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N. P. GOSS ET AL

3,258,328

METHOD AND APPARATUS FOR TREATING STEEL

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FIG. 1

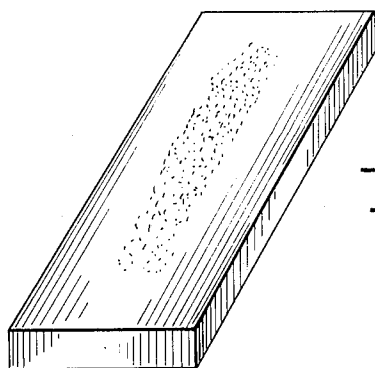
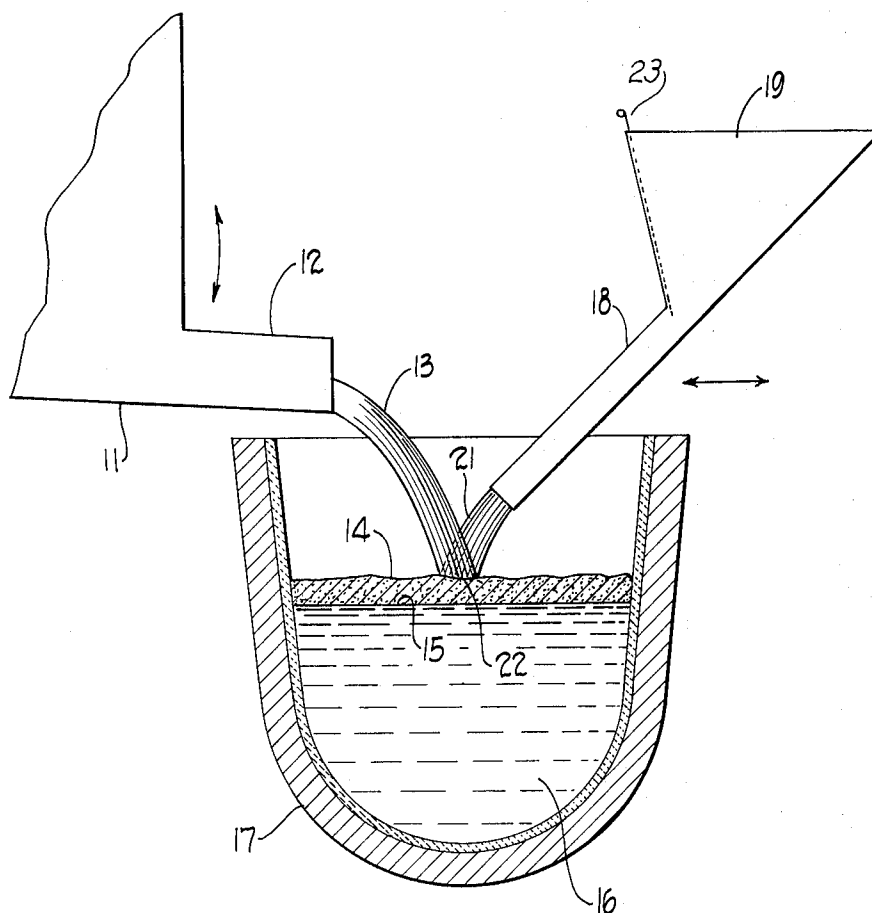


FIG. 2

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3,258,328 METHOD AND APPARATUS FOR TREATING STEEL

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3 Claims. (Cl. 75—57)

This application is in part a continuation of our co-pending application Serial No. 280,907 filed concurrently with the present application.

This invention relates to improvements in the quality of metals of a wide range of steels including alloy steels, carbon steels, etc.

The primary object of the invention is to achieve simultaneous deoxidation and desulphurization of the steel. Another object is to have the molten-formed slag absorb the inclusions, especially deoxidized products formed in a tap ladle; and, on the other hand, to make the slag-forming agent, contained in the molten steel, combine and coagulate the deoxidized products and make them float up to the top in order to obtain purified steel which contains comparatively small amount of Al_2O_3 inclusions and a very small amount of SiO_2 inclusions of the fish-eye type. Still another object is to simultaneously accomplish ingredient addition by adding the necessary amount of metallic oxides all at the same time.

It is generally known that a highly fluid slag prevents the formation of colloidal type oxides. A large portion of the colloidal type oxides remaining in the steel, not only impair the physical properties of the steel but also cause difficulty when aluminum is to be added for the purpose of controlling its crystal grain sizes, which often is an important factor in the control of steel manufacturing procedure. Also, such oxides together with sulphur tend to increase the hardness of steel and impair particularly the facility with which the steel may be worked and fabricated.

