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CONTINUOUS CASTING OF STEEL

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3 Claims. (Cl. 164—73)

ABSTRACT OF THE DISCLOSURE

A high-temperature liquid-solid lubricant suitable for using in the continuous casting of molten steel comprising submicron spheroidal oxides not susceptible to phase changes at temperatures up to 1600° F. and a carrier having a high flash point and a low carbon residue on burning.

Related case

This case is a continuation-in-part of application Ser. No. 615,077, filed Feb. 10, 1967 having the same title, now abandoned.

Background

The commercial use of processes for the continuous casting of steels seems destined to take an increasingly important position in future steelmaking. Its many advantages in terms of cost, labor, and simplicity make it very attractive to an industry becoming highly automated. The concept of continuous casting of steel is not new, however. As early as 1865, Sir Henry Bessemer envisioned the continuous casting of a steel plate or the like by continuously pouring molten metal between two water-cooled rollers to recover a strip of steel.

A recent article [1] is recommended for a detailed study and analysis of the evolution of processes for the continuous casting of steel from the early work of Bessemer to many contemporary processes. As pointed out by the article, two of the more important and critical parts or steps in contemporary processes for the continuous casting of steel are considered to be:

(1) The actual pouring of a carefully regulated stream of molten metal into an initial "freezing" stage or mold, and

(2) The actual cooling or "freezing" step itself.

In this latter step, a peripheral skin or shell is formed about a core of molten metal as it passes through the cooling stage or mold. This skin or shell formation must be carefully controlled if a "breakout" of molten metal is to be prevented. The eventual recovery of a billet of fairly uniform dimensions also depends on the skin formation. If the stream of molten metal being poured into the cooling or freezing stage is not constant in volume and cross-sectional configuration, the formation of a uniform and sufficiently strong skin is made difficult, if not impossible.

In many of the present practices, the semisolidified stream is subjected to a "pulling" action by frictional engagement with driven rollers, or by frictional engagement with upwardly- and downwardly-reciprocating mold walls in the initial cooling stage. Of course, gravity itself can be of substantial effect in placing stresses on the evolving semisolidified stream because of the substantially vertical process flow path present practices utilize.

One of the more essential factors controlling the freezing step is lubrication of the mold. The molds are typically water-cooled copper with highly machined surfaces. Their temperature never exceeds about 2000° F., which

[1] Leonard V. Gallagher et al., authors, Scientific American, December 1963.

is about the melting point of copper. However, portions of the mold have a temperature exceeding 1000° F. Obviously, ordinary oils and greases which begin to oxidize badly at temperatures above 600° F. are not adequate. Rapeseed oil is the traditional lubricant now being used by continuous casting operators. Several synthetic oils, such as silicone-based oils, have been used with limited success. One unusual lubricant used is a mixture of fly ash and alkali oxides, which creates an extremely fluid slag. Typical solid lubricants, such as graphite, and those of the molybdenum disulfide type, cannot be used as they would build up on the copper mold and tend to contaminate the steel surface.

The general requirements of a lubricant for continuous casting are that it prevents welding of the liquid steel to the solid copper mold wall, and that it reduces the sliding friction between the skin and the newly formed casting and the mold wall. More specific requirements of fluid lubricants are that they must not break down at temperatures under 400° F., they must not produce coke deposits, and they must not contaminate the casting surface.

It is an object of this invention to provide an improved lubricant for the continuous casting of steel which has all of the good qualities of rapeseed oil, but which has improved high-temperature lubricating characteristics.

Brief description of the invention

Broadly, according to this invention, there is provided a method of continuously casting molten steel and water-cooled copper molds. According to this invention, the molds are lubricated with a composite liquid-solid lubricant comprising from 10 to 80%, preferably 10 to 60%, by weight, submicron spheroidal oxides not susceptible to phase changes at temperatures up to 1600° F. and 20 to 90%, preferably 40 to 90%, by weight, of a carrier having a high flash point and a low carbon residue on burning. Suitable submicron spheroidal oxide is volatilized silica which is manufactured by the oxidation and collection of silicon vapors. Submicron spheroids of titania and zinc oxide are also available and suitable. Suitable carriers include rapeseed oil, crambe oil, glycerol, polyethylene glycol, and silicone-based oils.

In this specification by "high flash point" I mean in excess of 300° F. By "low carbon residue" I mean equivalent to rapeseed or crambe oil. By "phase change" I mean crystallographic rearrangement.

