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CONTINUOUS CASTING OF TUBES

Douglas C. Yearley, Westfield, N.J., assignor to Phelps Dodge Copper Products Corporation, New York, N.Y., a corporation of Delaware

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ABSTRACT OF THE DISCLOSURE

Continuous casting of tubes by solidfying molten material as it is withdrawn from a solidification zone defined by the insertion of a central mandrel into the exit aperture of a liquid zone to create an annular aperture of adjustable dimensions to control the characteristics of the cast product.

SPECIFICATION

This invention relates to a method and apparatus for the continuous casting of hollow metal tubes.

Continuous casting of tubes comprises the uninterrupted flow of molten metal to one end of a casting mold and the removal of heat from the metal to solidify it as it is formed into the desired sectional shape during passage of the metal through the mold. Tubing is cast continuously by the use of an inner core or mandrel positioned within a cylindrical mold or die. The molten metal is supplied under pressure or by gravity feed to the annular space between the mandrel and the cylindrical mold. The mold is cooled to solidify the metal, and cast tube is drawn from the mold by rollers or the like which grip the outer surface of the tubing.

In general, the relatively slow rates of continuously casting tubing in prior apparatus and the poor quality of such tubing are serious problems which heretofore have made it economically impractical to continuously cast tubing for direct fabrication into commercial tubing. Those problems are due in part to adhesion of the metal to the surfaces of the mold and the mandrel and to shrinking of the metal on the mandrel during the cooling and solidifying phase of the process. These difficulties have persisted despite various counteracting measures which have been attempted, such as vibrating the mold and providing the mandrel with a taper in the direction of the metal movement through the mold.

Other factors which have precluded extensive use of continuous tube casting for direct fabrication to commercial tubing include the difficulty in starting the tube casting process, the tendency for the cast tube to have an intolerable degree of eccentricity and lack of control over the solidification process in the mold during the casting operation.

Control over the solidification process is important since the process of solidification, including the rate of solidification and its location, determines the properties of the resulting tubing such as surface quality, tensile strength, elongation, grain size, etc.; and lack of control of that process will, of course, give poor properties in the tubing.

This invention provides an improved apparatus for the continuous casting of tubes and a new method for such casting, which will allow for the manufacture of high quality tubes on a commercial and economical basis. It eliminates start-up difficulties, provides a concentric tubing of good quality which may be rapidly and economically fabricated into commercial tubing. Another important aspect of this invention is that it permits the molten metal used to form the tubing to be fed to the casting mold by gravity without any need for metering that flow or the use of a feed spout to deliver and position the metal in the mold.

According to the present invention, the mandrel is mounted for vertical movements relative to a mold which is fed from a molten pool of metal maintained in a reservoir above the mold. The latter, in turn, is mounted for vertical vibratory movements in which it is guided by means for preventing lateral displacement of the mold. In starting the tube casting operation, molten metal is first fed to the mold from the overlying reservoir while the mandrel is withdrawn, whereby solid rod is drawn initially from the exit or lower end of the mold; and then, as the feed of molten metal is continued, the mandrel is lowered through the reservoir so that the tapered lower end of the mandrel enters the mold to a depth sufficient to effect transition from rod to tube casting. The mandrel is guided in its vertical movements by guide means overlying the reservoir and adjustable laterally to effect accurate centering of the mandrel relative to the mold.

In the preferred form of the new apparatus, the mold and the mandrel are provided with separate cooling systems. Also, to prevent adhesion of the metal during casting and to improve the grain structure of the cast tube, the mold and the mandrel are vibrated vertically either in unison or separately.

The method and apparatus of my invention have been used successfully to produce good quality phosphorous deoxidized copper tubes having overall diameters of 1½ to 4 inches with wall thicknesses ranging from 0.17 to 4.45 inches, at speeds in excess of 2 feet per minute and with an error of concentricity of less than 0.01 inch.

The invention may be better understood from the following description of a specific example as illustrated by the accompanying drawings, in which:

FIGS. 1*a* and 1*b* are together a vertical view of a preferred form of the apparatus of my invention;

FIG. 2 is an enlarged vertical sectional view of the mold and the crucible forming the feed reservoir, as shown in FIG. 1*a*; and

FIG. 3 is an enlarged vertical sectional view of a modified form of the mandrel having a separate cooling system.

Referring to the drawings, particularly FIG. 1*a*, metal M in molten form is introduced from an external source, not shown, by means of a launder or trough **11** into a generally cylindrical crucible **12** of graphite mounted on a vertically movable platform **13**. The latter has a generally rectangular shape in plan view and any conventional means (not shown) may be used to support it.

The platform **13** has attached to its intermediate its right front and rear corners and left front and rear corners supports **36** and **36'**, respectively. Struts **37** and **37'** reinforce cross bracket **35** which is attached at each of its ends to supports **36** and **36'**. These members support the upper portion of the apparatus, as more fully hereinafter explained.

The platform has attached to its a vibrator (shown schematically) which may be of any conventional design, preferably one to impart a vertical sinusoidal vibratory motion to the platform **13** and thus to the casting apparatus. By rigid connection (by means not shown) of supports **36** and **36'** with the bar **30** both the mandrel and the mold may be vibrated by the same means. Without that connection the mandrel may be used without vibrat-