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PRODUCTION OF SOUND INGOTS

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My invention relates to the production of sound steel ingots and has particularly in view certain operating conditions that I have discovered are beneficial and of great utility. In my prior application, S. N. 318,190, filed November 9, 1928 and in my French Patent No. 666,567 and my British Patent 342,716, I have disclosed an apparatus and method for the production of sound steel ingots by jarring the metal in the ingot mold during pouring. In that apparatus, I jar the metal from the beginning of pouring, with a regulated rise and fall of one half an inch and at the rate of approximately 60 rising and falling jars per minute. Steel that is subjected to this treatment is remarkably free from slag inclusions.

In carrying out my aforesaid method of jarring in actual operation, I have discovered that steel can be poured at much higher temperatures than heretofore, i. e., in a superheated condition, and that high carbon steels i. e. containing from .15 C. to .60 C. can be poured without being "killed".

It is desirable to pour steel at as high a temperature as possible, thereby eliminating the skulls in ladles and other wastage from too quick chilling of the metal. The higher the temperature, however, the greater the amount of occluded gases in the metal. If the steel is too hot when poured into the ingot mold, the metal becomes "wild" and is projected out of the mold due to the rapid escape of occluded gases.

Since the metalloids or alloying materials are added in the ladle, a heat tapped at normal or below normal temperature will have a tendency to leave some undissolved manganese, which in turn causes segregation and lamination, thereby causing serious loss in the finished product. Heats tapped at or below normal temperature have a tendency to hold the non-metallic inclusions in suspension, but steel tapped at a higher temperature will cause a coagulation of the non-metallic inclusions which consequently rise to the surface and are thrown off. By jarring the metal in the mold during the pouring and in accordance with my invention, the metal in the mold is kept in constant agitation, so that any gases liberated can be expelled through the open top, and I am thus enabled to pour at the higher temperature with its attendant advantages. Furthermore, as the metal is cooled, it loses its power for retaining the dissolved gases and much gas is consequently given off, but the body of the ingot is already solidified to the point where it is impossible for the gas to escape through the top and as a result blowholes are formed. The amount of gases held in solution is dependent upon conditions under which the heat was made, the tapping temperature, teeming temperature and the carbon and manganese content of the heat.

Steel to which a deoxidizer, such as silicon, has been added in the ladle is known as "killed" steel, meaning that it is completely deoxidized. Other steel is known as "open steel".

High carbon steel i. e. containing above .15 C., when poured without jarring must be "killed", due to the large amount of dissolved gases in the metal. By jarring when pouring, I have discovered that I can make "open" steel up to .60 C. By making such steel "open" the yield can be substantially increased and a better product for bending purposes produced than with silicon or aluminum "killed" steel.

To the experienced open hearth operator, the mould action of steel is a very positive indicator of the quality of the heat. From experience it has been found that ingots that "drop" or "sink" one or two inches in the moulds are usually thick skinned, which means deep seated blow-holes, consequently producing a better quality product; but ingots which "rise" or "grow" in the mould are thin skinned and have blow-holes very close to the surface. This type of ingot produces a seamy and scabby product, unfit for a good quality product. Very often due to furnace conditions and the manner in which a heat was "worked down", a heat will drop in the moulds and then immediately begin to rise again. This also produces a very inferior product. Higher carbon "open" steels all have a tendency to grow in the moulds. This is particularly true of steels ranging from

.15 to .65 carbon. Heats tapped excessively hot also have a tendency to grow in the moulds. By jarring the metal in accordance with my invention, it does not "grow" or "rise" in the moulds, regardless of the tapping temperature or the carbon content.

Tapping steel at a higher than normal tapping temperature, i. e., in a superheated condition has long been the aim of open hearth operators, as there are a number of advantages to be gained, which are all offset if a heat is produced which rises in the moulds and causes the formation of a thin skinned ingot. It is therefore evident that by jarring, the mould action of a heat tapped at a higher than normal temperature can be controlled to produce ingots "down" in the moulds, which will insure ingots reasonably free from segregation below the crop, uniform composition and comparatively free from non-metallic inclusions, with a crystal structure widely different than non-jarred ingots, caused by the setting of the crystals under the jar of the machine. .15 to .65 carbon steel shows a very marked tendency to "rise" in the moulds, regardless of whether tapped on the high or low side of standard tapping temperature, but by jarring the same beneficial results will be realized as noted for steel in the low carbon range.

