The Related Characteristics of Square Billet Continuous Casting Mold Electromagnetic Stirring

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Abstract. With the rapid development of electromagnetic stirring continuous casting process, In order to get high quality casting, it is necessary to understand the characteristics of molten steel in mould, The flow of liquid steel in mold internal affects the casting out of the mold of the solidified shell uniformity degree, At the same time, the flow of liquid steel in mold inside also affects the distribution of temperature. Reasonable flow field distribution of bubbles in liquid steel and nonmetal inclusion floatation, and thus prevent slag, The phenomena of reasonable temperature distribution, and can reduce the degree of superheat of molten steel is too high, is advantageous to the slab equiaxed grain increment, Can get high quality casting. Therefore understanding of liquid steel in mold electromagnetic stirring in the feature, it is very necessary.

Keywords: Mold electromagnetic stirring; molten steel flow characteristic; Temperature distribution characteristics of the molten steel; the numerical simulation.

1. Introduction

In recent years, Due to the increasing of steel production in Chinese year by year, it has become a big iron and steel industry in the world. But compared with foreign advanced iron and steel industry, the iron and steel products in chinese is single, Compare with other country our technical was lack of innovation in the iron and steel industry, So we still need the high quality steel imported from abroad. Continuous casting practice shows that using electromagnetic stirring process, can expand and improve the quality of casting billet continuous casting process conditions. Such as, It can reducing the surface and subcutaneous quality, reduce the center shrinkage cavity and improve equiaxial crystal, etc. So the electromagnetic stirring has become an important technical means for continuous casting [1-5].

2. Under the action of mold electromagnetic stirring flow characteristics of liquid steel inside

As we all know, the flow characteristics of liquid steel in the mold had a significant impact of the metallurgical quality. In conventional continuous casting conditions without the electromagnetic stirring, The characteristics of the flow of molten steel in mould is roughly: molten steel continuously from the submerged nozzle (SEN) flow, At the same time ,it could be flow down to the depths of the liquid core, When the molten steel exposure to the crystallizer wall, it can made the molten steel upward reflux in the crystallizer, But due to the flow of molten steel in mould continuity, it just be formed a single annular flow. However the liquid steel in mold electromagnetic stirring by M - EMS, the flow of the molten steel presents three regions: the upward circulation area, the down circulation area and the mainstream area, Such as be shown in Figure One (a). For example, we can used the length of the round billet 2000 mm and the diameter of the round billet Φ300mm, With the precise calculate of the flow field, shown in Figure One (b) can be obtained the conclusion. So can deduce the principle of molten steel flow as follows: When in the mold electromagnetic stirring with M - EMS, We can know the action of liquid steel in the main role by two electromagnetic force, the tangential electromagnetic force and the radial electromagnetic force. The tangential electromagnetic force

made the molten steel in mold inside to rotary motion, while the radial electromagnetic force made the molten steel flow from the center to the outer wall in the crystallizer.

The mainstream area is mainly by the tangential electromagnetic force and make the mould molten steel within the rotary motion, It changed the direction of the molten steel from the submerged nozzle flow down, It sames as that the molten steel have originally vertical downward flow change to rotate, With this it can cause the favorable effects, Firstly, due to the effect of shear force on the front edge of solidified shell, and it prompt the adsorption on it bubbles and inclusions were cleaning out the steel billet, Eventually to improve the quality of the billet; Secondly, As a result of the solidification front cleaning, it prompted the shell growth uniformity; Thirdly, with the presence of shear force on the front edge of solidified shell, the presence made the dendrite tip broken and increase of equiaxed grain; The Lastly, due to the rotation of the molten steel in mould movement, the centrifugal force could be produced, with this it encouraged the bubbles and inclusions in molten steel to center gathered and buoyancy.

