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COMPOSITION AND METHOD FOR MAKING DEOXIDIZED STEEL

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The present invention relates to a novel method for making deoxidized (killed or semi-killed) carbon steel; and, more particularly, the invention relates to an improvement in the manufacture of deoxidized carbon steels whereby deleterious inclusions produced by virtue of the added deoxidizing agent are markedly reduced. The present invention also relates to a novel flux composition for adding to molten deoxidized carbon steel for reducing the aforementioned inclusions.

In the manufacture of deoxidized carbon steel, a deoxidizing agent, usually either silicon or aluminum, is added to the molten steel in the ladle or in the ingot mold to remove the oxygen normally present. The amount of deoxidizing agent added depends upon the extent of deoxidation desired; that is whether the ultimate steel product is to be "semi-killed," in which the oxygen is only partially removed, or "killed" in which the oxygen is completely removed. For example, for the production of semi-killed steel using silicon as the deoxidizing agent, sufficient silicon is added to result in a silicon content in the finished steel of something less than 0.15%; whereas for killed steel, the contained silicon content is in the neighborhood of 0.20–0.25%. The amount of deoxidizing agent that must be added also depends upon the carbon content of the steel since the lower the carbon content the higher the melting temperature of the steel and hence the greater the ability of the steel to absorb oxygen. Furthermore, aluminum also causes the formation of fine grained steel; and, when a fine grained product is desired, the amount of aluminum required for fine graining as well as for deoxidation will be taken into consideration. In aluminum-killed steel which is also fine grained, the aluminum content of the final steel is usually less than about 0.15%, and most often between about 0.03 and about 0.07%.

At any rate, the addition of silicon or aluminum to carbon steels as aforesaid, causes the formation of non-metallic inclusions, mainly silicates or aluminates, as the case may be. To the extent these remain in the steel, they result in a faulty product. Those inclusions trapped internally tend to weaken the steel; those remaining on the surface produce sites of stress during rolling where tearing tends to occur. The problem is more acute with aluminum additions than with silicon since the resulting silicates are more easily removed from the melt than are aluminates.

Prior attempts to reduce or eliminate the stated inclusions from killed or semi-killed steels have involved the addition to the molten steel, of calcium fluoride alone or in admixture with sodium carbonate and sodium nitrate. This was normally done during teaming, that is, during pouring of the molten steel into the ingot mold. Such additions have helped to some extent, but since a relatively large amount was required (1 to 2 lbs./ton of steel) this meant the addition of much non-metallic material, which itself tended to form undesirable inclusions, unless great care was taken. Moreover, the composition containing the sodium carbonate and sodium nitrate caused excessive gassing since the composition is primarily a rimming agent for use in making rimmed steels where the formation of gas bubbles in the ingot beneath a skin (rim) of substantially carbon-free iron is the aim. In making rimmed steel the oxygen, which is normally present in steel, is not reduced or eliminated as in making deoxidized steels to which the present invention is directed.

It is, therefore, the principal object of the present invention to provide an improved method of making deoxidized (killed or semi-killed) carbon steel.

It is another object of the present invention to provide an improved method of making deoxidized carbon steel whereby non-metallic inclusions, principally silicates or aluminates, are materially reduced or eliminated.

Still another object of the invention is to provide an improved method of making deoxidized carbon steel whereby silicate or aluminate inclusions are reduced or eliminated without introducing further unwanted non-metallic impurities into the steel and without causing objectionable gassing.

A further object of the present invention is to provide novel flux compositions for addition to molten killed or semi-killed carbon steel to reduce or eliminate silicate or aluminate inclusions.

These and other objects will become apparent from a consideration of the following specification and claims.

The present invention comprises, in the manufacture of deoxidized (killed or semi-killed) carbon steel, the addition to the molten steel of a flux composition consisting essentially of an intimate mixture of from about 75 to about 90% of calcium fluoride, from about 3 to about 8% of sodium fluoride and from about 2 to about 20% of lithium fluoride, said proportions being by weight and based on the combined weight of the three stated materials.

The flux composition described above may be in the form of a free-flowing mixture of the materials in finely-divided (granular to powder) form, or the composition may be in the form of agglomerated bodies, as compressed briquettes or rolled pellets, or even in the form of fused bodies. In any event, the three stated materials will be intimately mixed, and this may be accomplished in any conventional mixing equipment. As noted in the preceding paragraph, the realtive proportions of the materials may vary somewhat. In the preferred flux compositions, the calcium fluoride will be present in an amount between about 82 and about 88%, the sodium fluoride in an amount between about 4 and about 6%, and the lithium fluoride in an amount between about 4 and about 12%, by weight, based on the weight of the three.

