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MAKING OF SEAMLESS TUBES

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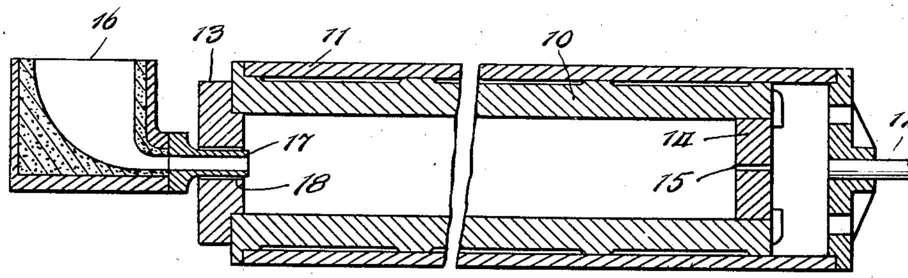


Fig. 1.

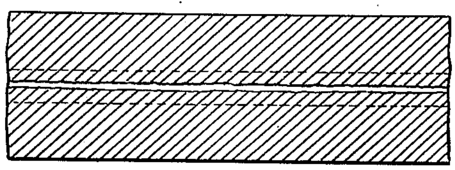


Fig. 2.

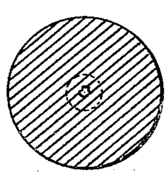


Fig. 3.

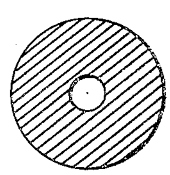
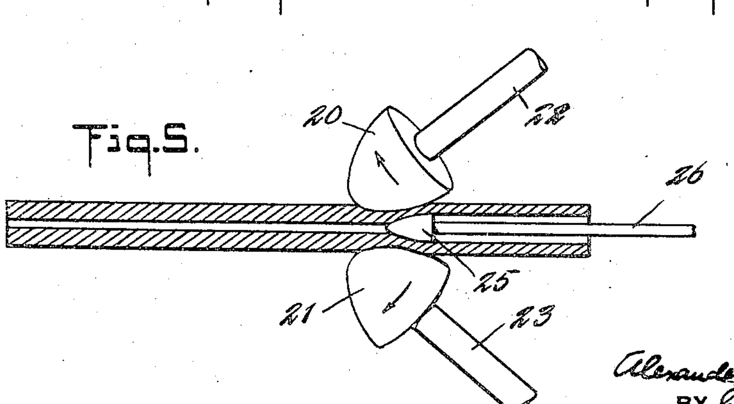


Fig. 4.

Fig. 5.



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MAKING OF SEAMLESS TUBES

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7 Claims. (Cl. 80—62)

This invention relates to the making of seamless tubes. The invention aims to reduce the cost and difficulty of making seamless metal tubes of high quality, and especially to provide an improved method of making tubes from high chromium ferrous alloys and other metal alloys the hardness or other properties of which make it difficult or impossible to produce pierced tubes according to the usual method. The difficulty with such alloys may be in the production of the billets, or tube rounds, of the necessary uniform and high quality required for piercing, or in the passing of the billets through the piercing mill. The difficulties may be such as to make the expense of producing the billets or of piercing or of both extremely onerous or even prohibitive, or such as to make it impossible to produce tubes in the customary way even from high quality billets.

Seamless metal tubes are commonly made by passing a heated round metal bar, usually termed a billet or tube round, endwise through a cross-rolling piercing mill having skewed rolls by which the billet is forged and cross-rolled and advanced over a piercing point or mandrel positioned between the rolls. To produce perfect tubes, the metal in the billets must be free from non-metallic inclusions and from gas pockets or other voids and from surface scorings or imperfections. Billets made in the usual way by rolling from large ingots can be produced substantially free from such defects, but the cost of making the billets in this way is comparatively high, and is especially so for billets of high chromium ferrous alloys and other hard or difficult-to-work alloys; and the loss resulting from the production of defective tubes because of the use of imperfect billets has been very great.

The present invention comprises a method of making seamless tubes wherein a substantially solid ingot is cast centrifugally in a cylindrical mold rotating on its longitudinal axis by filling the mold with molten metal, and then a small hole is drilled or otherwise bored longitudinally through the center of the cylindrical ingot to remove the porous and impurity-containing metal, and the billet thus produced is heated and formed into a tube of the desired internal diameter and wall thickness, most desirably by passing it endwise between the skewed rolls of a cross-rolling piercing mill by which the metal is compressed and cross-rolled and advanced over a mandrel to form the tube. The invention includes a method of making billets or tube rounds.

