

UNITED STATES PATENT OFFICE.

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PRODUCTION OF RIMMED STEEL INGOTS.

No Drawing.

Application filed February 8, 1927. Serial No. 166,816.

This invention relates to the manufacture of "rimmed steel".

One of the objects of the invention is to provide for the beneficiation of rimming steel ingots by the addition thereto, of certain agents.

Another object of the invention is to provide a more solid rimmed ingot, i. e., one that is freer from blowholes, than has heretofore been obtained, and in which such defects as "black butts" are more or less completely obviated.

These and other objects of the invention will appear in the course of the following discussion of rimmed ingots in general and particularly the causes leading to the above-mentioned defects.

As is well known, rimmed steel, variously called open or effervescing steel, to distinguish it from killed or partly killed steel, is made by a process which permits the free escape of gases from the metal during solidification in the molds. These gases are believed to be chiefly carbon monoxide, hydrogen and nitrogen, and in the course of their evolution, the ingot solidifies, those gases which remain and are occluded, forming blowholes of varying form and character. Some of the blowholes are close to the surface of the ingot and extend from the surface toward the center of the ingot, giving a sponge-like appearance to the skin, and which in many top-cast ingots makes the lower half appear much darker in color than the top half when it is stripped from the mold. Ingots presenting this defect are commonly designated "black butt ingots." An ingot with this kind of skin will tear and crack under the action of the rolls and produce a scabby and seamy bar, unfit for most purposes.

The evolution of the escaping gases is apparently caused by the reaction between the iron oxide and the carbon present in the molten steel ($C + FeO \rightarrow Fe + CO$). The proper rate of their evolution is such that the steel will not rise as it solidifies and the ingot has a flat top when frozen. The casting temperature and the rapidity of pouring have a great effect on the evolution of these gases.

Generally speaking if the temperature is moderate and the slag on which the heat was

made was of medium heaviness, then the ingots will fall 2" to 3" in the molds and remain there, freezing over to a distance of 5" to 6" from each side (in a 15" x 16" ingot). As the reaction diminishes in intensity, the metal is forced through the hole in the center of the crust and the action ceases.

The following factors modify the conditions accompanying freezing:

A. Those which tend to make the ingot fall in the molds:

1. Heating to the cool side of "normal" temperatures (not too cold or the ingot will simply freeze in situ).

2. Finishing heat on a thin slag.

3. Having a low carbon and manganese content in the steel.

B. Those which tend to make the ingots rise in the molds:

1. High temperature.

2. Heavy slag.

3. High carbon and manganese.

It is the balance between the above factors that determines the rise or fall of the ingot, or as happens in many cases, the rise after a fall. "Falling in the molds" is usually accompanied by a prolonged reaction and rimming proceeds to a small hole. "Rising in the molds" is accompanied by a short period of action, and rimming proceeds to a large hole.

Owing to the cessation of the reaction in such cases before the bulk of the metal has reached the point of solidification, the subsequent evolution of gas at the critical change of gaseous solubility from the liquid to the solid state has no free path for its escape. (The stirring action due to "effervescence" would permit the free passage of such gases from the metal.) The inability of the gas to escape gives rise to the formation of blowholes.

The essentials for the production of good rimming steels are therefore (a) to have "clean" steel by making it under a good creamy slag and (b) at the same time to give a sufficient period of reaction to the metal in the molds to permit the escape of gases at the change of state. It follows that an agent which will prolong this period of reaction, and preserve the fluid condition so necessary for the release of the gases, will

materially enhance the character and appearance of the ingot.

With the above considerations in view, I recently made a series of exhaustive experiments to ascertain the effects of various addition agents on rimming ingots. Among such agents were baking powder, chrome ore, roll scale, sodium chloride, and fluorspar and other fluorides such as sodium and barium fluoride.

Chrome ore and roll scale had some slight beneficial effects but the fluorides and especially fluorspar proved to be the only agents which gave highly effective and satisfactory results. The tests made in connection with the use of the fluorspar were briefly as follows:

An 85-ton basic open hearth heat containing .12 carbon and .50 manganese, was poured into sixty 15" x 16" ingot molds, approximately 55 to 60 inches in height, and each holding approximately 3100 lbs. of metal.

