Patented May 28, 1946 2,401,075

UNITED STATES PATENT OFFICE

2,401,075

PROCESS OF CASTING INGOTS

George Walter Humes, Sharon, Pa., assignor to Carnegie-Illinois Steel Corporation, a corporation of New Jersey

No Drawing. Application May 6, 1942, Serial No. 441,954

5 Claims. (Cl. 22—200)

In the casting of ferrous metal ingots, the importance of elimination of internal defects in the casting and the obtaining of a maximum mold life have been given considerable study and attention, because, obviously, the minimizing of internal defects in the ingots and maximum possible mold life mutually contribute importantly to increased production, which in times of emergencies is of paramount importance.

The present invention introduces an additional factor to the above considerations in that it not only reduces internal defects in the ingots and increases mold life, but also increases production by enabling a more rapid stripping of the cast ingots from the molds, thereby preparing the molds more quickly to receive further charges of metal, consequently reducing very materially the casting time, and also, through the rapid transfer of the ingots from the molds to the soaking furnaces enables the attainment of substantially improved operating economies and increased efficiencies.

In the usual casting of ingots, it is customary, when the molds employed are of the big-end-down type of molds, to remove the cast ingot by stripping the mold off the ingot by holding the ingot down while the mold is being lifted forcibly from the ingot, the ram or plunger of the stripping crane bearing against the ingot during the lifting of the mold.

Consequently, it has been considered essential that the solidification of the ingot must have reached completion in the mold, the length of time required for this solidification depending obviously upon the size of the ingots. Thus, for an ingot measuring 21 inches by 23 inches in cross section this length of time averages from about 90 minutes to 120 minutes.

In accordance with the practice of the present invention, this complete solidification of the ingot in the mold is not required, as the invention is based upon the discovery that a thick solidified layer may be produced at the top of the ingot by chilling the ingot adjacent its top, thereby solidifying enough metal to withstand the holding pressure of the ram of the stripping crane during lifting of the molds from the ingot, leaving the interior of the ingot still molten. In this condition the ingots are transferred to the soaking pits while the ingot is still partially molten, resulting in there being required less fuel and time for the heating of the ingots to rolling temperature.

It will be apparent, therefore, that the present invention relates to a method of solidifying ferrous metals, and more particularly killed ferrous metals as poured into open-topped ingot molds.

By the operation of the present invention, there is enabled to be obtained a substantially higher yield of sound product after the ingots are rolled, and at the same time, securing other important operating advantages, such as increased life of the ingot molds; quicker moving of the molds from the pouring platform; having the ingots hotter as charged into the soaking pits; less fuel and time required for heating the ingots to rolling temperature, and thus practically doubling the effective capacity of the soaking pits; requiring less scaling and damage to the surfaces of the ingots during such heating; and finally obtaining a much shorter time interval between the pouring of the ingots and their rolling in the mill, thus reducing delays on the mill while waiting for hot ingots to roll.

In general, the present invention consists of the following three essential steps, the combination of the second and third of which is contrary to the teaching of the prior art and prior mill practices:

1. Pouring a killed ferrous metal in an open-topped mold.

2. Allowing the metal to cool in the mold for a length of time sufficient to cause non-metallic inclusions to rise to a point adjacent to the top of the ingot, and thereafter,

3. Rapidly chilling or cooling the top of the ingot with any effective cooling medium, such as water, so as to solidify the areas containing the non-metallic inclusions.

As has been pointed out above herein, the practice of the present invention is particularly applicable to big-end-down molds, since, as is well known, this type of mold tends to produce an elongated pipe or shrinkage cavity in the ingot, which, if it is contaminated with non-metallic matter, will not weld when the ingot is rolled, thus causing large losses for laminations.

In the operation of the present invention, it is preferred to equip the molds with any suitable type of "hot-top" to assist in keeping the steel liquid in the top of the ingot until the step of causing it to solidify is completed. Additionally to assist in keeping the steel suitably liquid, it is preferred to cover the top of the steel, after the ingot is poured, with a suitable insulating medium, such as small-sized anthracite coal, crushed brick, and the like. The foregoing are preferred provisions, but it will be understood that these steps are merely to assist in obtaining

the maximum benefit from the invention and that at least certain of the benefits can be secured without their aid.

The length of time which is allowed to elapse between pouring the ingot and applying the cooling medium is not particularly critical, since some of the non-metallic matter rises to the top almost as soon as the ingot is poured, and this separation may continue until the ingot is solidified completely. In the practice of the present invention, however, it is found that substantially all of the benefits of the present improved procedure are secured by using a time interval of 20 to 45 minutes for an average size ingot, for instance, 21 inches by 23 inches in cross section, although substantial benefits are secured by shorter or longer times, and smaller or larger ingots could employ proportionately shorter or longer time intervals.

It will be obvious that the choice of a cooling medium is of convenience only, and may be a gas, or liquid, or solid, since the whole object of the cooling step is to entrap the non-metallic metal in the top of the ingot by causing it to solidify, so that it cannot drain down into and contaminate the lower parts of the central shrinkage cavity.

It is found in practice that the method of the present invention is applicable to ferrous metals of any analysis, but is particularly beneficial when used with steels which tend to have large or deep shrinkage cavities. Steels having considerable silicon content, for instance, 0.10% or more, especially are benefited, as are those steels which are killed by the use of killing agents in amounts sufficient to fully kill, or "over-kill" the steel, such as is the case with "fine-grain" or "non-aging" steels.

