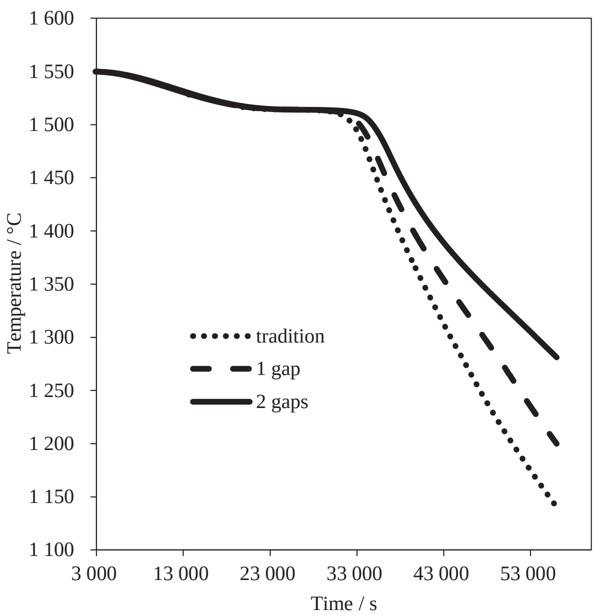

Figure 5 Temperature curve of center node of ingot riser line

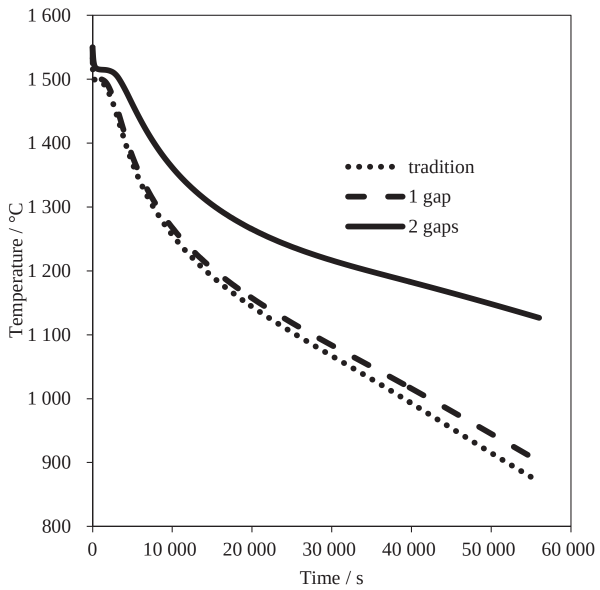

Figure 6 Comparison of temperature curves of shoulder joints of ingot riser line

close to the side wall of the ingot mold. Compared with the trend of three schemes, the cooling trend of the central node of the riser line is similar, the average cooling rate of the traditional ingot is 0,0098 / °C/s, the 1gap is 0,0093 / °C/s, and the 2 gaps is 0,0063 / °C/s,. The cooling of shoulder joints with 2 gaps is more significant than that with center joints. As the angle of the steel liquid solidification front is directly related to the cooling rate of the shoulder joints, the 2 gaps scheme is more conducive to the expansion of the angle of the solidification front and fully recharge.

CONCLUSIONS

The solidification time of riser molten steel is the longest in the 2 gaps scheme. The solidification time of central molten steel is 31 417 / s, which is much higher than the other two schemes.

The heat flux in riser of 2 gaps scheme is obviously larger than that of other two schemes, which slows down the advance of solidification front.

The 2 gaps scheme is stronger than the other two schemes for reducing the cooling speed of the riser line center and the shoulder joint. It is particularly significant to reduce the cooling rate of the shoulder joints, which is more conducive to expanding the angle of the solidification front and fully filling.

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Note: The responsible translator for English is Yan Wu, University of Science and Technology Liaoning, Anshan, China