Detailed description of invention

This invention is a considerable departure from the modern theories of lubrication. Lubricants are usually considered to be fluids which, through the phenomena of hydrodynamic pressure, separate two moving surfaces. Solid lubricants are typically materials such as graphite or molybdenum disulfide which easily shear or flow similar to fluids. Applicant's lubricant is a combination of a fluid lubricant and a nonshearing solid. The solid portion of applicant's lubricant is comprised of submicron spheroidal oxides which behave similar to thousands of roller bearings. The spheroidal particles have a tendency to increase the thickness of the carrier oil film, thus improving the fluid lubrication so long as the carrier fluid lasts. Thereafter, the spheroidal oxides must act as a dry bearing. The oxides are about twenty times more effective than oil films for conducting heat away from the steel billet and, hence, improve the efficiency of the copper molds.

The submicron spheroidal oxide must not experience a phase change below about 1600° F. This is because phase changes are usually accompanied by change in volume or shape and other properties such as strength. Oxides are used because they have little tendency to react with the surface of the billet as would, for example,

metals. I have found that a particularly suitable oxide is vitreous silica. Submicron spheroids of vitreous silica can be prepared by vapor deposition and are commercially available. Submicron spheres of titania and zinc oxide are also commercially available and suitable according to this invention.

Carrier fluids used according to this invention should have a flash point in excess of 300° F., and should burn with no metallic or carbonaceous residue. Carrier fluids should have a viscosity sufficient to hold the spheroidal particles in suspension at room temperatures. Low viscosity liquids such as kerosene fail to hold volatilized silica in suspension.

The following are examples of liquid-solid lubricants according to the teachings of this invention. A mixture of 23% volatilized silica and 77% glycerol was combined and agitated until the volatilized silica was completely dispersed within the glycerol. This is the best mode now known for the practice of this invention. The lubricant was submitted to two tests to determine its tendency to ignite. The lubricant was first spread over a concrete surface and subjected to the flame of a blow torch. It did burn but there was no explosion, and no organic residue remained. In another test, the lubricant was poured on a brass plate which was water-cooled on its other face. The lubricant was subjected to the flame of a blow torch but could not be ignited.

Another lubricant according to this invention was prepared by mixing 60% volatilized silica and 40% ethylene glycol. In certain continuous casting machines operating at higher pressures as much as 80% volatilized silica or other submicron spheroidal solid is desirable in the lubricant.

The lubricant film is provided in continuous casting molds through slits in the mold wall, about 0.020 inch high, and having a width to suit. The lubricant runs down the side of the mold wall from the slits. The lubricant is supplied to the slits from a well inside the mold wall which is in turn connected to the lubricant's source. The lubricant is usually delivered by a pump which has an output of about 0.4 to 8.0 gallons per hour. The lubricant usage is in the range of 0.7 to 1.0 pound per ton of steel.

Having thus described the invention in detail and with sufficient particularity as to enable those skilled in the art to practice it, what is desired to have protected by Letters Patent is set forth in the following claims:

I claim:

1. In a method of continuously casting molten steel by introducing a molten stream of steel into water-cooled copper molds and freezing the stream within the molds, the improvement comprising the steps of:

(1) lubricating a portion of the mold walls by introducing a composite liquid-solid lubricant comprising from 10 to 80%, by weight, submicron spheroidal oxides selected from the group consisting of titania and silica and 20 to 90%, by weight, of a carrier fluid having a high flash point and a low carbon residue on burning, which lubricant provides hydrodynamic lubrication, and

(2) lubricating the remaining portion of the mold walls with the submicron spheroidal oxides of the lubricant introduced in step **1** after the carrier fluid has been burned away, which lubricates in a manner similar to a plurality of dry bearings.

2. The method of claim **1** in which the carrier fluid is selected from the group consisting of rapeseed oil, crambe oil, glycerol, polyethylene glycol, and silicone-based oils.

3. The method of claim **1** in which the lubricant comprises 10 to 60%, by weight, submicron spheroidal oxides.

References Cited

UNITED STATES PATENTS

2,419,252	4/1947	Bychinsky et al.	252—25
2,466,642	4/1949	Larsen	252—25
2,609,342	9/1952	White et al.	252—25
2,926,138	2/1960	Huet	252—25
3,103,491	9/1963	Wright	252—25

FOREIGN PATENTS

700,512	12/1964	Canada.
1,138,493	10/1962	Germany.

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