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METHOD FOR ADDING MANGANESE ALLOYING MEMBER TO STEEL

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ABSTRACT OF THE DISCLOSURE

A method for adding a manganese-base alloying agent to ferrous liquid metal by inserting into the liquid metal a wire-like configuration having a composition, by weight, of from about 65% to about 85% manganese, from about 10% to about 35% nickel, and with or without a balance of up to about 15% iron and/or up to about 0.5% aluminum with incidental impurities.

BACKGROUND OF THE INVENTION

(1) Field of the invention

This invention relates to a method for using a manganese-base alloy as an additive or alloying element in liquid metal baths and particularly liquid steel melted under vacuum conditions and, more particularly, it pertains to a manganese-base alloy to be used for replacing manganese lost due to exposure to the vacuum during melting of the liquid metal.

(2) Description of the prior art

During the melting and casting of metal such as steel, various alloying elements such as manganese are partially eliminated from the molten bath due to various factors such as oxidation and evaporation. Where the melting and casting of metals such as steel are conducted under high vacuum conditions and particularly where the bath is heated by an electron beam, manganese is substantially completely lost. As is known, manganese is an important alloying element in steel and is specifically of value in preventing problems with "hot shortness." It is necessary, therefore, to add manganese as an addition agent to the molten metal.

A conventional manganese addition agent in electron beam melting and casting has been crushed manganese or ferromanganese which is added to the molten metal or ingot during casting. One problem with the use of such addition agents has been a manganese recovery of only about 30% which is probably due in part to the slow rate of solution of the cold solid particles of manganese or ferromanganese when they strike the liquid metal surface. Usually, the particles tend to heat and dissolve at the surface of the liquid steel and thereby create locally high manganese concentrations on the liquid metal surface. Inasmuch as manganese has an unusually high vapor pressure, there is a rapid loss of manganese to the high vacuum above the liquid metal. Moreover, the liquid metal steel is contaminated by oxygen pickup due to the high oxide content of both electrolytic manganese and ferromanganese additives.

SUMMARY OF THE INVENTION

In accordance with this invention, it has been found that the foregoing problems may be overcome by providing a high manganese alloy member having an elongated configuration such as ribbon, rod, or wire (all of which are hereinafter referred to as "wire-like") which alloy is readily fed into the liquid metal bath and below the surface thereof at a controlled rate. Inasmuch as the melting of the manganese addition agent occurs within the molten metal and below the surface thereof, there is a

better recovery of manganese. The manganese addition agent of this invention is a solid solution alloy comprising, by weight, of from about 65% to about 85% manganese, from about 10% to about 35% nickel, with or without iron and/or aluminum, and incidental impurities.

The advantage of this invention is twofold in that there is a decided improvement in manganese recovery as a wire-like alloying element and the avoidance of contamination of the liquid metal by undesirable elements such as oxygen.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Although this invention describes the addition of a manganese-base alloy addition agent to liquid metal steel, it is understood that non-ferrous liquid metals requiring manganese additions are also included within the scope of this invention, particularly where the liquid metals are maintained and cast under vacuum.

All percentage values enumerated herein are by weight.

The manganeses-base alloys used in the method of the invention include, in addition to manganese, the element nickel, and when present one or both of the elements iron and aluminum. All of the elements, when combined with manganese, form a solid solution alloy and a single-phased material whereby the recovery of manganese in the molten metal is enhanced. It has been found that the solid solution alloys of manganese and nickel with or without partial substitutes of iron and aluminum in a single phase are conducive to the optimum recovery of manganese in the molten metal into which the alloy of this invention is fed as an addition agent. Broadly stated, the alloys consist essentially of from about 65% to about 85% manganese, from about 10% to about 35% nickel, up to about 15% iron, and up to about 0.5% aluminum, the iron and nickel when present being present as partial substitutes for the nickel.

One particularly useful group of alloys of this invention contains the above specified elements in the range of from about 20% to about 35% nickel, and the balance being manganese. A preferred composition within these ranges comprises from about 22% to about 27% nickel and from about 73% to about 78% manganese. The optimum alloy contains about 75% manganese and about 25% nickel.

Other desirable alloy compositions with the scope of the invention comprise from about 10% to about 22% nickel, from about 4% to about 15% iron, and the balance being essentially manganese. The composition of this group of alloys within preferred range comprises from about 12% to about 18% nickel, from about 7% to about 12% iron, and about 70% to about 81% manganese. The optimum composition comprises about 15% nickel, about 10% iron, and about 75% manganese. These alloys containing iron have been found suitable as additions to some iron-base nickel alloys with the iron being substituted in part for the nickel because iron is less costly than nickel.