Only five of the ingots were treated and of those remaining, the average ingot fell 1" in the molds and rose again from 1½ to 2 inches, and rimmed to a 5½ x 6½ inch hole. The rimming period of nine of the untreated ingots was carefully observed, and the average period from the finish of the pouring to the completion of the rimming action for these ingots was found to be 9 min. and 35 seconds. These ingots rimmed to a 5½ x 6½ inch hole.

Additions of about 1 ounce of commercial ground fluorspar were made to five of the ingots, and the observed result were as follows:

Ingot No.	41	42	43	44	45
Rimming time...	10 min. 20 sec.	10 min. 50 sec.	10 min. 40 sec.	10 min. 45 sec.	10 min. 50 sec.

All of these ingots fell 2 to 3 inches in the mold and remained at this level. They rimmed to a 3" x 4" hole. The smallest addition of fluorspar was made to ingot No. 41, which fact probably accounts for the slightly shorter period of rimming than observed for the other four ingots. These five ingots tended to rim downward and when capped were free from all "puffiness", while the untreated ingots rimmed upwards and exhibited "puffed tops".

The treated ingots comprised the second batch of five stripped, and were easily differentiated from the untreated ingots by their light colored butts, as compared with the dark appearing butts of the third batch which was stripped five minutes later. Ten minutes after twenty ingots had been stripped, it was seen that in the untreated ingots (those stripped immediately after the five treated ingots were stripped), a similar

condition of darkness extended six inches higher up the butt than in the case of the treated ingots.

In practice it is desirable to vary the amount of fluorspar or other fluorides employed, from 1 to 6 ounces per 3000 lbs. of metal, although the smaller amount is usually sufficient to produce effective results. The fluorspar is preferably added to the mold after a small amount (about 6 inches) of the metal has been poured.

It is to be understood that the invention is not restricted to the mode of application of the fluorspar to the molds, and that while all fluorides may not be effective to produce the desired results, those which have been employed are especially effective, and I therefore believe that I am entitled to claim the use of fluorides in general, and fluorspar, specifically, for the purposes stated. It is obvious also that the fluorides might be added to the molten metal in the ladle, prior to pouring the latter into the ingot molds, without departing from the scope of the invention.

I claim:

1. The method of enhancing the character and surface appearance of rimming steel, which comprises adding a fluoride in the proportion of 1 to 6 ounces of fluoride to 3000 lbs. of steel, to the molten steel, subsequent to tapping it from the furnace.

2. The method of enhancing the character and surface appearance of rimming steel, which comprises adding fluorspar in the proportion of 1 to 6 ounces of fluorspar to 3000 lbs. of steel, to the molten steel, subsequent to tapping it from the furnace.

3. The method of enhancing the character and surface appearance of rimmed steel ingots which comprises adding a fluoride in amounts varying from 1 to 6 ounces per 3000 lbs. of steel, to the ingot molds at the time the ingots are poured.

4. The method of enhancing the character and surface appearance of rimmed steel ingots which comprises adding fluorspar in amounts varying from 1 to 6 ounces per 3000 lbs. of steel, to the ingot molds at the time the ingots are poured.

5. The method of making rimmed steel ingots which comprises pouring steel of rimming qualities into an ingot mold, and adding thereto a fluoride in amounts sufficient to prolong the rimming action of the steel.

6. The method of making rimmed steel ingots, which comprises pouring steel of rimming qualities into an ingot mold, and adding thereto fluorspar in amounts sufficient to prolong the rimming action of the steel.

7. The method of making rimmed steel ingots, which comprises adding to a ladle containing steel of rimming qualities, a fluoride

in amounts sufficient to prolong the rimming action of the steel, and then pouring the steel into ingot molds.

8. The method of making rimmed steel ingots, which comprises adding to a ladle containing steel of rimming qualities, fluor-spar in amounts sufficient to prolong the rimming action of the steel, and then pouring the steel into ingot molds.

9. The method of controlling the evolution of gases from basic open hearth low

carbon "rimmed-in" steel, which consists of the addition of fluor-spar to the steel in the ladle.

10. The method of controlling the evolution of gases from basic open hearth low carbon "rimmed-in" steel, which consists of the addition of fluor-spar to the steel in the molds.

In testimony whereof I affix my signature.

ARTHUR TREGONING CAPE.