METHOD OF REMOVING ALUMINA SCUM FROM A CONTINUOUS-CASTING MOLD

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ABSTRACT
A method of removing alumina scum from the mold of an aluminum-killed continuously cast steel by adding calcium carbide to the molten metal, reacting the calcium carbide with alumina in the molten metal to form a liquid calcium aluminate, and removing the calcium aluminate from the steel.

9 Claims, No Drawings
METHOD OF REMOVING ALUMINA SCUM FROM A CONTINUOUS-CASTING MOLD

In the continuous casting of steel, molten steel is poured from a refractory-lined vessel or ladle into an intermediate vessel or tundish and then into an open-ended, water-cooled, continuous casting mold blocked at its lower end by a starter bar. As molten steel solidifies, the starter bar and attached casting are moved downwardly by means of pinch rolls. When aluminum-killed steel is being continuously cast, nonmetallic particles accumulate atop the molten steel in the mold. This accumulation of non-metallics on the surface of steel is termed "scum." The scum usually consists of macroscopic alumina particles on liquid steel. Frozen steel on the top surface of molten metal, with or without entrapped nonmetallics, is known as "skull." Often skimmings from the mold surface are essentially steel with only a few macroscopic particles of alumina. There are a few clusters of alumina within the metal in the skull but the original surface skull layer consists of fine alumina particles in steel and this dispersion approaches a cermet in form. Fine oxides dispersed in metal are termed "cermet."

As soon as the surface layer of steel in the mold becomes sufficiently saturated with Al₂O₃ particles to form the cermet layer, the surface (cermet) layer is stabilized, the viscosity is greatly increased, and, as heat is dissipated to the water-cooled copper mold above the surface of the liquid, the thin crust of metal freezes. Once frozen, the thickness of the crust increases because heat continues to be dissipated from the surface. It is at this stage that the scum, as well as the metal crust, may become entrapped in the skin of the slab to form a breakout or an internal defect in the steel.

One method of casting in which the formation of mold scum is controlled is teeming with a special submerged nozzle and, while casting, covering the steel with a low-melting mixture of lime, fluorides and borates to combine with the alumina particles. However, some of this mixture usually becomes entrapped beneath the skin of the slab and, when rolled, the product usually shows seams. This condition is also intolerable.

It is the principal object of my invention to provide a method of continuously casting scum-free aluminum-killed steel.

It is another object to provide a method of fluidizing scum and removing fluidized scum from aluminum-killed, continuously cast steel.

It is also an object to reduce internal defects in aluminum-killed, continuously-cast steel castings.

It is a further object to provide a method of casting aluminum-killed steel that on subsequent rolling of the casting will result in a steam-free rolled product.

According to my invention I prevent alumina particles from forming a stable cermet layer in the mold by continuously feeding a small amount of calcium carbide to the molten steel in the tundish. I add from one-eighth to two pounds of calcium carbide per ton of steel to the tundish. The addition is preferably made at the point where the stream enters the molten metal pool in the tundish. The calcium carbide is pulled under the surface and moved turbulently throughout the tundish where it reacts with alumina in the steel. Calcium oxidizes to form calcium oxide, which unites with the alumina particles to form a calcium aluminate.

The heat of formation of both calcium oxide and calcium aluminate, as well as the partial burning of the liberated carbon from the calcium carbide to carbon monoxide, raises the temperature of the steel in the tundish as well as in the mold which helps prevent further skull formation. When calcium carbide is fed to the surface of steel in the mold, the heat generated is sufficient to melt skull. Much of the calcium aluminate formed floats to the surface of the metal in the tundish where it remains until the end of the cast. Some of the calcium aluminate is poured into the mold where it continuously floats to the faces of the casting by the action of the metal in the mold. The calcium aluminate then moves downwardly with the casting and subsequently either peels or spalls off the surface of the casting, because of the difference in coefficient of thermal expansion between it and steel.

While other calcium-bearing alloys such as calcium silicon or calcium-silicon-barium alloys might be considered as addition agents, the addition of silicon-bearing alloys raises the silicon content of the steel, and removal of the excess silicon is impossible. Calcium-silicon-barium alloy contains some aluminum, thus the additional aluminum must be removed along with the alumina in the scum. This compounds the problem. Calcium carbide raises the carbon content only a small amount as some carbon is burned off. Carbon is a much more readily controlled element than silicon.

The calcium carbide can be added to the mold at a position adjacent to that at which the metal stream enters the mold. It can alternatively be added in the tundish above the tundish nozzle or the molten metal stream feeding the mold. Additions at these positions will cause the calcium ions to deoxidize the steel and to flux alumina particles that may be in the steel at either position or which forms in the steel because of the aluminum content and the oxygen content of the steel.

My usual calcium carbide addition is from one-eighth to two-thirds pounds per ton of steel, but a larger addition is required when the steel is highly oxidized or where the tundish stream is ragged or excessively turbulent. Then up to two pounds of calcium carbide per ton of steel may be added. When more than one-fourth pound of calcium carbide per ton is to be added, it is desirable to have a lower than normal carbon content in the ladle.

It can readily be seen from the foregoing that I have invented a method of continuously casting scum-free aluminum-killed steel in which the scum is fluidized and removed from the casting, resulting in reduced internal defects in the casting and a resultant seam-free rolled product.

I claim:

1. In the continuous casting of an aluminum-killed steel wherein molten steel is poured from a vessel into an open-ended mold to form a molten metal pool therein and a partially solidified casting is continuously removed therefrom, the combination therewith of a method of removing alumina scum from the mold comprising the steps of:

adding calcium carbide to the molten metal, exothermically reacting said calcium carbide with alumina in the molten metal and with the scum on the surface of the molten metal pool to form a liquid calcium aluminate,
floating the calcium aluminate toward the walls of the mold, causing the calcium aluminate to solidify on the casting faces, moving the casting downwardly out of the mold, and removing the solidified calcium aluminate from the faces of the casting.

2. A method as defined in claim 1 in which said calcium carbide is added to the molten metal stream feeding the mold.

3. A method as defined in claim 1 in which said calcium carbide is added to the molten metal in said vessel.

4. A method as defined in claim 3 in which said vessel has a bottom-pour nozzle and said calcium carbide is added to said vessel directly above said nozzle.

5. A method as defined in claim 1 in which said calcium carbide is added to the molten metal in the mold at a position adjacent that at which the stream impinges on the molten metal pool.

6. A method as defined in claim 1 in which said solidified calcium aluminate is removed from said casting faces by peeling.

7. A method as defined in claim 1 in which said solidified calcium aluminate is removed from said casting faces by spalling.

8. A method as defined in claim 1 in which said calcium carbide is added in the amount of from one-eighth to two-thirds pounds per ton of steel.

9. A method as defined in claim 1 in which said calcium carbide is added in the amount of from one-eighth to two-thirds pounds per ton of steel.

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