PLASMA TUNDISH HEATING IN CONTINUOUS CASTING

XIA Weidong, WAN Shude, ZHAO Liangji, WANG Hai, WANG Wenhao
WANG Congrong, YANG Weihong, WANG Nianchun

(University of Science and Technology of China, Hefei, Anhui 230027 China)

ABSTRACT: A plasma heating system installed in Second Steel Plant of Maanshan Iron & Steel Co. is used for controlling the steel liquid temperature in tundish in continuous casting procession. Plasma gas is argon. Plasma torch with water cooling is of one megawatts' power. The thermal cathode of the torch is made of alloy of W-Ce. The lifetime of cathodes is 30~60 hours. The heating efficiency is about 70%. This paper is the introduction of some technical features of our plasma heating system.

I. INTRODUCTION

In continuous casting operation, the temperature control of molten steel in the tundish is very important. It is proved effective to improve the steel qualities, increase the steel output, decrease the iron loss, prolong the lifetime of furnace, ladle and tundish.

Compared with methods of oxygen jet, alumino-thermic process, graphite electrode arc and induction heating, plasma heating possesses following advantages: heating atmosphere selectable, [C], [N], [O] not rising, non-pollution, arranged easily, heating efficiency high, and heating power controllable. So the plasma heating system with water cooling plasma torch is one of the best choice to achieve the temperature control.

Below is the general introduction of our plasma heating system installed in Second Steel Plant of Maanshan Iron & Steel Co.: The caster is 4 strands billet. Capacity of tundish is 14 tons. Mass flow rate is 1.3 t/min. Plasma torch is thermal cathode with argon used as plasma gas. The range of heating power is 50kW~1000kW. The consumption of argon is 3.6~9 SNm^3/h when the current is 5000A. Under these conditions, the heating efficiency is about 70%.

II. PLASMA TORCH

2-1. Main features of plasma torch

It is a thermal cathode torch. Plasma gas is argon. The cathode is made of alloy of W-Ce that is nonradioactive. The length of nozzle of torch is 300mm and the nozzle can be assembled and disassembled easily. Cooling water passes in and out of the torch through a pair of pipes. The refractory coat on outside surface of torch can decrease the heat loss efficiently.

2-2. W-Ce Cathodes

The cathodes of high-power plasma torches are mostly made of W-Th alloy. It is known that thorium is of radioactivity. To avoid its damage to human body, we use cerium as a replacement of Th. After tested its ability of loading current and lifetime, cathode of W-Ce satisfied the practical objection.

The density of electrodes is 17.8g/cm^3 without being forged. For this high density, the electrode has good thermal conductivity and electric conductivity. The cathode can keep operating for 30~60 hours under the current of 5000A. If the cathodes are forged hot, the density of cathodes will be higher and then current loading and the lifetime of cathodes will increase.

The cathodes are cone-shape whose maximal diameter is 25 mm and length is 25 mm. After operating for some time the cathode tip will be melted and become spherical because of surface tension and gravity force.

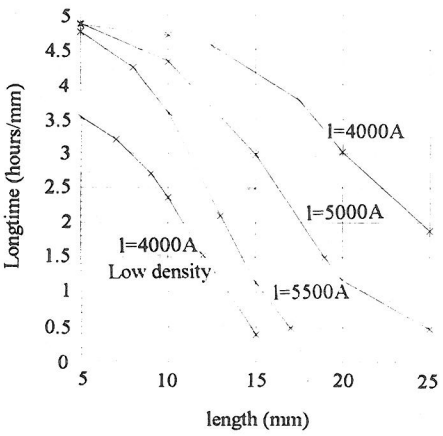

Fig.1 Tests of cathodes' exhaustion

The results of testing the exhaustion of cathodes are shown on Fig.1. It shows the relationship between cathodes' length, current and lifetime. The exhaustion of cathodes becomes faster as the cathodes' length or the loading current increases. When the loading current is more than 5500A, the consumption of cathodes increases rapidly. When the cathodes' length is longer than 25 mm, cathodes' exhaustion increases apparently. Longer cathodes lengthen the path of conducting thermal from arc foot of cathodes' tip to the end of water cooled. So increasing cathodes' length is not very effective to prolong the lifetime of the cathodes. Numerical simulation agrees with the results of tests. When the length of cathodes is more than 25mm and current more than 5500A, temperature of the tip of cathodes will rise to evaporating point.

Fig.2 is a photograph of molten hollow of a cathode in which tungsten liquid is removed from the melting area., The size of hollow of molten area is of 8~12mm diameter and 3~5mm depth, with 5000A operating current. The result of experiment agrees with the numerical simulation. The large size of melting area shows the surface tension of molten tungsten is very high.

Fig.2 Photo of Cathode

2-3. Refractory coat

It was found that heat loss of torch is mostly resulted from heat being transferred to cooling water of nozzle and outer tube of torch. This loss is 70~95% of the total heat loss of torch. It depends on the insert length of torch into tundish and operating

current. The outer tube is wrapped with thick oxide alumina refractory and anode is sprayed coat by oxide alumina. With refractory coat, the heat efficiency will rise 7%.

III. THE EFFECT OF TECHNOLOGY CONDITION

3-1. The Effect of Tundish Cover on Heating Efficiency

Without tundish cover , heating efficiency will be decreased about 30% for the increased loss of radiation and convection. With tundish cover, arc radiation will heat the inner cover to 1750~1800°C. Then the cover radiates plenty of heat to the molten steel. Also, the tundish cover decreases the loss of radiation of molten steel. With tundish sealed cover, the loss of thermal convection with air decreases above 90%.

3-2. The Effect of Sealed Tundish Cover on V-I Characteristics of Arc

With tundish sealed cover, the drop of air convection makes argon density and atmosphere temperature in tundish increase. As the result, arc voltage is lower and arc power decreases. It is shown as Fig. 3. To increase heat power, it is required to increase density of air and nitrogen in tundish. The cover that seals not well is useful for increasing arc voltage. But it will cause [N] or (and) [O] in steel liquid to rise a little.

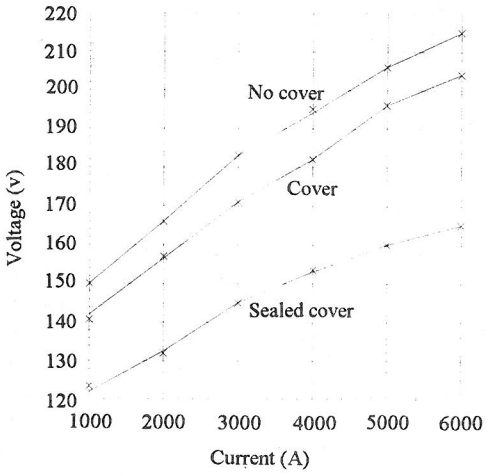

Fig.3

3-3. The Effect of Thick Slag on Plasma Torch and Heating Efficiency

The speed of plasma jet is not very high, it can not blow away the molten slag of thickness more than 30~50mm which cover the steel liquid surface. The splashed slag can damage the cathode tip, anode and may lead to extinction of arc. Also, the crust of slag has a high resistance which increases the voltage drop of circuit, so high power electric source is required. The slag prevents the arc plasma to radiate and convect to molten steel that decreases the heating efficiency about 20~30%. The surface of steel without slag is of most advantage.

REFERENCES

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