The average open hearth practice is to tap heats at a temperature so that a small skull remains in the ladle after the heat has been poured. The weight of the skull is used as an indicator of the tapping temperature with a good tap. Since the temperature of the metal in the moulds is directly responsible for the type of mould action, it is the aim of steel makers to keep heats down in the moulds by tapping at standard or below standard tapping temperature. The resulting product, naturally shows the defects which accompany cold heats. Heats tapped above normal tapping temperature eliminates all skulls and by the use of the jarring machine, ingots tapped considerable above normal tapping temperature, i. e., in a superheated condition can be made to drop in the moulds, which produces thick skinned ingots; whereas, heats tapped above normal tapping temperature and poured straight will rise in the mould consequently producing thin skinned ingots.

Thick skinned ingots can be produced regardless of how high the tapping temperature may be, although the extreme temperature possible in an open hearth furnace is but 300–350 degrees higher than the normal tapping temperature.

To determine whether the metal in the furnace is at normal tapping temperature or above or below normal, the experienced open hearth furnace operator may use different tests.

One of these is known as the spoon test. A long handled spoon or dipper of about the capacity of a drinking cup is inserted into the furnace and a spoonful of the slag which covers the bath is withdrawn. The spoon is manipulated so as to secure an even coating of slag over the entire inner portion of the spoon. After this layer of slag has hardened, a second layer of slag is applied in the same way as the first layer. The spoon is then inserted deeply into the bath and a spoon full of molten steel is withdrawn and is poured very slowly on the floor in front of the furnace. If a portion of the metal adheres to the slag covered spoon, the metal is below normal tapping temperature. The amount below the normal tapping temperature is determined by the amount of steel left in the spoon. If the metal clears the spoon, and does not cut the slag on the spoon, the heat is at a normal tapping temperature. If the metal clears the spoon but cuts out the slag on the spoon at the point where the metal is flowing out, the heat is above the normal tapping temperature. The amount above the normal tapping temperature is governed by the depth the slag is cut out.

Another test is known as the rod test. A steel rod 1¾″ square is inserted into the furnace through a small opening in the door, and the operator keeps the rod in motion by moving it to and fro very slowly until the portion immersed in the liquid steel is burned off. The balance of the rod is then withdrawn and the condition of the burned end is noted. If the end is pointed or "rat tailed" the heat is below normal tapping temperature. If the end is burned off square the heat is at normal tapping temperature. If the end is burned off square but the corners of the rod, within a foot of the end, are chewed or bitten out, the heat is above the normal tapping temperature.

Assuming that the heat is in the ladle and the mould conditions are normal, the steel pourer sets the jarring machine in operation before the stopper is opened, which allows the metal to flow into the moulds. The rate of jarring is of uniform speed throughout the operation. The speed however, is dependent upon the size ingot to be jarred. The smaller the ingot the more rapid the jar required. A deep narrow ingot requires a quicker jar than a shallow wide ingot. In the latter case, as low as twenty-four rising and falling jars may be sufficient.

From the above description it will be clear that my jarring process produces surprising results in connection with certain operating conditions for the production of steel ingots as will be hereinafter more particularly set forth in the appended claims.

In my aforesaid copending application I have disclosed and claimed a method of jarring steel upon which my herein described discoveries are an improvement. I do not

claim, broadly, herein that method of jarring steel, although it may be used in connection with the claimed improvements.

I claim

1. The method of producing high carbon steel ingots containing from .15 carbon to .60 carbon that are "flat" or "down" in the mold and have a thick skin and deep seated blow-holes, comprising jarring in the mold the high carbon steel which is made "open".

2. The method of producing high carbon steel ingots containing from .15 carbon to .60 carbon that are "flat" or "down" in the mold and have a thick skin and deep seated blow-holes, comprising jarring in the mold the high carbon steel, which is made "open" and is jarred from the beginning of pouring in order to keep it in such agitation as will eliminate the large amount of occluded gases through the open top of the mold before solidification of the metal, thereby inhibiting the "growing" or "rising" of the metal in the mold.

3. The method of producing steel ingots that are "flat" or "down" in the mold and have a thick skin and deep seated blow-holes comprising superheating the steel, pouring the steel in the mold in the superheated condition and jarring the steel in the mold from the beginning of pouring in order to keep it in such constant agitation as will eliminate the large amount of occluded gases through the open top of the mold before solidification of the metal, thereby inhibiting the "growing" or "rising" of the metal in the mold.

4. The method of producing high carbon steel ingots containing from .15 carbon to .60 carbon that are "flat" or "down" in the mold and have a thick skin and deep seated blow-holes, comprising superheating the steel, pouring the steel in the mold in the superheated condition, and jarring in the mold the high carbon steel, which is made "open" and is jarred from the beginning of pouring in order to keep it in such constant agitation as will eliminate the large amount of occluded gases through the open top of the mold before solidification of the metal, thereby inhibiting the "growing" or "rising" of the metal in the mold.

In testimony whereof I affix my signature.

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