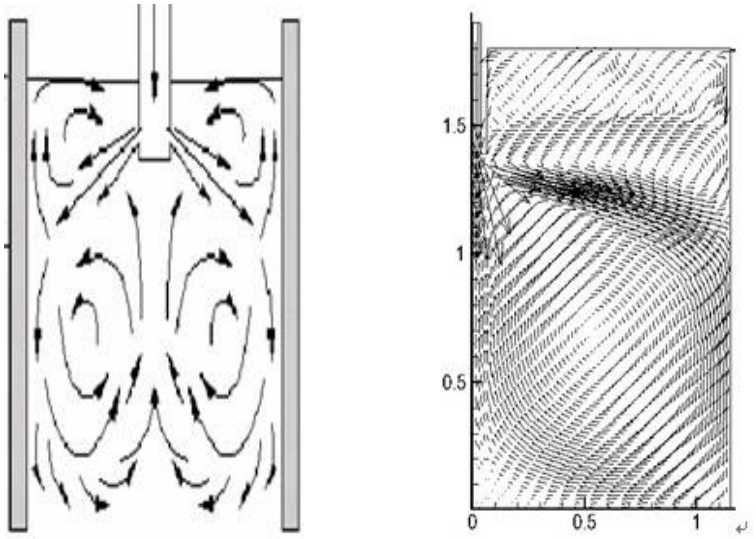

Fig.1 (a) under the effect of the M - EMS steel flow characteristics (b) in the molten steel flow field in under the action of the M – EMS

The upward circulation area is mainly formation on the tangential electromagnetic force and the radial electromagnetic force, the center of liquid steel in the continuous flow to outside and when it contact the solidification molten steel surface, With this , it gradually formed the molten steel by solidification oriented but circulation center downward, The upward circulation area was the major role to the liquid level fluctuation, Firstly, It can improved the hotspot location inside the crystallizer and prompted the meniscus near the temperature, for these matters, It had greatly strengthened the protection the lubrication effect and absorption of bubbles and slag inclusions; Secondly, It could reduce the degree of superheat by this way and slow down the speed of liquid steel solidification; Then Compared to the conventional continuous casting, it made the initial freezing point position down and reduce the influence of vibration marks, And finally the upward circulation area can improved and enhanced the surface quality of slab.

The down circulation area is mainly formation the tangential electromagnetic force and the radial electromagnetic force make molten steel flow from center to the outside, Then it gradually formed the molten steel from the center of the solidification under oriented upward circulation, For its effect that it prompt crystallizer internal molten steel temperature distribution more uniform, So that the core temperature gradient decreases and higher temperature gradient on the front edge of solidified shell, It is much better promote the molten steel temperature to heat transfer; Most importantly, It can reduce the superheat of molten steel further, The final result than can improve the quality of the casting.

In the crystallizer in the circulation area of the liquid steel will directly affects the liquid level fluctuation of molten steel and shape. In the upward circulation area, the stronger impact strength may more likely to cause crystallizer internal happen floating slag and slag phenomenon, eventually it is resulting in the molten steel flow in secondary bare. In the down circulation area mainly is closely

related with the crack of slab surface, When impact strength the deeper in the down circulation area, the inclusion floatation more difficult, For this reason, it made presence of inclusions in molten steel not clean and reduce its cleanliness.

3. Mold electromagnetic stirring under the action of molten steel temperature distribution inside the crystallizer

Molten steel inside the mould, With the condition of the conventional continuous casting, the liquid steel temperature distribution within the roughly single hump shape, it is a complex heat exchange process, When the superheat of molten steel from the submerged nozzle pours out, down and intrusion into the depths of the liquid core, The liquid steel superheat will slowly disappeared, And in the section of casting, Compare with the casting, core temperature was the highest and the outermost shell temperature was lowest depend on the casting, Through careful observation we can found that presented single hump shape . Such as shown in Figure Two, We can understand the presence of electromagnetic stirring crystallizer center of axial velocity and temperature distribution along the axial direction.

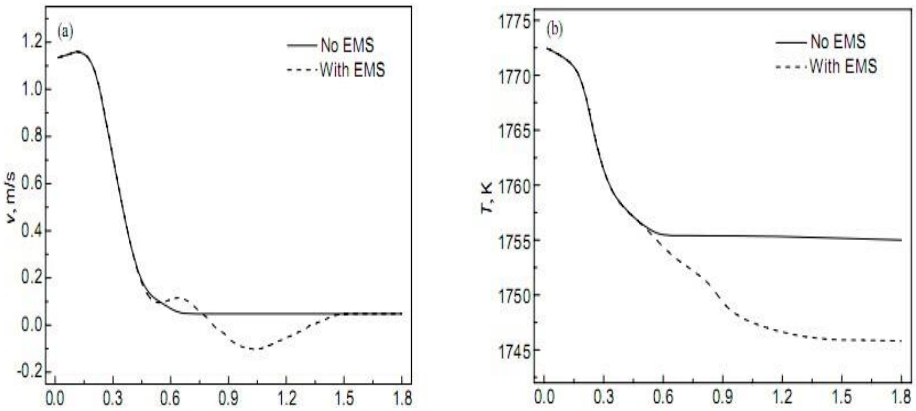

Fig.2 Electromagnetic stirring is or is not adopt that the crystallizer center axial velocity and temperature distribution along the axial direction

