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FEED TIP FOR CONTINUOUS STRIP CASTING MACHINE
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Fig. 1.

Fig. 2.

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ABSTRACT OF THE DISCLOSURE

Molten aluminum is fed into the space between two slightly-spaced-apart, water-cooled rolls of a continuous strip casting machine through a feed tip made of fibrous refractory material known as Marinite, which is lined on the inside with fiberglass cloth, which becomes calcined by the molten aluminum. This fiberglass lining prevents the formation of voids in the cast strips.

Background of the invention

This invention pertains to an improved form of feed tip used in the continuous strip casting machine shown and described in U.S. Patent No. 2,790,216 to J. L. Hunter.

In the said casting machine, there are two water-cooled casting rolls mounted side-by-side with a slight space between them, and these rolls are slowly turned in opposite directions while molten aluminum is fed into the space between them from below, through a feed tip. The feed tip is made of a fibrous refractory material consisting of distilled silica, asbestos fiber, and a binder, which is marketed by Johns-Manville under the trade name of "Marinite." These feed tips made of Marinite have been found to operate satisfactorily for up to about 24 hours from start-up, after which voids begin to appear in the strip. It is extremely rare for a feed tip to run for more than 2 or 3 days before producing voids in the cast strip, and at that point it becomes necessary to shut down the casting machine and replace the feed tip with a new one.

The cause of these voids was not immediately apparent, and at first it was thought that they were due to build-ups of oxide or dirt, which accumulated on certain projections within the tip and impeded the flow of molten aluminum. However, modifying the configuration of the passageways to eliminate restrictions or obstructions resulted in little or no improvement, and it was concluded that this was not the cause of the trouble.

Further analysis of the trouble suggested that the voids in the strip might be caused by gas or vapor released from the Marinite upon prolonged exposure to the high temperature of the molten aluminum. Attempts were made to seal the inner surface of the tip by coating the Marinite with various coatings or linings, such as graphite, boron nitride, molybdenum sulfide, asbestos paper, and an alumina-silicate coating cement sold by Carbordum Co., under the trade name of Fiberfrax. None of these coatings or linings resulted in much improvement.

Finally, in an experiment that did not seem to hold much promise of success, a feed tip was lined on its inner surfaces with a double thickness of fiberglass cloth. The reason that fiberglass had not been considered suitable as a tip liner is that fiberglass cannot withstand exposure to the high temperature of molten aluminum for more than a very brief period of time without calcining. Calcined fiberglass retains the weave and fibrous appearance of the original fiberglass cloth, but is very delicate and crumbles to powder when handled. Since the fiberglass cloth liner is completely porous, both before and after calcining, it was not expected that this would provide any barrier for gases released from the Marinite. Moreover, there seemed to be no logical reason why fiberglass should be any more effective than asbestos paper as a tip liner, and the latter has produced little if any improvement over the unlined tip.

The only reason that fiberglass cloth was even considered for this experiment is that it had been used successfully (for an altogether different reason) in the continuous casting machine of U.S. Patent No. 3,110,941, and the fiberglass cloth had withstood contact with molten aluminum for extended periods of time. However, the fiberglass cloth of the machine in the patent is backed up by water-cooled platens, which cool the cloth and prevent it from becoming overheated. As a result, the fiberglass cloth is undamaged by its exposure to the molten aluminum, and retains its normal characteristics for as long as the machine remains in continuous, uninterrupted operation. The fiberglass cloth liner of the present feed tip is not cooled, as in the patent, and it was therefore anticipated that it would probably be destroyed by the high temperature.

However, contrary to all expectations, the fiberglass cloth liner proved to be the solution to the problem. Cast strip without voids has been produced with fiberglass-lined tips for periods of 6 to 9 days of continuous operation, before the machine is shut down for other reasons. This is in marked contrast to the 1 to 3 days of operation, which was all that could be expected of unlined tips.

