COATED CASTING NOZZLES

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14 Claims

ABSTRACT OF THE DISCLOSURE

A vitreous molten metal supply device formed of a refractory oxide material, such as a fused silica continuous casting nozzle, having on the surface thereof a thin metal coating of a thickness ranging between 0.002 and 0.02 inch selected from the group consisting of tungsten, molibdenum, niobium and tantalum, which protects the vitreous oxide material against attack by a molten casting slag having a high solubility for oxides. The thin coating of metal is preferably applied by a plasma spray process in order to avoid devitrifying the fused silica nozzle.

The present invention relates generally to an apparatus for the continuous casting of molten metal and more particularly to an improved tubular supply device for introducing molten steel into a continuous casting mold.

In the continuous casting of a molten metal, such as steel, it has been found that improved casting results can be achieved by introducing the molten metal below the surface of the pool of metal maintained in the upper end of the mold. Various tubular devices have been designed for conveying and discharging molten metal into a continuous casting mold, such as the improved casting nozzle structures of the Mills et al. U.S. Pat. No. 3,517,726. Most of the supply nozzles used for conducting molten steel into a continuous casting mold below the surface of the pool of metal therein are made of fused silica.

It has also been found that further improvements in casting results are obtained by providing on the surface of the molten metal pool maintained in the upper end of the continuous casting mold a protective layer of slag. It is important that the slag layer, in addition to reducing heat losses and oxidation at the surface of the molten metal, also readily dissolves oxides, such as alumina, which are rejected by the molten metal and form a scum on the surface of the pool of molten metal in the mold. Many different compositions have been used to form the slag layer, including borax, sodium silicate, blast furnace slag, window glass, bottle glass and other improved synthetic slags. An example of an improved continuous casting synthetic slag composition which readily dissolves alumina is found in the Halley et al. U.S. application Ser. No. 52,750, filed July 6, 1970, now Pat. No. 3,647,249.

Certain of the continuous casting slag compositions, particularly those which have a high solubility for alumina, also rapidly attack refractory oxide nozzles, such as the fused silica nozzles. In many cases the wall of the nozzle is eaten away or completely dissolved at the slag line within the mold during the casting operation with the result that the quality of the remainder of the casting is poor.

It is, therefore, an object of the present invention to provide a molten metal supply device for the continuous casting of metal which is resistant to attack by slags having a high solubility for oxides.

It is a further object of the present invention to provide a metal coated fused silica supply device for conveying molten metal into a continuous casting mold which is highly resistant to attack by a continuous casting slag having a high solubility for silica.

It is still another object of the present invention to provide an improved method of increasing the resistance of a fused silica molten metal supply device to attack by a continuous casting slag having a high solubility for silica.

Other objects of the present invention will be apparent from the detailed description and claims to follow.

It has been found that a molten metal supply device made of a refractory oxide, such as a fused silica nozzle, can be provided with increased resistance to attack from a continuous casting molten slag composition which has a high solubility for alumina (i.e., at least 20% by wt.), silica, and the like refractory oxides and which normally rapidly attacks a fused silica nozzle by applying to the nozzle on at least the surfaces thereof which come in contact with the molten slag layer in the mold an adherent surface coating or film of a metal having a low vapor pressure at steel casting temperatures (i.e., up to 3100°F.), a melting point above 3600°F., a low rate of solution in molten steel, and a very low solubility in the continuous casting composition. Materials having the foregoing properties and which can be used in the present invention include tungsten, molibdenum, niobium and tantalum.

It has been found that the best results are obtained when a relatively thin coating of the metal is applied having a thickness ranging between about 0.002 and 0.020 inch. When the metal coating is substantially below 0.002 inch thick significantly less protection is provided and when the metal has a thickness substantially greater than 0.020 inch, there is a tendency for the coating to spall from the surface of the refractory oxide.

It has also been found that when coating a fused refractory oxide nozzle, particularly a fused silica nozzle which has a vitreous internal structure, the nozzle should not be allowed to heat to a temperature which results in devitrifying the nozzle, since a devitrified nozzle will shatter under normal operating conditions during the continuous casting of molten steel.