Still other desirable alloy compositions with the scope of this invention comprise from about 10% to about 20% nickel, up to about 15%, iron, about 0.5% aluminum, and the balance being essentially manganese.

In view of the foregoing, it is evident that the manganese-base alloys of this invention may be either binary, ternary, or quaternary alloys. Their specific compositions are dependent upon considerations such as cost of the final product to which the alloys are added; and aluminum and iron being less costly may be added as partial substitutes for nickel. It is essential, however, to the success of this alloy that the manganese be wholly contained in solid solution form to provide the malleability necessary for processing into ribbon, rod, or wire in order to

obtain the most satisfactory recovery of manganese and to avoid the high manganese vapor pressure normally developed at the surface of the liquid metal bath to which manganese is added under high vacuum conditions.

The alloys of this invention have been prepared particularly for use in steel of SAE grades 4320, 4620, 4720, and 52100, which are useful as bearing steels among other purposes. As an addition agent, the manganese-base alloy has been prepared in an induction furnace and cast into 300-pound ingots which are subsequently forged into 2½ inch square billets. The billets are then hot rolled to ½ inch round bars which are then cold drawn to a wire of No. 8 gauge. Although nickel is a desirable element where the alloy is added to one of the above indicated SAE grades steels, it is a favorable alloying element with manganese because the manganese-base alloy is more malleable for forming the No. 8 gauge wire in the manner indicated above. The resulting alloy has a tetragonal crystal structure.

If the amount of manganese as the base metal is increased above about 85%, the malleability of the alloy greatly decreases to the detriment of the formation of the wire form in which it is preferably used as an addition agent. If the amount of manganese is less than 60%, the efficiency of the manganese-base alloy as an addition agent diminishes and greater amounts of the alloy are required to obtained the desired manganese content in the resulting iron-base alloy to which the manganese adding agent is added.

The following examples are illustrative of the present invention:

EXAMPLE I

An 8-gauge wire of a solid solution alloy containing 75% manganese, 15% nickel, and 10% iron is fed into a molten bath of steel such as SAE grade 4620. The steel is contained within an electron beam furnace under a vacuum pressure of less than 1 micron. For a given weight of liquid metal a calculated amount of the manganese-base alloy wire is added into the bath and below the surface thereof in order to obtain maximum manganese recovery and in order to avoid the dissipation of manganese which occurs if the manganese is otherwise added to the surface from which it would evaporate under the vacuum due to its high vapor pressure characteristics. After the desired amount of alloying wire has been added, the molten bath is cooled to the desired temperature after which it is fabricated in a conventional manner.

EXAMPLE II

An alloy of the composition set forth in Example I is added to a molten steel of SAE grade of 4620 as it is poured into an ingot mold. The rate of feed of the wire of addition agent is the function of the rate of pouring, the pressure within the chamber, and the temperature of the steel.

The recovery rates of manganese were found to be highly satisfactory with the melt temperatures being maintained in a temperature range of from 2825° to 2840° F.

The alloys of this invention having composition in which the components are within the range enumerated above are solid solution alloys having a single phase and are conducive to maximum recovery of manganese. Moreover, the alloy is malleable for forming elongated members of the alloy such as rods, ribbons, or wires, that can be fed lengthwise into the molten bath of steel.

Although the invention has been shown in connection with certain specific embodiments, it will be readily apparent to those skilled in the art that various changes may be made to suit requirements without departing from the spirit and scope of the invention.

What is claimed is:

1. A method for adding a manganese-base alloying agent to molten steel under vacuum melting and casting conditions comprising the step of inserting a wire-like member of the alloying agent into the molten steel which member has a melting point below the temperature of the molten steel, continuously feeding the member until the desired amount of alloying agent has been added, the alloying agent being a solid solution alloy consisting essentially of, from about 10% to about 35% nickel, up to about 15% iron, up to about 0.5% aluminum, and the balance being essentially manganese.

2. The method of claim **1** wherein there is from about 15% to about 35% nickel.

3. The method of claim **2** wherein there is about 22% to about 27% nickel.

4. The method of claim **2** wherein there is about 25% nickel, and about 75% manganese.

5. The method of claim **1** wherein there is from about 10% to about 22% nickel, and from about 4% to about 15% iron.

6. The method of claim **5** in which there is from about 12% to about 18% nickel, and from about 7% to about 12% iron.

7. The method of claim **6** wherein there is about 15% nickel, about 10% iron, and about 75% manganese.

8. The method of claim **7** wherein there is about 0.5% aluminum.

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