Examination of the fiberglass cloth liner in the tip after a period of operation reveals that the cloth is, indeed, calcined by the heat of the molten aluminum, and is so delicate that it crumbles to powder when handled. However, the calcined cloth stays intact within the tip, and shows no signs of erosion or other damage. Since the fiberglass cloth is quite porous, both before and after calcining, it is obvious that the cloth liner does not seal the Marinite from the molten aluminum, and therefore the hypothesis that gas or vapor was being released from the Marinite by the 1200°F. temperature appears to be disproved. Whatever the cause of the voids which had heretofore begun to appear in the cast strip with in 1 to 3 days after start-up when using unlined feed tips made of Marinite, the trouble is completely eliminated by lining the inner surfaces of the tip with fiberglass cloth.

Summary of the invention

The primary object of the invention is to provide a new and improved feed tip of the class described, for use in a continuous casting machine, whereby substantially void-free cast aluminum strip is produced as long as the machine remains in continuous, uninterrupted service.

More specifically, the object of the invention is to provide a liner for a feed spout made of fibrous refractory material consisting essentially of diatomaceous silica, asbestos fiber, and a binder (e.g. Marinite) which eliminates the tendency of said material to cause voids to develop in the cast aluminum strip produced by the machine after a period of from 1 to 3 days of operation. The particular liner with which the present invention is concerned is fiberglass cloth.

Description of the drawings

FIGURE 1 is a sectional view through the casting rolls and feed tip of a continuous casting machine such as the one illustrated and described in U.S. Patent No. 2,790,216, showing the location of the feed tip and the manner in which it cooperates with the rolls.

FIGURE 2 is a perspective view of the feed tip, by itself;
FIGURE 3 is an enlarged sectional view through the tip, taken at 3—3 in FIGURE 2;
FIGURE 4 is a sectional view, somewhat reduced in scale, taken through the tip at 4—4 in FIGURE 3;
FIGURE 5 is a view similar to FIGURE 4, but looking in the opposite direction, as indicated at 5—5 in FIGURE 3;
FIGURE 6 is an enlarged fragmentary sectional view, taken at 6—6 in FIGURE 4;
FIGURE 7 is another enlarged fragmentary sectional view, taken at 7—7 in FIGURE 4; and
FIGURE 8 is still another enlarged fragmentary sectional view, taken at 8—8 in FIGURE 2.

Description of the preferred embodiment

In FIGURE 1 of the drawings, the feed tip of the present invention is designated in its entirety by the reference numeral 10, and is clamped onto a cast iron housing 12. The feed tip 10 and housing 12 extend longitudinally under parallel, water-cooled casting rolls 14 and 16, and are centered with respect to the slot formed between the adjacent sides of the rolls. The casting rolls and feed tip are part of a continuous casting machine that is shown and described in detail in U.S. Patent No. 2,790,216, to which reference may be had.
The rolls 14 and 16 are rotatably supported at their ends by suitable midget blocks mounted on a frame (not shown), and are driven in opposite directions, as indicated by the arrows A and B. Each of the rolls 14, 16 includes a relatively thin outer shell 18 of high alloy steel, which is shrunk over an inner core 20. The outer surface of core 20 is provided with longitudinally extending channels 22 which cooperate with the inner surface of shell 18 to form narrow passageways, through which coolant water is circulated at high velocity.

In the operation of the casting machine, molten aluminum is fed into the gap between the casting rolls 14, 16, through the feed tip 10, and the solidified, continuous strip or sheet S of aluminum issues upwardly from between the rolls. The feed tip 10 is made up of two sides 24 and 26, each of which comprises several short sections 28 that are machined to the desired shape and fastened together end-to-end by staples 30, as shown in FIG. 5. The tip is preferably made of the fibrous refractory material sold by Johns-Manville under the trade name of “Marinite.” Marinite consists essentially of diatomaceous silica, asbestos, and cooks in the form of flat slabs, which can be sawed, drilled, or otherwise machined, in much the same way as wood. While the sides 24 and 26 could be made of single large sections of Marinite, it is preferred to divide them up into relatively short sections 28, to facilitate manufacture and replacement of the same.