Due to the radial centrifugal force acting on the molten and solidifying metal in the rotating mold, the results of the shrinkage are concentrated along the longitudinal axis of the ingot and nonmetallic inclusions such as slag and other impurities are moved inward to a comparatively narrow axial portion of the ingot, leaving the rest of the metal dense and pure. By boring a relatively small hole longitudinally through the axial center of the ingot, all such porous and impurity-containing metal can be readily removed. The area of this hole in an ingot so cast of reasonably pure metal need not be more than about ten percent of the cross area of the ingot, the required size of the hole depending on the purity of the metal and the shrinkage coefficient of the metal. The metal of the ingot after removing this comparatively small portion is dense and singularly free from slag and other impurities, gas pockets and other voids, and other defects commonly found in ordinary ingots and billets produced therefrom. It has been found that the physical properties of the metal in the as-cast condition are equal to and in some alloys superior to those of an ordinary cast ingot of the same metal or alloy after several forging operations.

Billets or tube rounds are readily produced in this way which are uniformly free from the imperfections which have heretofore caused high losses due to the production of defective tubes when using billets made according to the customary practice; and the cost of the billets is much less. The character or condition of the metal, due to the centrifugal action, is such that it is well adapted to withstand the severe twisting and tension stresses to which it is subjected in passing through a cross-rolling piercing mill, and due to this and partly also to the axial bore of the billet, the billets are readily converted into tubes in a cross-rolling mill even when of alloys which are extremely difficult or even impossible to pierce in the form of the usual billets produced in the customary manner.

Because of the small axial bore, less power is required in passing the billet through the piercing mill, and there is also less wear on the mandrel and guides. On the other hand, because of the smallness of the bore of the billet as compared not only to the outside diameter of the billet but also to the inside diameter of the tube as it leaves the piercing mill, the metal in passing through the piercing mill is adequately worked so as to give an additional grain refinement. For billets from 4″ to 6″ in diameter, the bore by which the porous and impurity-containing metal will be removed will ordinarily be not more than about 1″ to 1½″ in diameter. Such billets are used for making tubes having as they come from a cross-rolling tube mill an internal diameter usually of from 3½" to 6".

Some alloys tend to form large dendritic grain structures with the grains radiating from the axis of the ingot, causing points or places of weakness where the grains come together adjacent the longitudinal axis of the ingot. A further advantage of the new invention results from the fact that such portions of weakness are removed from the billet.

Tubes made by this new method are apparently equal in all respects to, if not better than, tubes made of the best obtainable billets made according to the customary practice of the same material, and in addition the cost of the billets, or rounds, and of the finished tubes made by this method is much less than with rolled billets, especially in the case of tubes made from high chromium or chromium nickel alloys.

I have referred to the ingot as substantially solid for the reason that even when the mold has been completely filled with the molten metal the ingot will have a small irregular shrinkage void or pipe extending longitudinally through the center. If the mold is nearly though not completely filled with the molten metal, such axial shrinkage void may be somewhat larger but still so small compared to the size of the ingot that the ingot may properly be termed substantially solid. In casting such substantially solid ingots the metal remains fluid in the mold for a longer time than when casting pipe even with a comparatively thick wall, and this gives a longer time for movement of impurities inward, resulting in a greater purification of the metal and concentration of the impurities in a small axial space or portion of the ingot.

Although the invention is believed to find its greatest value in the production of tubes of high chromium ferrous alloy and other metal alloys which are difficult or impossible to make into pierced tubes according to the customary method, the invention is also useful for making tubes of plain carbon steel and other metals which are relatively easy to work.

The accompanying drawing shows somewhat diagrammatically illustrative apparatus suitable for practicing the invention. In said drawing:—

Fig. 1 is a sectional elevation of the principal parts of a centrifugal casting machine suitable for casting substantially solid ingots;

Fig. 2 is a fragmentary longitudinal view, and Fig. 3 is a transverse sectional view, of one of the substantially solid ingots as it comes from the mold;

Fig. 4 is a transverse sectional view of the ingot after removal of the porous and impurity-containing metal from the axial center of the ingot; and

Fig. 5 is a plan view of the principal parts of one form of skewed roll tube mill, with a billet passing through the mill shown in section.

