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LUBRICATING METHOD FOR THE CONTINUOUS CASTING OF READILY OXIDIZABLE METALS

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The invention relates to an improved mold lubricant for the continuous casting of readily oxidizable metals such as magnesium, aluminum, and their alloys.

In the continuous casting of readily oxidable metals, the lessening of the undesirable effects of oxygen attack on the hot metal is a matter of considerable concern. In the casting of magnesium alloys and magnesium-base alloys, for example, flash burning of the ingot or slab as it emerges from the mold, has constituted a persistent problem. The burning constitutes a fire hazard. It also results in substantial metal loss in scarring or otherwise damaging the metal surface. Sometimes the burning of the ingot or slab as it emerges from the mold generates sufficient heat to remelt some of the metal thereby creating channels which result in serious run-out of molten metal and damage to the ingot or slab. Attempts to solve the problem of flash burning of the cast metal at the exit side of the mold have not been satisfactorily solved.

Directly introducing sulfur dioxide at the outlet of the continuous casting mold to provide a protective atmosphere about the magnesium or magnesium-base alloy as it emerges from the mold as a formed ingot or slab, is a known method employed to discourage the flash burning. The use of sulfur dioxide at the outlet of the mold has associated therewith a number of disadvantages among which are cost, offensive fumes, and the formation of corrosive sulfurous and sulfuric acids by the reaction of the sulfur dioxide with the cooling water. Corrosion by the thus-formed acids on the casting equipment results in increased material and maintenance costs.

The surface of ingots of aluminum and magnesium-base alloys, produced by continuous casting, have darkened areas giving a mottled effect thereto. These darkened areas are due to rapid oxidation of certain metal compositions formed by the alloying metals some of which compositions exude to the surface. They are there generally referred to as exudate and have presented an additional problem in continuous casting of those alloys.

A further problem associated with continuous casting of readily oxidizable metals is the formation of irregularities in the mold-contacting surface of the cast ingots known as laps or folds. These irregularities are formed at or near the level at which the edge of the molten metal contacts the inner surface of the mold during the casting operation. These laps or folds appear to be due to small variations as the early stages of solidification occur about the periphery of the molten metal at its top surface in the mold. The variations in the early stages of solidification, which is a skin-forming process at the interface of the mold and the metal being cast, is due to slight fluctuations in temperature at the interface.

Among the readily oxidizable metals at casting temperatures, the oxidizability of magnesium is more drastic than aluminum. In the case of magnesium, for example, the oxidation frequently results in open burning of the magnesium. The laps and exudate and damaged surface are common to both aluminum and magnesium.

The principal object of the present invention, therefore, is to reduce the oxidation of readily oxidizable metals and particularly to eliminate burning of cast magnesium as it emerges from the forming mold in a continuous casting operation.

A further object of the invention is to reduce the

irregularities in the mold-contacting surface of the cast ingots which are due to folds or laps.

A still further object is to produce a smoother and brighter surface on the ingots having less-pronounced darkened areas thereon due to exudate.

The objects of the invention are attained by the employment of a novel mold lubricant which provides an inexpensive and effective method of reducing the oxidation of a readily oxidizable metal, and particularly of preventing burning of magnesium, as it emerges from the mold in a continuous casting operation.

The present invention consists of dispersing boric acid in a suitable oily or oily base material to make an oxidation-preventive lubricant which is then applied to the inner surface of a continuous mold used in the continuous casting of readily oxidizable metals, e.g., magnesium and aluminum and their alloys.

Among the oily or oily base materials suitable for practicing the invention are vegetable, animal, and mineral oils which possess a sufficient high oxidizing temperature to resist charring, a low moisture and impurity content, safe flash and fire points, and a pour point and viscosity which impart fluidity without excessive accumulation of oil at the edge of the top surface of the molten metal and without excessive drainage at the temperatures employed in the casting operation. Palm and peanut oils, lard oil, and petroleum-derived fractions having a Saybolt Universal viscosity at 100° F. of about 200 seconds are examples of suitable oils.

The oil used may advantageously have oil-suspended graphite or carbon particles added thereto.

Lard oil is the preferred oil used in the preparation of the lubricant of the invention. It consists chiefly of triglycerides of fatty acids, particularly of oleic acid, pressed from hog fat. The following values are typical of a lard oil which is well suited to the practice of the invention:

Acid No.	5 to 8
F.A.C. [1] color	5 to 9
Titer ° C.	32 to 34.5
Iodine No.	70 to 74.5
Saponification No.	192 to 198
Pour point, A.S.T.M. ° F.	35 to 45
Cloud point ° F.	40 to 54
Melting point F.A.C.[1] ° F.	65 to 75
Smoke point, open cup ° F.	265 to 295
Flash point, open cup ° F.	510 to 550
Fire point, open cup ° F.	650 to 670
Sp. Gr., 25/25° C.	0.910 to 0.915
Refractive index, 40° C.	1.460 to 1.461
Saybolt Universal, viscosity at 100° F. seconds	200 to 210
M.I.U. (moisture, insoluble and unsaponifiable matter) percent	Not over 1.0

[1] Fat Analysis Committee of the American Oil Chemists Society.

Oil-suspended graphite particles may be advantageously added to the mixed glyceride oil above. Preferably the graphite is in flake form and the suspending oil contains a thickening agent such as a soap.