The feed tip 10 is an elongated, narrow body, as shown in FIG. 2, which extends substantially the full length of rolls 14, 16, and the upper portion of the body is cylindrically concave on both sides to form converging arcuate sides 32 that conform to the curvature of the rolls. The upper edge of the feed tip defines a long, narrow nozzle which extends up into the converging space between the rolls 14, 16 to a point just below a plane passing through the axes thereof. Molten aluminum issuing from this nozzle fills the space between the water-cooled rolls, where it is chilled and solidified into a continuous strip, or sheet S, of the same thickness as the distance between the roll surfaces at the point where they come closest together.

The center section of the tip body projects downwardly below the bottom edge of the tip ends to form a manifold section 34, which is fed with molten aluminum through a tube 36 of refractory material. Tube 36 projects laterally through the side wall 38 near the bottom of the manifold section 34, and is connected to a head box (not shown) associated with a melting furnace.

Each of the feed tip sections 28 is machined out on its inner face to form a shallow channel 40, and the channels of the opposed sides 24, 26 cooperate to form a longitudinally extending passageway 42 which tapers at the top to a narrow nozzle slit 44. At its ends, the tip body is closed by end pieces 46, the tips of which project slightly above the orifice 44, which provides dams which keep the molten aluminum from spilling out at the ends until it has solidified. Attached to the manifold section 34 along the lower edge thereof is a bottom strip 48. The end pieces 46 and bottom strip 48 may also be attached to the adjoining tip body sections 28 by means of staples. The tube 36 passes through the side of the tip body at the junction of the bottom strip 48 with the manifold section 34, and the bottom half of the aperture 38 is formed as a semicircular cavity 39 in the top edge of the strip 48.

Mounted within the passageway 42 of the feed tip body in the corners thereof are triangular filler blocks 50, 51, 52 and 53, which completely fill these corners and thereby eliminate the pockets, which tend to cause undesirable turbulence in the flow of the molten metal. The flow is also strengthened out and distributed uniformly across the width of the nozzle slit 44 by means of a diamond-shaped baffle 54, and a plurality of laterally spaced, triangular reinforcement blocks 56, which are arranged in a straight line parallel to the top edge of the sides 24, 26, just below the point at which the strip 48 begins to taper. The reinforcement blocks 56 provide support for the slender nozzle lips, and prevent the tip from collapsing in the center.

The feed tip described to this point is essentially the same as that shown and described in Patent No. 2,790,216, and differs therefrom only in structural details. The unique feature of the present invention resides in the liner, which will now be described.

Completely covering the inner surface of the feed tip sections 28 and secured thereto by staples 58, is a liner of fiberglass cloth 60. The liner 60 is preferably of fairly heavyweight fiberglass cloth, approximately .006" thick, doubled back on itself as best shown in FIG. 6. The double thickness of fiberglass cloth is particularly important in the nozzle slit 44, where the velocity of metal flow is highest. The crease, where the fiberglass cloth is folded at the discharge end of the nozzle slit, is given initial stiffness by painting it with a ceramic coating cement marketed by Carborundum Co., under the trade name of “Fibrefrax” coating cement. Fibrefrax coating cement is a paste of heavy cream consistency, having 69% solids content and consisting essentially of SiO₂, Al₂O₃, and minor amounts of Na₂O, B₂O₃, and MgO. Fibrefrax coating cement is also painted on the exposed sides of the filler blocks 50, 51, 52 and 53, baffle 54, and triangular reinforcement blocks 56. The coating of Fibrefrax cement is designated by the reference numeral 62 in FIGURES 3 and 7.

At the extremities of the tip body, the fiberglass cloth 60 is bent around the ends of the outer sections 28, and is held down by the end sections 46. The end sections 46 are faced on their inner surfaces with a layer of Fibrefrax fiber 64 (also made by Carborundum Co.), which is a felt-like material, in sheet form, consisting of alumina-silicate fibers held together by an organic binder.