The casting apparatus shown by Fig. 1 comprises a cylindrical mold 10 mounted to rotate about its longitudinal axis, which may be horizontal as shown or suitably inclined. As shown, the mold is mounted within a rotor formed by a steel cylinder 11, which is supported in any suitable manner for rotation about its longitudinal axis and is driven through a shaft 12. The end of the mold into which the metal is poured is closed by a removable end-piece 13, and the opposite end of the mold is closed by a removable plug 14 which has an axial vent 15 for the escape of gas. The molten metal enters the mold from a pouring basin 16 through a spout 17 which extends through an axial opening 18 in the end-piece 13, the spout fitting closely in the opening 18.

In casting the billets, the molten metal is poured into the basin 16 and passes therefrom through the spout 17 into the mold while the latter is in rapid rotation. Because of the large mass of metal in the mold, the metal remains fluid for a considerable time, giving opportunity for slag and other impurities in the metal to move inward toward the longitudinal axis as the heavier pure metal is urged outward by the centrifugal force. As the metal solidifies, the openings or voids resulting from shrinkage will also be concentrated at and close to the longitudinal axis of the ingot. There will thus result a substantially solid ingot having a small irregular shrinkage void or pipe extending through the longitudinal center of the ingot and having more-or-less porous and impure metal closely adjacent to this opening in a central space or portion which may be roughly represented by the dotted lines in Figs. 2 and 3. Outside of this small central portion, the ingot will be of dense, pure metal. In order that the shrinkage opening through the axial center of the ingot shall be as small as possible, it is desirable that the mold be completely filled with the molten metal.

During pouring, the mold should be rotating at a rapid rate sufficient to secure quick distribution of the metal in the mold and to secure by centrifugal action the desired purification of the metal and movement of impurities toward the longitudinal axis. The rate at which the mold should be rotated will vary according to the diameter of the ingot and the nature of the metal being cast. The greater the diameter of the ingot, the lower the R. P. M. To avoid surface cracks, when the surface metal has cooled adjacent the mold surface the speed of rotation should be reduced. As an example, for casting a 5" ingot 10' long, the mold should be rotating at from 500 to 1200 R. P. M. during pouring. Assuming that the pouring takes about 15 seconds, the speed of rotation should be cut down in about 40 to 50 seconds from the time pouring starts to about half or less, and the mold should then be kept rotating at this relatively slow speed until the metal is completely solidified.

In order to remove the porous and impurity-containing metal from the longitudinal center of the ingot, a small hole, as shown by Fig. 4, is drilled or otherwise bored longitudinally through the center of the ingot. The hole should be as small as is sufficient to remove the porous and impurity-containing metal. Ordinarily, the cross-area of the hole of sufficient size for this purpose will be, as stated, not more than about 10% of the cross-area of the ingot.

The billet, or tube round, is then ready to be formed into a tube of the desired inside diameter or wall thickness, except for the removal of oxide formed on the surface of the ingot and any slight surface imperfections. This may be accomplished by machining off the outer surface, or by grinding or chipping out the defects, or by merely pickling if the surface is sufficiently smooth except for oxide which will be thus removed.

If the billet is to be formed into a tube in a rolling mill, it goes to the mill in its as-cast condition, that is, without forging. Most desirably, as stated, it is passed through a cross-rolling tube mill, after being heated to a suitable working temperature, which will depend on the particular material of which the billet is formed, but will be approximately the same as is required for a rolled billet of the same material.

Any suitable form of cross-rolling tube mill may be used. The mill may, for example, be one having, as shown by Fig. 5, two conical rolls 20 and 21 carried by shafts 22 and 23 mounted with their axes at an angle of approximately 30° from the center line of the machine. In order that the rolls shall act to feed longitudinally forward a billet gripped between them, they are skewed in the usual manner, that is, set at different slight angles to a plane passing through the center line of feed of the billet and through the roll axes. A mandrel, or piercing point, 25 is held between the rolls by means of a mandrel rod 26. The roll shafts may be driven by any usual or suitable means, and the usual guides will be provided for guiding the billet as it advances between the rolls.