The oil-suspended graphite which may be used usually consists of a mineral oil having a Saybolt Universal viscosity at 210° F. and between 600 and 700 seconds as determined according to the American Society for Testing Materials test A.S.T.M., D–88–53, thickened with a metallic soap, e.g., calcium stearate, and containing 10 to 15 percent of fine graphite in suspension. The thus-described in oil-suspended graphite usually has a work penetration of between 265 and 295 millimeters as determined by A.S.T.M. penetration test D–217–52T and meeting the specification of the National Lubrication Grease Institute described as No. 1.

Appropriate lard oil may be procured under the proprietary name EWS Lardex from Swift and Co., Chicago, Illinois. Appropriate soap-thickened oil-suspended graphite may be obtained under the proprietary name Gredag from Gredag, Inc., Niagara Falls, New York.

The oily base material which is particularly suitable for practicing the invention is prepared by admixing the mixed glyceride oil e.g., lard oil, with the oil-suspended graphite described in the two paragraphs immediately above. The ratio of the oil to the oil-suspended graphite is not critical but the preferred ratio has been found to be 2 parts of the oil to 1 part of the oil-suspended graphite.

The boric acid is employed according to the invention in an amount between 0.5 and 10 pounds per 100 pounds of mold lubricant, but is preferably employed in an amount between 2 and 6 pounds per 100 pounds of lubricant.

Technical grade boric acid is fully satisfactory for the purposes of the invention and is readily available. Its use entails substantial savings over the use of known oxidation protective agents such as sulfur dioxide.

In preparing the lubricant of the invention, the boric acid is added directly to the mold lubricant and mixed therewith by a conventional means such as a spatula or paddle mixer until it is substantially uniformly dispersed therein. The thus-prepared lubricant of the invention is then applied to the interior of the mold. Application of the lubricant to the entire surface of the mold before the casting operation is begun and followed by application over that portion of the inner surface of the mold above the molten metal at intervals is recommended. The lubricant is easily applied intermittently as necessary by hand, as by using a brush, but it may be applied through a mechanical pressure and swabbing system, if desired, either intermittently or continuously.

The following example illustrates a preferred formula and method of using the invention.

A lubricant, consisting by weight of ⅔ lard oil falling within the values set out hereinbefore and containing the glycerides set out below, ⅓ calcium stearate-thickened oil-suspended graphite as described hereinbefore containing 12½ percent electric furnace graphite, and 2 percent anhydrous boric acid by weight, was prepared.

The lard oil used contained glycerides of the following fatty acids:

Glyceride of:	Weight percent
Myristic acid	1
Palmitic acid	25
Stearic acid	12
Oleic acid	48
Linoleic acid	12
Linolenic acid	1
Arachnidonic acid	1

The lard oil and oil-suspended graphite described above were mixed together in a 2 to 1 ratio by weight at room temperature. To 50 pounds of the resulting mixture thus prepared, 1 pound of technical grade boric acid powder was added and mixed into the lard oil and oil-suspended graphite mixture.

A mold, for continuous casting of magnesium ingot, similar to that described in U.S.P. 2,503,819, but without the stilling plate or vibrator shown therein, was prepared for operation. Magnesium metal was melted in a kettle equipped with a heating means and pumped therefrom to the continuous mold. Prior to its receiving molten magnesium into the mold from the heated kettle providing a continuous source of the metal, a thin coating of the lubricant prepared above was applied by a brush to the interior of the mold. Molten metal was then received into

the mold and the casting, as described generally in U.S.P. 2,503,819, was started. As the casting operation proceeded, additional applications of the boric acid-treated lubricant of the invention were made by brushing the interior of the mold above the level of the molten metal. After coming in contact with the interior of the mold, the viscosity of the lubricant was lowered and the lubricant therefore flowed gradually downward to the point of contact of the molten magnesium and the interior of the mold wall. It was thereafter carried along with the magnesium as the magnesium moved downward. The magnesium gradually solidified and emerged below the mold. No sulfur dioxide or other oxidation-preventive was employed. No tendency to flame or burn was detected in the emerging magnesium due to the presence of the boric acid-treated lubricant. The fire hazard and metal loss were therefore clearly lessened. The exudate appearing along the surface of the magnesium thus cast was definitely less oxidized as shown by a marked reduction in darkening due to the exudate when compared to magnesium ingots which were cast in a similar manner but in which no boric acid was employed in the lubricant. Irregularities due to lapping and folding were clearly less prominent in the ingots produced.

The mold lubricant made and used in accordance with the invention, when compared to known lubricants and their use in casting operations, offers advantages of greater safety, economical operation, and a superior product.

Having described the invention, what is claimed and desired to be protected by Letters Patent is:

1. The process of treating the interior of molds used in continuous casting of readily oxidizable metals which comprises admixing between 0.5 and 10.0 percent by weight of boric acid into an oil containing at least one of the triglycerides of palmitic, oleic, stearic, and the linoleic acid, having less than 1.0 percent moisture and unsaponifiable matter therein, to make a lubricant and applying the lubricant to the exposed inner surfaces of the mold.

2. The process which comprises applying an admixture of boric acid and an oil selected from the class consisting of animal and vegetable oils which is heat-stable at the mold temperatures employed in continuous casting of readily oxidizable metals, to at least the upper portion of the interior of an open-bottom mold, admitting molten metal to be cast into the top of the mold, and causing the metal to emerge from the bottom of the mold as a formed ingot in a continuous operation.

3. The process of treating the interior of a mold used in continuous casting of readily oxidizable metals which comprises admixing between 0.5 and 10.0 percent by weight of boric acid into an oil selected from the class consisting of animal and vegetable oils to make a lubricant having improved metal oxidation-inhibiting properties, and applying the lubricant to the exposed inner surfaces of the mold.

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