Thus, with the exception of the narrow edges of filler blocks 50, 51, 52 and 53, baffle 54, reinforcement blocks 56, and the inner surfaces of ends 46, all of the exposed inner surface of the Marinite feed tip are faced with a double thickness of fiberglass cloth 60. The filler blocks 50, 51, 52 and 53, baffle 54, reinforcement blocks 56, and ends 46 are all made of Marinite, the same as sections 28, and ideally, should have their edges lined with fiberglass cloth. The Marinite is so cut to affix the fiberglass cloth to these narrow surfaces, and since the total area of these surfaces is only a small fraction of the total inner surface of the feed tip, the effect of such surfaces is relatively unimportant. Coating the surfaces with Fibrefrax coating cement or fiber somewhat reduces the liberation of gas from the breakdown of the Marinite in these
parts, but such coatings are not nearly as effective as the fiberglass cloth liner 60, which virtually eliminates the fiber.

Prior to the first start-up, the completely assembled tip is preheated in an oven to 400°F for at least two hours to remove absorbed moisture. The tip assembly is then removed from the preheat oven, placed in the cast iron housing 12, and raised into place between the rolls 14, 16.

As the machine is started up for the first time, molten aluminum at approximately 1200°F is flowed into the feed tip 10, and out through the nozzle slot 44, then into the space between the rolls 14, 16, where it is chilled and solidified. In a matter of seconds, the starch binder in the fiberglass cloth is burned off, and then in a few minutes, the fiberglass cloth becomes calcined. By this time, the fiberglass has lost all of its fibrous characteristics, and has become a delicate substance that crumbles to powder at the slightest touch. However, despite its delicacy, the calcined fiberglass remains in place on the inner surfaces of the feed tip, and is not carried away or eroded by the flowing stream of molten aluminum.

Just why the fiberglass lining in the feed tip should work as it does to prevent the liberation of gases resulting from the breakdown of Marinite, is not known to applicant. The fact remains that it works, and nothing else tried by applicant has been effective. Casting runs have been increased from 2 to 3 days, up to 6 to 9 days, with potential tip life of up to 30 days.

While I have shown and described in considerable detail what I believe to be the preferred form of my invention, it will be understood by those skilled in the art that various changes may be made in the configuration of the feed tip and its fiberglass liner without departing from the broad scope of the invention as defined in the claims. The term “cloth” as used herein includes any flexible sheet material, either woven, knitted, netted, or felted, and whether made of monofilaments, yarns, rovings, or twisted strands.

I claim:

1. In a machine for the continuous casting of aluminum or its alloys, said machine including means defining a mold cavity to receive molten aluminum, and means for chilling said aluminum to solidify the same, the improvement comprising:
   a feed tip connected to a source of molten aluminum, and having a nozzle disposed to discharge said molten aluminum into said mold cavity; said feed tip comprising a body made of a fibrous com-
   position consisting essentially of diatomaceous silica, asbestos fiber, and a binder;
   said body having an internal passageway formed there-in along which said molten aluminum flows;
   and a liner of fiberglass cloth covering at least a major portion of the exposed surface in said internal passageway.

2. The invention as set forth in claim 1, wherein said feed tip has projections of the same material as said body extending across said passageway, the exposed edges of said projections being coated with a composition consisting essentially of SiO₂, Al₂O₃, and a minor amount of Na₂O, B₂O₃ and MgO.

3. The invention as set forth in claim 1, wherein at least a minor portion of the exposed surfaces of said internal passageway is lined with a felt-like material in sheet form, consisting of aluminosilicate fibers bound together by an organic binder.

4. The invention as set forth in claim 1, wherein said fiberglass liner is in a calcined condition.

5. A feed tip adapted for use in the continuous casting of aluminum comprising a fibrous body consisting essentially of diatomaceous silica, asbestos fiber and a binder, said body having an internal passageway, and a fiberglass liner attached to and covering at least a major portion of said internal passageway.

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