As stated, the field to which this invention is applicable is the manufacture of deoxidized—that is, killed or semi-killed—carbon steel. As is well known, carbon steel, as distinguished from alloy steels, is essentially an alloy of iron and carbon containing up to 1.7% carbon. Carbon steels may also contain small amounts of other elements, like up to 1.6% of manganese, up to 0.60% of silicon, up to 0.40% of copper, traces of phosphorus and sulfur, or the like. Deoxidized carbon steels, as explained previously, have had silicon or aluminum added thereto to reduce (semi-kill) or eliminate (kill) the oxygen content normally present in steel. The preparation of deoxidized carbon steel is well known and, as such, forms no part of the present invention; the invention being directed simply to the treatment of such steel while in molten form for the stated purpose.

The flux composition will, as stated, be added to the molten steel. While this addition could take place in the ladle or partly in the ladle and partly in the ingot mold, it is preferably made to the mold since it is in the mold during teeming that the preponderant inclusions are formed, and since whatever inclusion formed in the ladle can be reduced or eliminated by treatment in the mold. In accordance with recognized practice in adding ma-

terials to the mold, it is advisable to add the composition in increments, preferably in substantially equal portions, during teeming. Thus, it is advisable first to form a cushion of molten steel. Such a cushion, as known in the art, is a small puddle of molten steel laid at the bottom of the mold usually to a depth of a few (2–10) inches. The first increment of the stated flux composition may then be added, and further additions made while the molten steel is running into the mold. Preferably, the addition of the flux composition, is complete by the time the mold is filled to about the three-quarter point.

While the total amount of the present flux composition required may vary somewhat, the amount used is generally less than about 1 pound thereof per ton of steel, and, in some cases, the amount employed may be as low as about 0.1 pound per ton of steel. Most often the amount employed ranges between about 0.3 and about 0.6 pound on the aforementioned basis. In the amount stated, the present flux composition results in mild gassing but to a degree which is beneficial in removing the stated inclusions, as will be discussed further hereinafter.

The components of the flux composition, upon addition to the molten steel, coact with each other and with the aluminate or silicate inclusions, rapidly and efficiently to remove the inclusions from the main body of the steel. Thus, the silicate or aluminate, having its melting point reduced, apparently by the lithium fluoride, is converted to a thin liquid. This, in turn, is driven rapidly to the surface of the molten steel, apparently by the more volatile sodium fluoride which gasifies in the molten steel, where it becomes trapped in a floating molten slag formed by the calcium fluoride. In the slag, the inclusions—and ultimately all components of the added composition—are held in a free-flowing liquid condition so that they cannot be re-trapped in the molten steel rising in the mold.

The improvement of the present invention will be more readily understood from a consideration of the following specific examples which are given for the purpose of illustration and are not intended to limit the scope of the invention in any way.

Example I

A flux composition is prepared by mixing 5 parts of lithium fluoride, 5 parts of sodium fluoride and 90 parts of calcium fluoride (fluorspar), all parts being by weight.

To several heats of commercial carbon steel (1.08% maximum carbon), killed and made fine grain through the addition to the molten steel of aluminum, are added the above described flux composition. The additions are made during teeming, being begun after a 6" cushion of molten steel has been laid on the bottom of the ingot mold and continuing in substantially equal increments until all the flux composition has been added by the time the mold is three-quarters filled. The flux composition added is at the rate of 0.4 pound thereof per ton of steel.

Thus, with a 12 ton ingot, only 4.8 pounds of the flux composition are added by the time the first 9 tons of steel are poured, and no further flux composition is added thereafter. The ingots ranged in size from 10 to 15 tons.

Cold finished sheets rolled from typical commercial untreated ingots made in the same way, except for the addition of the flux composition, show as high as 13% rejects due to surface defects, with the average rejection rate being about 3%.

Cold finished sheets rolled from the treated ingots show a maximum of 3% rejects, with the average rejection rate being about 1.75%.

Example II

The procedure of Example I is followed including type of steel and range of ingot sizes, except that the flux composition is a mixture of 10 parts of lithium fluoride, 5 parts of sodium fluoride and 85 parts of calcium fluoride (fluorspar).

As compared to cold finished sheets made in the same manner except for the use of the flux compositions, the reject rate of cold finished sheets rolled from ingots made according to this example is reduced by about 40%.

