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METHOD OF TREATING LOW CARBON
OPEN HEARTH STEEL

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This invention relates to low carbon open hearth steel and more particularly to the deoxidation or degasification thereof.

5 In the making of those special grades of low carbon open hearth steel containing unreacted or alloyed aluminum in excess of the amount required to fully deoxidize (that is, to fully kill or degasify) the steel, much difficulty has heretofore been encountered in securing a substantially complete removal, from the steel, of the reaction products of the deoxidizing agents used. The effect of these entrapped reaction products has been to impair the cleanliness, and therefore the surface perfection and physical properties, of the products made from these special grades of low carbon open hearth steel.

15 The problem of securing adequate cleanliness in medium and high carbon steel (higher than 0.15% carbon) has not been so difficult as in the case of low carbon steels, due to the smaller amounts of oxygen present in the former steels, and therefore the smaller amounts of deoxidation products formed. When the steels contain less than 0.06% carbon, the difficulties have been very great.

25 It will be understood that the present invention is not concerned with the common and widely used grades of steel known as "semi-killed," and also all those special grades of fully killed low carbon steel wherein the presence of an excess of unreacted or alloyed aluminum is not an essential requirement.

35 Heretofore, the complete deoxidizing of these special grades of low carbon open hearth steel containing excess aluminum, has, so far as I am aware, been performed by adding the required amount of aluminum, with or without other deoxidizing agents, to the furnace, runner or ladle, to the exclusion of the molds.

40 I have discovered that the difficulty encountered in securing a substantially complete removal of reaction products from the steel can be overcome if the steel is deoxidized by adding the deoxidizing agent or agents in two portions, separated by the longest practicable time interval, rather than by making the deoxidizing addition wholly at any one time as in prior art practice, with the further provision that the first addition must be so adjusted in amount as to leave a very substantial proportion of the iron oxide, originally in the steel, in an unreacted state. This first addition may consist of any usual deoxidizing agent or agents. Provided further that this second addition, in addition to other deoxidizing agents if desired, must con-

tain an amount of aluminum sufficient in itself to react with all of the iron oxide still remaining in the steel after the first addition, and also leave an excess of aluminum in an unreacted or alloyed condition in the steel.

5 The longest practicable time interval between the two additions is secured by making the second addition invariably in the molds, the first addition being optionally in the furnace just before tapping or in the runner during tapping, or in the ladle during tapping, thus taking advantage of the comparatively long interval between tapping and the pouring of the ingots.

10 The following is a full and complete description of the method of the present invention:

15 (a) A heat of low carbon steel is made in the usual way in the open hearth furnace.

20 b) To the heat, before or while tapping into the ladle, one or more deoxidizers are added, which may be aluminum, ferro-silicon, titanium, or other usual and effective deoxidizing agents, singly or in any suitable combinations, but in total amount substantially less than is required to combine with all the oxygen contained in the steel. I prefer to limit these additions to between 50% and 75% of the total amount needed to fully deoxidize the steel. I usually prefer to make these additions to the runner or ladle rather than in the furnace, although this is optional.

30 (c) To the ingot molds, while the heat is being teemed thereinto, I then add enough additional aluminum, with or without other deoxidizers, to fully deoxidize the steel, and leave an excess in the unreacted or alloyed condition.

35 (d) The ingots are then further processed in the usual manner into any desired product.

While I have found that the greatest benefits of my process are secured when not less than 50% or more than 75% of the total amount of deoxidizer or deoxidizers required to react with the aluminum is added to the furnace, runner or ladle, and the remainder, in the form of aluminum, added to the molds, a portion of the benefits of my process can be obtained when not less than 35% or more than 90% of the total amount of deoxidizer or deoxidizers required is added to the furnace, runner or ladle.

40 For the purposes of illustration, the following detailed example is submitted:

50 In a basic open hearth furnace, 75,000 lbs. of scrap, 136,000 lbs. of molten pig iron, 15,000 lbs. of raw limestone, and 22,800 lbs. of ore are charged. The heat is worked down with ore in the usual manner. There are added 925 lbs. of

ferromanganese and 625 lbs. of ferrophosphorous to the ladle during tapping, and also 300 lbs. of ferrocabor-titanium (20% titanium) and 150 lbs. of aluminum. (For complete deoxidation in the ladle, approximately 50% more of both titanium and aluminum would be required.)

In the molds, aluminum in the amount of one pound per ton of steel is added uniformly to the steel, by means of a chute, while the ingots are being teemed. Such a heat might analyze as follows:

	Per cent
Carbon.....	.09
Manganese.....	.42
15 Phosphorous.....	.081
Sulphur.....	.026
Silicon.....	.007

It will be understood that, except for the carbon limitations, the analysis of the iron or steel is immaterial.

The ingots are then heated, rolled, and further processed in the usual manner.

The following advantages are obtained by practicing the method of the present invention:

(A) The steel is much cleaner, that is, much freer from injurious nonmetallic inclusions, than similar steel produced by any other method of complete deoxidation now known to me.

(B) The steel when cast in ordinary big-end-down, non-hot-topped molds, gives a rolled product substantially free from "pipe" or "pipe laminations." This appears to be due, not to the absence of the usual upper central shrinkage cavity in the ingots, but to the fact that the pipe cavity is clean, or free from injurious nonmetallic inclusions, and thus welds during rolling.

(C) Substantially less deoxidizer is required than by the usual process of adding all of the deoxidizer to the furnace, runner or ladle, to the exclusion of the molds.

While I have described several specific embodiments of the invention, it will be seen that I do not wish to be limited exactly thereto, since various modifications may be made without departing from the scope of the invention, as defined in the appended claims.

I claim:

1. In the making of low carbon open hearth steel of not more than 0.15% carbon, the method of deoxidation which includes adding to the said steel prior to its introduction to the ingot molds substantially less deoxidizer than is required for complete deoxidation, and then adding to the steel while it is being teemed into the ingot molds a greater amount of aluminum than is required for complete deoxidation, whereby the steel contains alloyed aluminum.

2. In the making of low carbon open hearth steel of not more than 0.15% carbon, the method of deoxidation which includes adding to the said steel prior to its introduction to the ingot molds substantially less deoxidizer than is required for complete deoxidation, and then adding to the steel while it is being teemed into the ingot molds a greater amount of aluminum than is required for complete deoxidation, whereby the steel contains alloyed aluminum, the first addition of deoxidizer being between 35% and 90% of that amount required for complete deoxidation.

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