This invention was made to solve the above difficulties with apparatus devised specially for the purpose.

We have found that by reducing the sulphur content to under 0.008% and preferably under 0.006% and holding alumina under 0.003%, the process of steel production, can be controlled more easily and especially the hardness of steel, can more easily be adjusted. Another advantage is that, by the decrease of inclusions, the punchability of the steel is improved, thus making it easy to produce at a lower cost such steel sheets as may prolong, for instance, the life of dies.

The outstanding differences between the conventional methods which have been widely used to achieve these objectives and this invention, are that this invention not only achieves deoxidation, desulphurization, purification, removal of inclusions, and, if necessary, ingredient action simultaneously and effectively as stated above, but also makes it possible to add the specific flux, as explained later, in either solid or granular form, without having to make it fluid, to the molten metal stream continuously from the beginning to the end of tapping in measured quantities in such a way that it will meet with the metal

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stream at the same point on the surface of the body of molten metal and mix with it thoroughly. Another characteristic of this invention is that the proper quantities of deoxidizer, desulphurizing agents and purification agents are mixed beforehand in accordance with the particular needs of each operation.

This invention, therefore, is different from the widely adopted conventional deoxidation techniques, or Rene Perrin's method or any other techniques based on similar concept for desulphurization and purification of steel.

As a result of the proper selection of chemical constituents, particles of such small size that they melt and react instantly with the molten metal stream, and supplied slowly but continuously, it is possible to avoid the expense and additional operations of pouring metal from a great height or resorting to blowing as in Perrin Patents 2,288,836 and 2,303,064. The present invention avoids the disadvantages of violent pouring into the ladle from a considerable height to obtain thorough intermixing of the fluxing and purifying materials with the metal. It is unnecessary to melt the metal and the slag separately and to transfer molten slag from one chamber to another.

The method of this invention is applicable to deep drawing steels and steels of any grade as well as other metals.

In the past, the flux was either added to the contents of the ladle at a certain moment of tapping, or else placed in the bottom of the ladle beforehand. These cannot be considered satisfactory methods of flux addition: they have been accompanied by difficulties in accurately mixing the necessary quantity at the proper moment. It is also known that, in the worst cases, different kinds of flux have been wasted under these methods.

A better understanding of the invention will be afforded by the following detailed description considered in conjunction with the accompanying drawing in which:

FIG. 1 is a diagrammatic showing of an embodiment of the invention, partially in section, representing a part of the furnace from which the melt is poured, a tap ladle and a device for adding flux to the molten metal, and

FIG. 2 is a perspective view of a slab produced in accordance with the invention.

Operational methods of this invention, made for the purpose of improving the aforementioned defects also, are explained below, using actual operations as an example.

A stream of slag-free molten metal 13 is tapped from a spout 12 attached to a tilting-type open-hearth furnace 11 into a tap ladle 17. Deoxidizer, desulphurizing agents and purification agents comprising thoroughly mixed aluminum, calcium silicide, soda ash, fluorspar, etc. are contained in the hopper 19 equipped with an apparatus which can regulate the quantity of the flux to be added and the point of its entry into the molten steel. The chute 18 with an adjustable gate 23 attached to the hopper 19 is so arranged, as stated above, as to cause measured quantity of the addition agents to fall continuously upon the point of entry of the molten metal stream into the molten metal 16 in the tap ladle 17. Flux added to the molten metal in the tap ladle contributes to deoxidation and desulphurization, while, on the other hand, mixtures of low melting points contained in the flux would melt immediately and cover the surface of the molten slag to cover the molten metal. The molten metal poured into the

tap ladle after this layer of molten slag 14 is formed, therefore, would pass through this layer.

The chute 18 is adjusted either automatically or manually so that the flux 21 will hit the surface of the molten slag 14 and join the stream of molten metal at the same point 22 on the surface of the molten metal 15 so as to be thoroughly mixed with the molten metal 16 in the tap ladle.

As an example, in our operations with a 100-ton- (heat-per)-tap ladle, we have obtained satisfactory formation of slag, deoxidation, desulphurization, as well as excellent purification effects by using the addition agents of the following weight:

	Kg.
Calcium silicide -----	150
Calcium fluoride -----	250
Soda ash -----	250
Aluminum -----	150
Ferro manganese -----	300

The mixture of these addition agents, either in the form of lumps or granules, has been added approximately at the point of entry of the molten metal stream at the time of its tapping into the ladle. The quantity of the addition agents has been adjusted throughout the entire period of tapping, and has been continuously added at a slow uniform rate to the molten metal in order to continuously perform deoxidation, desulphurization and addition of ingredients with good effects.