In the operation of the mill, the billet, guided and advanced endwise to enter its forward end between the rolls 20 and 21, is gripped by the rolls and rotated and drawn forward to force the metal over the mandrel 25, thus forming in the usual way a tube or hollow having the desired inside diameter. The tube thus formed may be further treated and finished in any usual or suitable manner.

Instead of forming the billet into a tube in a rolling mill, it may be forged into the desired tubular form, as by hammering or pressing over a mandrel in known manner.

It will be understood that the invention is not limited to the use of any particular forms of apparatus, excepting as specified in the claims. The reference to billets of from 4" to 6" in diameter is not to be taken as implying that the invention is not applicable to the making of billets of much greater diameter. And in using the term "tube" I do not mean thereby to confine the invention to hollow cylindrical articles which are of great length relative to their diameter, although I have more especially in mind the making of comparatively long tubes in a cross-rolling mill.

What I claim is:

1. The method of making seamless metal tubes, which comprises supplying to a cylindrical rotary mold an amount of molten metal sufficient to fill substantially the whole mold interior and rotating the mold rapidly on its longitudinal axis with such axis closer to the horizontal than to the vertical to produce a substantially solid ingot having impurities in the metal concentrated in a slender column containing said axis, removing the porous and impurity-containing metal by boring a small hole longitudinally through the center of the ingot, and heating the ingot and passing it endwise through a cross-rolling tube mill to form a tube.

2. The method of making seamless metal tubes, which comprises casting an ingot centrifugally in a cylindrical mold rotating on its longitudinal axis by filling the mold with molten metal, thereby producing a substantially solid cylindrical ingot of substantially pure consolidated metal except for a relatively small axial portion extending substantially uniformly along the length of the ingot containing the shrinkage voids and the impurity-containing metal, boring a small hole longitudinally through the center of the ingot to remove the porous and impurity-containing metal, and heating the ingot and passing it endwise through a cross-rolling tube mill to form a tube.

3. The method of making seamless metal tubes, which comprises making a billet by casting a substantially solid cylindrical ingot by subjecting the metal while in molten condition and during solidification to centrifugal force acting radially of the longitudinal axis of the ingot to produce an ingot having the shrinkage voids and impurities in an axial portion of relatively small cross-area extending substantially uniformly along the length of the ingot, and removing the porous and impurity-containing metal by boring a small hole longitudinally through the center of the ingot, and forming the billet into a tube of the desired inside diameter and wall thickness.

4. The method of making seamless tubes, which comprises making a billet by casting a substantially solid cylindrical ingot by subjecting the metal while in molten condition and during solidification to centrifugal force acting radially of the longitudinal axis of the ingot to produce an ingot having the shrinkage voids and impurities in an axial portion of relatively small cross-area extending substantially uniformly along the length of the ingot, and removing the porous and impurity-containing metal by boring a small hole longitudinally through the center of the billet, and forging the ingot into a tube of the desired inside diameter and wall thickness.

5. The method of making seamless tubes of high chromium ferrous alloys, which comprises casting a substantially solid cylindrical ingot in a mold rotating rapidly on its longitudinal axis to produce an ingot having the shrinkage voids and impurities in an axial portion of relatively small cross-area extending substantially uniformly along the length of the ingot, and removing the porous and impurity-containing metal from the center of the ingot by boring a small hole the cross-area of which is not more than 10% of the cross-area of the ingot, and passing the ingot endwise through a cross-rolling tube mill to form a tube the inside diameter of which is substantially greater than the diameter of said hole.

6. The method of making seamless metal tubes, which consists in making a billet by casting a substantially solid ingot of substantially the size of the desired billet with the porous and impurity-containing metal concentrated close to the longitudinal axis of the ingot and extending substantially uniformly along said axis by subjecting a solid body of molten metal while in molten condition and during solidification to centrifugal force acting radially of the longitudinal axis of the ingot and boring a small hole longitudinally through the center of the ingot to remove the porous and impurity-containing metal, and passing the billet thus formed endwise through a cross-rolling tube mill to form a tube.

7. The method of making tube rounds, which consists in casting centrifugally a substantially solid ingot in a cylindrical mold rotating on its longitudinal axis to produce an ingot having the shrinkage voids and impurities in an axial portion of relatively small cross-area extending substantially uniformly along the length of the ingot, and boring a small hole longitudinally through the center of the ingot to remove the porous and impurity-containing metal.

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