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EFFECT OF PROCESS FACTORS ON SOLIDIFICATION PROCESS OF 10B21 STEEL BLOOM

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In this study, Finite Element Method (FEM) was used to simulate the solidification process of a large blank (280 mm × 325 mm) under different technological conditions. The influence of casting speed and superheat on solidification process of bloom was analyzed. It was found that as the casting speed increases, the solidification position of the bloom moved backward by 3,68 m, and the time required for complete solidification increased by 1 min; When the superheat gradually increased, the position of complete solidification of 10B21 steel bloom moved by about 1,5 m.

Keywords: 10B21 steel, steel bloom, temperature field, solidification, FEM

INTRODUCTION

CRS (Cold rolled steel) generally requires superb appearance and surface quality as well as stronger plasticity and flexibility in production and processing [1]. As a representative of boron bearing cold heading steel, 10B21 was mainly used to produce high strength standard parts of grade 8,8 and above with complex section shape. It has good plasticity and cold heading performance, good hardenability, and small tendency of quenching deformation and cracking. The process control of continuous casting solidification process directly affects the surface and internal quality of the bloom, due to mass, momentum and heat transfer in the solidification process of the bloom, and it can not be directly judged by measuring tools. The influence of continuous casting process parameters on solidification and heat transfer behavior of bloom shell can be analyzed by computer numerical simulation, which can provide theoretical guidance for reasonable control of actual production process parameters [2]. Thermal stress, the continuous casting process, is primarily caused by the uneven temperature field in the continuous casting slab, which is the main factor leading to internal cracks in the generous slab [3,4]. Finite element method will be used to simulate the solidification process of 10B21 steel bloom, and analyze the influence of different technological parameters on the solidification process, which provides a theoretical basis for determining the position of solidified end and formulating an appropriate soft-reduction.

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MODEL ESTABLISHMENT AND DESIGN

The selected object is the bow-type continuous caster with a cross-sectional size of 280 mm × 325 mm. 1/4 cross section was taken as the modeling area. Figure 1 shows the cross-section diagram after grid division.

The cooling process of bloom is mainly carried out at the inlet-outlet of mold, the secondary cooling zone and the straightening part in the continuous casting process. The continuous casting bloom process system and heat transfer coefficient are determined by the references [5,6] and the data is provided by the enterprise.

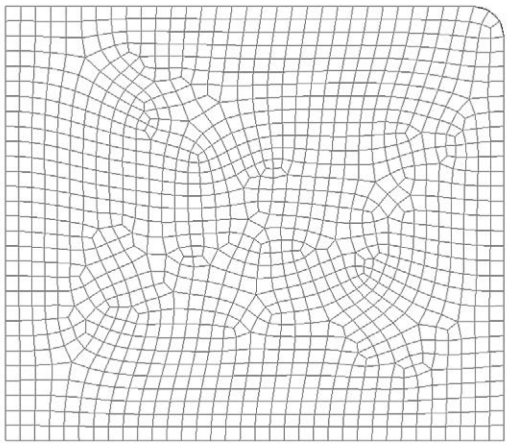

Figure 1 Schematic diagram of cross section

THERMAL PHYSICAL PROPERTY PARAMETERS

According to the field data, the cooling rate of the strand in the secondary cooling zone was usually in the range of 0,3 °C ~ 1,0 °C/s, and the cooling rate was lower in the air cooling zone.

The content of each element in steel was obtained by searching for information and input into JMatPro. In order to facilitate the simulation calculation, 1 °C/s was set as the cooling rate of the secondary cooling zone. The calculation results are shown in Figure 2. According to the simulation calculation, the solid phase temperature of 10B21 steel is 1 472 °C, and the liquidus temperature is 1 515 °C.

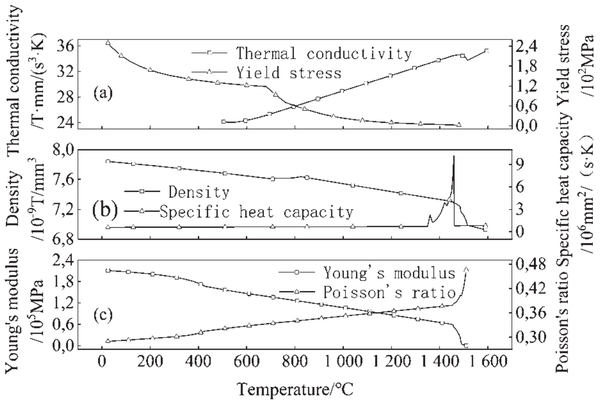

Figure 2 Thermal properties of 10B21 steel
(a) Young's modulus and Poisson's ratio distribution;
(b) Density and specific heat capacity distribution;
(c) Thermal conductivity and yield stress distribution

RESULTS AND DISCUSSION
Comparison of the existing mode

Influence of casting speed on solidification process of bloom

The thermo-mechanical coupling module in ABAQUS software was used to simulate the temperature field of bloom.