The former practice in making fully killed steels usually has been to allow the hot-topped ingots to solidify completely at the pouring platform without moving the molds. For ingots 21 inches by 23 inches in cross section this waiting period usually requires at least 90 minutes, and more often 120 minutes, as has been indicated above, as compared with, for instance, 20 to 45 minutes, required for the same size of ingots in accordance with the practice of the present invention. The reasons for the usual practice of causing the ingots to solidify completely before removing from the mold have been, first, the fullest possible feeding of liquid metal from the hot-top to the ingot proper was believed to be essential, and this could be achieved only by waiting until all of the metal had solidified; second, in the case of big-end-down molds, since the metal in the hot-top was the last to solidify, any attempt to strip the mold off the ingot while this latter was not fully solidified, by using the ram or plunger of the stripping crane to hold the ingot down while the mold was being lifted forcibly off the ingot, would cause the ram to be forced into the still-liquid metal of the hot top and the liquid or mushy metal of the ingot proper, thus producing a large hole in the upper part of the ingot, and this portion of the ingot, of course, would be rendered worthless.

In accordance with the present improved process, there is caused a substantial layer of steel to solidify above the still-liquid metal in the ingot proper, so that the ingot can be moved to the stripping crane, the mold stripped off, and the ingot charged into the soaking pit while the ingot still is partly molten, all without damage to the ingot, since the stripper ram will not be forced through this solidified layer of steel.

It is this promptness with which ingots made by the improved process of this invention can be handled and further processed after pouring, that produces the substantial operating benefits referred to earlier herein, such as longer life of ingot molds, for example. In this connection it may be noted that mold life is reduced somewhat in proportion to the time during which the white-hot ingots remain in the molds. Other advantages have been mentioned above, such as less pouring platform surface required, ingots delivered hotter to the pits, requiring less fuel and heating time, with greater resultant capacity of the soaking pits, and fewer mill delays, all of which follow from the quicker handling of the ingots made by the improved process, as will be apparent.

The reason for the success of the improved operations is not definitely known, but apparently when water is applied to the top part of the ingot in the manner described above, it permits the ingot to be stripped and charged into the soaking pits before a secondary internal contraction of the metal takes place. Apparently also, the hot top acts as it is expected to do, that is, as a reservoir of liquid steel to fill up any void caused by contraction, but by the process of the present invention the outside skin of the ingot is shrunk to a greater degree than in normal cooling so that there are less voids permitted to form within the ingot. The process of solidification appears to be, first, contraction of the skin of the ingot, followed by a secondary contraction from the inside outwardly, so that any increase in the outside contraction would reduce the seriousness of the inside contraction. Apparently, also, in the present process, the greatly reduced time from pouring to rolling which is obtained by the present invention prevents some of the secondary contraction taking place, and the steel may be somewhat mushy in the center when rolled, thus permitting a compression of the center of the ingot and elimination of voids.

As has been indicated above herein, production is increased substantially by the method of the present invention. The present invention also enables a rapid moving of the ingots through the soaking pits and a substantially effective doubling of ingot capacity in the same pits coupled with about 25% to 30% longer mold life than heretofore. Additionally, the process of the present invention results in substantially decreased fuel consumption for resoaking.

I claim:

1. The process of producing ferrous metal ingots of killed metal, which comprises pouring the killed metal into open-topped molds, providing a hot top for each of the molds, allowing the metal in the molds to stand until at least the major portion of the non-metallic inclusions rise to the top of the metal, chilling the metal adjacent to the top portions thereof until a solidified layer of substantial thickness is formed at the top of the ingot sufficient to withstand pressure exerted thereon by a plunger of a stripping ram employed to remove the mold, removing the mold from the ingot while the said ingot is still molten internally, and transporting the still partially molten ingot to a soaking pit.

2. The process of casting ferrous metal ingots of killed metal, which comprises casting molten metal into and open-topped mold provided with a hot top, allowing the metal to stand until segregation of the non-metallic inclusions rises to a point adjacent to the top of the metal in

the mold, applying a chilling method to the upper portions of the metal in the mold until there is formed a solidified layer of metal of sufficient thickness to withstand holding pressure of a plunger of a stripping ram while the ingot is still interiorly molten, stripping the said mold from the interiorly molten ingot and transferring the ingot while still interiorly molten to a soaking pit.

3. In the casting of ingots of killed steel, the improvements which consist in applying a chilling medium to the upper portion of molten metal contained in a hot top mold until a solid layer of substantial thickness is formed on the top portions of the metal while leaving the metal interiorly molten, and removing the thus partially solidified ingot from the mold.

4. In the casting of ingots of killed steel, the steps which consist in pouring molten killed steel into an open-topped ingot mold, mounting a hot top for the mold allowing the molten steel to stand in the mold until segregation of non-metallic inclusions rises to a point adjacent to the top of the molten steel, chilling the top portions of the molten steel to cause solidification of a substantially thick layer of solid steel thereon, while leaving the ingot interiorly molten, and removing the resulting partially solidified ingot from the mold.

5. In the casting of ingots of killed steel, the steps which consist in pouring molten killed steel into an open-topped ingot mold, mounting a hot top for the mold allowing the molten steel to stand in the mold until at least the major portion of inclusions have risen to the top of the molten steel, chilling the top portions by directing water against the said top portions to cause solidification of a substantially thick layer of solid steel thereon, while leaving the ingot interiorly molten, and removing the resulting partially solidified ingot from the mold.

GEORGE WALTER HUMES.