When coating a fused silica continuous casting nozzle or the like vitreous structure with a surface coating of tungsten, molibdenum, niobium or tantalum where it is essential that the vitreous structure not be heated to the devitrification temperature thereof, and where the melting points of each of the coating metals to be applied to the vitreous structure is substantially above the devitrification temperature of the structures, the coatings can not be applied by the usual process of dipping in a bath of the molten metal. It has been found, however, that a strong and tenacious coating of any of the coating metals of the present invention can be applied to a fused silica nozzle or like vitreous structure without raising the temperature thereof to its devitrification temperature by means of a plasma spraying, vacuum vapor deposition, or sputtering process. The plasma spraying process is particularly suited for coating the vitreous structures of the present invention, because plasma spraying does not require vacuum operating conditions and provides very high temperatures in the arc for melting the metal while permitting independent control of the surrounding atmosphere so that independent control of the molten metal particles formed can be minimized.

In the plasma spraying process which is the preferred method of applying the metal coatings in the present invention the metal, as wire or powder, is melted in an inert atmosphere, such as argon, by a non-transferred plasma arc and propelled to the surface of a vitreous structure, such as a fused silica continuous casting nozzle, by the force of the plasma jet. The droplets of molten metal upon striking the surface of the fused silica having a multiplicity of microscopic surface pores flatten out and anchor in the surface irregularities of the pores to form a continuously adherent surface coating and provides a base
for building up additional layers of the droplets during the plasma spraying process.

When a coating of molybdenum, for example, having a thickness of 0.010 inch is applied to the outer surface of a fused silica continuous casting nozzle in accordance with the above described preferred process, the coating adheres firmly to the fused silica surface when the nozzle is maintained in contact with a molten slag having a high solubility for oxides during the continuous casting of steel and while the coating is heated to an elevated temperature, despite the fact that the silica nozzle exhibits very little, if any, thermal expansion which could be expected to cause the molybdenum coating to break away from the surface of the silica nozzle.

Similar deposits of the coating metals are formed by the vapor deposition and sputtering processes, because in each of the latter processes atoms or very small molten particles of the metal are formed and deposited on the surface of the unheated fused substrate in the above described manner.

We claim:

1. In an apparatus for the continuous casting of a molten metal including a continuous casting mold, a tubular molten metal supply device for conducting molten metal from a supply source and discharging the molten metal below the surface of a pool of molten metal maintained in the upper end of a said mold wherein in use said pool of molten metal has on the surface thereof a protective layer of a molten slag comprised of oxides and fluorides which has a high solubility for refractory oxides, the improvement wherein said tubular molten metal supply device is formed of vitreous refractory oxide material having on the outer surface thereof exposed to said layer of molten slag a protective surface coating of a refractory metal selected from the group consisting of tungsten, molybdenum, niobium and tantalum.

2. In the apparatus of claim 1, the further improvement wherein said vitreous refractory oxide material is fused silica.

3. In the apparatus of claim 1, the further improvement wherein said surface coating material is tungsten.

4. In the apparatus of claim 1, the further improvement wherein said surface coating metal is molybdenum.

5. In the apparatus of claim 1, the further improvement wherein said surface coating metal is niobium.

6. In the apparatus of claim 1, the further improvement wherein said surface coating metal is tantalum.

7. In the apparatus of claim 1, the further improvement wherein said surface coating of metal has a thickness between about 0.002 and 0.020 inch.

8. A method of increasing the resistance of a vitreous molten metal supply device formed of a fused refractory oxide material against attack by a molten layer of slag having a high solubility for oxides when said supply device is maintained in contact with said slag within a casting mold which comprises plasma spraying the surface of a fused vitreous refractory oxide molten metal supply device at least in the area where said supply device is adapted to contact said molten layer of slag, with an adherent coating of a metal selected from the group consisting of tungsten, molybdenum, niobium and tantalum.

9. A method as in claim 8, wherein said coating as applied has a coating thickness between about 0.002 and 0.020 inch.

10. A method as in claim 8, wherein fused vitreous refractory oxide is fused silica.

11. A method as in claim 8, wherein said surface coating metal is tungsten.

12. A method as in claim 8, wherein said surface coating metal is molybdenum.

13. A method as in claim 8, wherein said surface coating metal is niobium.

14. A method as in claim 8, wherein said surface coating metal is tantalum.

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