Under the condition of superheat of 25 °C, the heat transfer coefficient was obtained by reference [7]. Moreover, the effect of casting speed on the solidification process of bloom was investigated with other un-

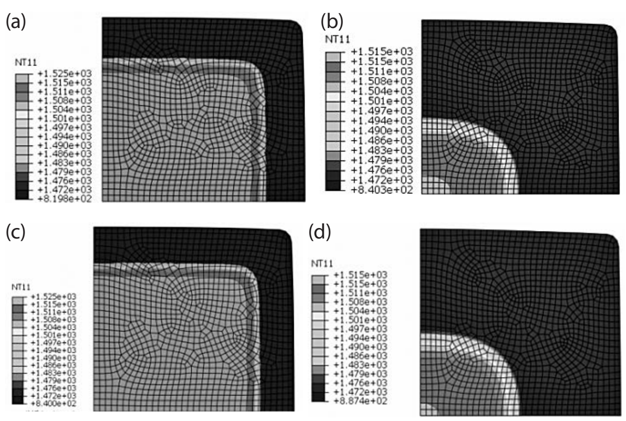

Figure 3 Interval distribution of two-phase region
(a) Exit of crystallizer, 0,6 m/min; (b) Liquid terminal, 0,6 m/min;(c) Mould outlet, 0,76 m/min; (d) Liquid terminal, 0,76 m/min

Table 1 **Influence of different casting speed on 10B21 steel bloom**

Casting speed / m/min	0,6	0,76
Thickness of bloom shell at exit of mould / mm	29	26,5
Distance between liquid end and crystallizer liquid level / m	5,35	6,99
Time required for complete solidification / s	1 075	1 139
Complete solidification distance from crystallizer interface / m	10,75	14,43

transformed parameters. Figure 3 shows the distribution of two phases in solidification process, and Table 1 shows the influence of different casting speed on the bloom.

Typically, the position of the solidification end is about 10,75 m when the casting speed is 0,6 m/min and the position of the solidification end is about 14,43 m when the casting speed is 0,76 m/min, the solidification end moves back 3,68 m. The time required for complete solidification of bloom increases by 1 min.

Influence of superheat on solidification process

Considering the influence of superheat on the solidification process, the casting speed of 0,76 m/min was adopted and other parameters were unchanged to simulate the influence of superheat of molten steel at 15 °C, 25 °C and 50 °C on the solidification process of the bloom shell, as shown in Figure 4.

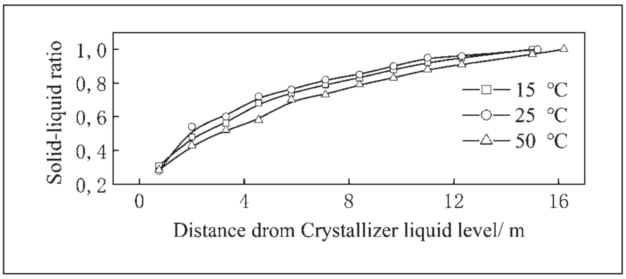

Figure 4 Influence of superheat on Solid-liquid ratio

According to the simulation calculation, the time required for complete solidification of continuous casting billet is 19,3 min, 20,0 min and 21,2 min when the superheat is 15 °C, 25 °C and 50 °C. The time required for solidification increases with the increase of superheat, and the position of complete solidification of the bloom moves backward. The position of complete solidification of bloom is 14,7 m away from the mould liquid when the superheat is 15 °C; Similarly, the position of complete solidification of bloom is 15,2 m away from the mould liquid when the superheat is 25 °C and the position of complete solidification of bloom is 16,2 m away from the mould liquid when the superheat is 50 °C. In addition, when the superheat increased from 15 °C to 50 °C, the temperature of each part of the bloom transformed little, the time required for complete solidification of the bloom increased.

CONCLUSION

This work is based on 280 mm × 325 mm generous billet of 10B21 steel and takes 1/4 cross section as the modeling area, in which a relatively accurate temperature field model is obtained through reverse calculation. The main conclusions are as follows:

(1) When the casting speed increases from 0,6 m/min to 0,76 m/min, the solidification end moves back 3,68 m, the time required for complete solidification of bloom increases by 1min.

(2) The position of complete solidification of the bloom was shifted backward by 1,5 m, the time required for complete solidification of bloom is increased by 1,9 min when the superheat increases from 15 °C to 50 °C.

(3) The casting speed has an important influence on the thickness of solidified bloom shell. The change of the casting speed affect the position of the soft reduction. If the position of the soft reduction deviates from the appropriate area, it may cause internal cracks and cannot reduce the segregation of the bloom.

Acknowledgments

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Note: Dong Xu is the responsible translator and the corresponding author, Handan, Hebei, China.