Temperature Holding Hood for Hot Charging of Continuous Casting Slab in Tangshan Iron and Steel Company

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Abstract: To improve the charging of high-temperature billets, it is crucial to produce them with zero defects and achieve effective insulation during their hot delivery. A mathematical model was developed based on the heat transfer characteristics of the billet during its hot delivery. The accuracy of the model was established by studying the thermal performance of the cover of the roller conveyer for small billets in Tangshan Iron and Steel Company. The results show that the cover of the roller conveyer of the continuous casting billet can effectively reduce the heat loss during the hot delivery of the billets, and the hot loading temperature was increased by 51.6 °C. The uniformity of the temperature of the casting billet section increased substantially. The temperature difference in the casting billet section was reduced by 120 °C. The heat preservation effects of temperature holding hoods of different materials were compared. It was found that the material of the temperature holding hood has slight effect on the heat preservation.

Key words: billet; hot charging; temperature holding hood; temperature; energy saving

With the development of hot delivery and hot charging techniques, the continuous high temperature charging of casting slab become one of the main features of hot charging technology[1-3]. To improve continuous casting slab temperature, the waste heat of the casting slab must be further utilized by hot charging technology. The slab is directly rolled after heating in a steel rolling mill to reduce energy consumption and burning and to increase productivity and rolling yield[4]. Therefore, in order to obtain the highest possible charging temperature of the continuous casting slab in hot charging process, the heat transfer during the hot delivery of slab must be strictly controlled. With the rapid development of computer technology, numerical methods are widely applied in studying the solidification heat transfer of a casting slab[5, 6]. This study is based on the numerical simulation of actual production, and the main factors affecting the hot charging temperature of casting slab in the second steel rolling plant of Tangshan Iron and Steel Company are analyzed. The study was carried out by simulating the billet heat transfer under different hot delivery conditions with the large-scale analysis software ANSYS[7]. The heat preservation effect by the cover of the roller conveyer for casting slab was studied to guide the actual production.

1 Production Situations

1.1 Process status

The continuous casting slab hot charging process has been achieved in one of the bar production lines of the second steel rolling plant of Tangshan Iron and Steel Company. The mode of continuous casting-direct hot charging rolling (CC-DHCR) is used[8, 9]. The high temperature casting slab without defects is transported to the heating furnace in the rolling production line by a high-speed transport track, and its rolling is carried out according to a production plan. The status of hot charging process (in 2012) in the second steel rolling plant of Tangshan Iron and Steel Company is shown in Table 1. The average hot charging temperature of casting slab in one bar production line is 728.4 °C, and the hot charging rate is 80.7%.

The hot charging temperature of casting slab in similar steel plants is usually in the range of 600–800 °C[10]. Therefore, there is scope for improvement in the hot charging temperature of the casting slab.

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Table 1 One bar billet hot delivery and hot charging conditions

Caster seat	Transport direction	Billet temperature/°C	Hot charging temperature/°C	Hot charging rate/%
No. 6 machine	One bar	941.7	728.4	80.7

1.2 Influencing factors of hot charging temperature of the billet

In recent years, the research and application of the billet hot charging technology is under vigorous development at Tangshan Iron and Steel Company. To save energy and reduce the costs, back in 2007, the second steel rolling plant of this company transformed the continuous casting and hot charging production line of one bar according to the circumstances. The billet transportation with thermal efficiency was achieved by using conveyor rail technology and rapid transmit technology, etc[11]. However, the distance of caster of one bar from the furnace (240 m) causes slower heating of the billet after entering the furnace. In the case of transportation track without any insulation measures, the drop in billet surface temperature is 200 °C, and the rate of temperature drop is about 19 °C/min (Table 2). Therefore, the billet temperature drop between the CCM and furnace is a major factor influencing the temperature of the billet after entering the furnace.

Table 2 One bar billet temperature drop in transportation process

Position	Surface temperature/°C
Slabs out of CCM	890
Entrance of furnace	690
Temperature drop	200

To improve the hot charging technology in general and to further increase the temperature of billet after entering the furnace, the second steel rolling plant of Tangshan Iron and Steel Company needs to minimize the billet temperature drop during the hot delivery. Therefore, it is worth studying the solutions offered by the heat preservation covers of the transportation track.

2 Process Analysis of the Cover of the Roller Conveyer

2.1 Heat transfer model during hot delivery

(1) Model building

To simplify the physical model, the following assumptions are made[12]:

(a) The impact of track on the lower surface of billet is not considered;

(b) The length of billet is considered as greater than its width and thickness to make the heat transfer in billet as two-dimensional heat conduction problem;

(c) The thermo physical parameters of temperature-maintaining equipment are assumed constant.

The heat conduction differential equation and the initial and boundary conditions for the billet are as follows[13]:

$$\rho_{\mathrm{cp}} = \frac{\partial t}{\partial \tau} = \frac{\partial}{\partial x}(\lambda \frac{\partial t}{\partial x}) + \frac{\partial}{\partial y}(\lambda \frac{\partial t}{\partial y}) \tag{1}$$

Initial condition: τ=0, after cutting the billet:

$$t(x, y) = t_0(x, y) \tag{2}$$

Boundary conditions:

$$\lambda \frac{\partial t}{\partial x}\bigg|_{x=0,a} = -q_x;\ \lambda \frac{\partial t}{\partial y}\bigg|_{y=0,a} = -q_y.$$

The heat transfer fluxes, q_x and q_y change over the boundary conditions and are analyzed as follows:

(a) The boundary conditions for the heat transfer differential equation without heat preservation covers:

The continuous casting slabs cool naturally if heat preservation covers are not provided on the hot delivery track. The main factors affecting the billet temperature are thermal radiation and heat convection. For different surfaces, the convection coefficients are assumed equal. The specific boundary condition is [14]:

$$-\lambda \frac{\partial t}{\partial y} = \varepsilon\sigma_0(T^4 - T_{\mathrm{a}}^4) + h(t - t_{\mathrm{a}}) \tag{3}$$

where t_{a} and T_{a} are the ambient temperature and absolute ambient temperature, respectively; t and T are the temperature of billet and absolute temperature of billet, respectively; h is the heat transfer coefficient of natural convection for surface; ε is the density of billet; and σ_0 is the Stefan Boltzmann constant.

(b) The heat boundary conditions with heat preservation covers:

Billets transfer heat to the inside surface of the heat preservation covers on the hot delivery track by radiation and convection. Then, the heat is transferred to the surrounding medium by the external surface of