A better and more complete intermixture of the addition agents and a greater economy in the use of addition agents are achieved than by intermittent surges resulting from the pouring of metal from great heights into a ladle containing slag or dumping the addition agents into a batch of molten metal.

Some of the results obtained by carrying this invention into effect are shown below: In other words, by treating the molten metal refined in the tilting-type open-hearth furnace with the above mentioned method and devices of this invention, we have obtained the following results.

Example 1

	C, per- cent	Si, per- cent	Mn, per- cent	P, per- cent	Soluble Al, percent
Before treatment.....	0.050	tr.	0.10	0.010	-----
After treatment.....	0.065	0.30	0.34	0.008	0.02

Example 2

	C, per- cent	Si, per- cent	Mn, per- cent	P, per- cent	S, per- cent	Sol. Al, per- cent
Before treatment....	0.08	tr.	0.09	0.012	0.015	-----
After treatment.....	0.08	0.32	0.36	0.009	0.008	0.02

In comparison with steel produced by the conventional method, the steel produced by using the method of this invention showed at 50% decrease of oxidized inclusions.

Microscopic examination has proved that the steel produced by this method is of extremely improved structure and purity, and that the very small quantity of inclusions remaining are all of the well-known, glossy fish-eye type and not finely divided, colloidal dispersions. The ingots obtained have been rolled into slabs in the usual way and the surface of the slab has been found to be exceptionally smooth.

It is needless to say that such elements as C, Si, Mn, etc., are to be adjusted, as required, during the process of melting and by the quantities of the alloys to be added,

but in the aforementioned cases the elements have been added in quantities and method as described above. Ingots, moreover, produced by this method have wide applications in improving the quality of alloys and carbon steels. They are particularly useful in the manufacture of hot and cold rolled steel plates, tin plates, silicon steels, etc. that require superior workability and tensile strength.

The addition agents to be used in connection with the method covered by this invention in order to obtain best results, should comprise, as deoxidizing and cleaning agents for example, calcium silicide, calcium fluoride and soda ash mixed at the ratio of 2-6 kg., 1-3 kg., and 1-3 kg., respectively, for a ton of steel; or 3-5 kg. of soda ash mixed with 3-6 kg. of calcium fluoride also for a ton of steel.

The usual sizes of these addition agents are 10 to 50 mm. in diameter for aluminum and manganese alloys and less than 10 mm. in diameter for other slag forming and purifying agents. For this invention to be practiced with good effect, however, it is recommended that the sizes of these agents be made as small as possible.

This is important in order that the addition agents will melt quickly. The flux introduced in solid form becomes highly fluxed at the base of the stream. Consequently, corrosive ingredients such as soda have performed their office and their potency is spent before they reach the ladle refractory and can attack it.

The soda ash may be replaced in whole in part by some other desulfurizer, such as for example, sodium hydroxide, magnesium hydroxide, or the like.

Another important matter is that it is more advantageous to keep the molten steel to be tapped at a higher temperature than the regular tapping temperature: at, for example, 1630° C. or above. In case the temperature is lower, melting and mixing may not be performed satisfactorily, and the inevitable result would be poor deoxidation, poor desulphurization and imperfect purification which together makes it difficult to achieve the expected results.

The ingots were rolled into slabs in the usual way, and after cooling in the slab yard, the surface of the slab was found to be exceptionally smooth. This is shown in FIG. 2 of the drawing, which represents one of the slabs rolled from this heat. Very little, if any, surface conditioning was required. No hot top was used and the yield was 82% useable steel from the heat.

While the invention has been described as embodied in concrete form and as operating in a specific manner in accordance with the provisions of the patent statutes, it should be understood that the invention is not limited thereto, since various modifications will suggest themselves to those skilled in the art without departing from the spirit of the invention.

What is claimed is:

1. A deoxidizer and desulphurizer flux composed of intermixed, solid particles of aluminum, calcium silicon flux, calcium fluoride, and a desulfurizer selected from the group consisting of NaOH, Na₂CO₃ and Mg(OH)₂ and ferro-manganese.

2. A composition for forming a highly fluid slag in reaction with molten steel, said composition comprising intermixed solid particles of ingredients in the proportion of approximately 150 kilograms of aluminum, approximately 150 kilograms of calcium silicide, approximately 250 kilograms of calcium fluoride (CaF₂), approximately 250 kilograms of sodium carbonate (NaCO₃), and approximately 300 kilograms of ferro manganese and substantially no other ingredients.

3. A composition for forming a highly fluid slag, said composition comprising solid particles of aluminum and manganese alloys between 10 and 50 mm. in diameter and solid particles less than 10 mm. in diameter of calcium silicide, calcium fluoride and soda ash.

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