Example III

A flux composition, prepared as in Example II, is added to several heats of commercial deep drawing carbon steel (0.04–0.06% carbon, about 0.35% manganese and about 0.01% silicon) killed and made fine-grained with aluminum. The flux is added in an amount of 0.5 pound per ton of steel, and the ingots are all 20 tons. The composition is added in the manner described in Examples I and II.

At this particular time, due to unusual problems, the steel (made in the same way except for the omission of the flux) was showing an abnormally high reject rate, due to inclusions, of 18 out of 30 coils (sheet rolled from ingot into coil form). However, coils made from ingots prepared as described above using the stated flux composition, show a reject rate of only 2 out of 30.

Modification is possible in the selection of materials and their equivalents and in the relative proportions thereof, as well as in the particular techniques used, without departing from the scope of the present invention except as limited by the claims.

I claim:

1. In the manufacture of deoxidized carbon steel the improvement, whereby inclusions resulting from incorporation of the deoxidizing agent are reduced, which comprises the step of adding to the molten deoxidized steel, in an amount between about 0.1 and about 1 pound per ton of steel, a flux composition consisting essentially of from about 75 to about 90% of calcium fluoride, from about 3 to about 8% of sodium fluoride and from about 2 to about 20% of lithium fluoride, said proportions being by weight based on the combined weight of the said three materials.

2. The method of claim 1 wherein said flux composition is added incrementally to said molten steel during teeming.

3. The method of claim 2 wherein the addition of said flux composition is begun after a cushion of molten steel is laid on the bottom of the mold and is substantially completed by the time the mold is about three-quarters filled.

4. The method of claim 3 wherein said flux composition consists essentially of between about 82 and about 88% of calcium fluoride, between about 4 and about 6% of sodium fluoride and between about 4 and about 12% of lithium fluoride; and wherein between about 0.3 and about 0.6 pound of flux composition are added per ton of steel.

5. In the manufacture of aluminum-deoxidized carbon steel the improvement, whereby aluminate inclusions resulting from the incorporation of the aluminum deoxidizing agent are reduced, which comprises the step of adding to the molten deoxidized steel, in an amount between about 0.1 and about 1 pound per ton of steel, a flux composition consisting essentially of from about 75 to about 90% of calcium fluoride from about 3 to about 8% of sodium fluoride and from about 2 to about 20% of lithium fluoride, said proportions being by weight based on the combined weight of the said three materials.

6. The method of claim 5 wherein said flux composition is added incrementally to said molten steel during teeming.

7. The method of claim 6 wherein the addition of said flux composition is begun after a cushion of molten steel is laid on the bottom of the mold and is substantially completed by the time the mold is about three-quarters filled.

8. The method of claim 7 wherein said flux composition consists essentially of between about 82 and about 88% of calcium fluoride, between about 4 and about 6% of sodium fluoride and between about 4 and about 12% of lithium fluoride; and wherein between about 0.3 and about 0.6 pound of flux composition are added per ton of steel.

9. In the manufacture of silicon-deoxidized carbon steel the improvement, whereby silicate inclusions resulting from the incorporation of the silicon deoxidizing agent are reduced, which comprises the step of adding to the molten steel, in an amount between about 0.1 and about 1 pound per ton of steel, a flux composition consisting essentially of from about 75 to about 90% of calcium fluoride, from about 3 to about 8% of sodium fluoride and from about 2 to about 20% of lithium fluoride, said proportions being by weight based on the combined weight of said three materials.

10. The method of claim 9 wherein said flux composition is added incrementally to said molten steel during teeming.

11. The method of claim 10 wherein the addition of said flux composition is begun after a cushion of molten steel is laid on the bottom of the mold and is substantially completed by the time the mold is about three-quarters filled.

12. The method of claim 11 wherein said flux composition consists essentially of between about 82 and about 88% of calcium fluoride, between about 4 and about 6% of sodium fluoride and between about 4 and about 12% of lithium fluoride; and wherein between about 0.3 and about 0.6 pound of flux composition are added per ton of steel.

13. A flux composition for reducing in molten deoxidized carbon steel, inclusions resulting from incorporation of the deoxidizing agent in the steel, which consists essentially of from about 75 to about 90% of calcium fluoride, from about 3 to about 8% of sodium fluoride and from about 2 to about 20% of lithium fluoride, said proportions being by weight based on the combined weight of said three materials.

14. A flux composition for reducing, in molten deoxidized carbon steel, inclusions resulting from incorporation of the deoxidizing agent in the steel, which consists essentially of between about 82 and about 88% of calcium fluoride, between about 4 and about 6% of sodium fluoride and between about 4 and about 12% of lithium fluoride, said proportions being by weight based on the combined weight of said three materials.

No references cited.

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