Compare to the conventional continuous we can know the crystallizer internal flow characteristics of steel by M - EMS, for this reason, the action of the molten steel temperature distribution will also change. Primarily, the higher degree of superheat of molten steel most of these will be stranded in the upward circulation area and the main area, Just for that will prompted the hotspot location raised, It will made the nearly meniscus of molten steel temperature will also increase, that would be about 5 ℃ to 10 ℃. Then with the action of mold electromagnetic stirring, We can know that the temperature of casting core will decrease sharply and the front edge of solidified shell will falling, For this change can be called peak "cut" of the image, Through used the action of the M - EMS, it could spur on the casting section temperature distribution can be relatively flat and made the molten steel can be more slow cooling. At the last, it can improve the molten steel solidification front with heat exchange and can be beneficial to eliminate the remaining overheating by this way.

Dissipation of electromagnetic stirring of molten steel overheating effect has been proved by theory and experiments. For example, Figure Three vividly expressed the M – EMS whether to be used that superheated liquid steel liquid phase area (L), the mushy zone (M) and the relationship between the solid phase areas (S). By Figure Three shows that without stirring condition is advantageous to the dendrite growth, it leads to the formation of a dendrite bypass and small ingot solidification organization. While with the effect of the M - EMS, we can know that the equiaxed gain will be risen. This is due to a stirring motion improved to the surface of the heat transfer from the casting center and accelerate the dissipation of the molten steel overheating. Only in the heat dissipation and cooled to between the liquid us and solidus temperature, that the isometric can exist in liquid core and coexist with the liquid phase. For this reason that could be avoided small ingot structure and segregation and other issues.

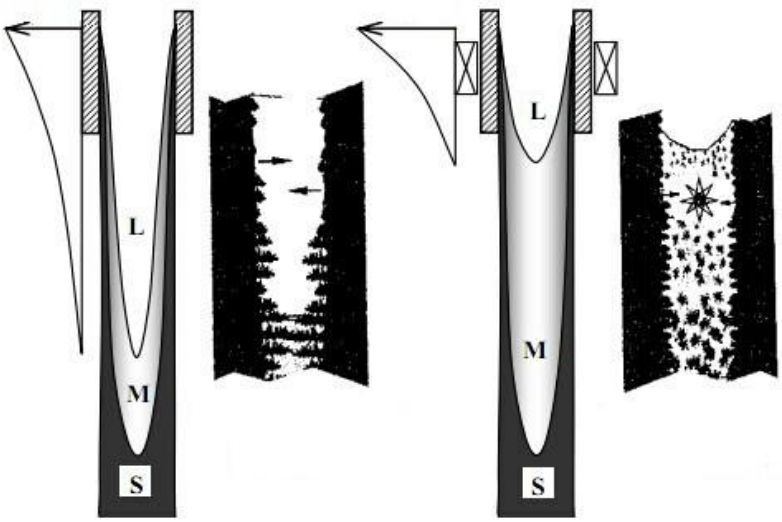

Fig.3 whether the action of the M - EMS cooling effect diagram

4. Conclusion

Primarily, with the condition of the conventional continuous casting that the molten steel will present a single circulation, while in the role of the M - EMS, it will consist of three circulation: the circulation, the circulation and the main circulation.

Secondly, Compare with the conventional continuous casting we can the temperature of molten steel distribution mainly presents the "single hump shape", While with the effect of the M - EMS, We can vividly described the temperature change as peak "cut", as soon as the section on the temperature gradually tend to be flat.

Most importantly, we should skilled master the molten steel in mould flow field and temperature field, for this it can reasonable to control the liquid level of slag is revealed and improve the quality of casting billet.

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