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ADDITION AGENT

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The present invention relates to a new article of manufacture comprising a new addition agent for the treatment of iron-base melts and to a process for treating iron-base melts, particularly cast iron melts, with said addition agent to produce ferrous products with improved properties and characteristics and to produce cast iron with graphite in a compacted form, particularly in a spheroidal form.

Heretofore, the art has taught that magnesium does not alloy with iron and, in fact, when attempts were made to introduce metallic magnesium into cast iron baths when the baths were at the ordinary casting heat required for successful casting (e. g., about 2700° F.) a reaction of such explosive violence took place that the molten iron was blown from its receptacle. It is known that the boiling point of magnesium (2030° F.) is below the melting point of most cast iron baths (e. g., about 2200° F.). The problem of introducing magnesium into a bath of molten cast iron, and particularly of incorporating and retaining residual magnesium in said cast iron without explosive results, was a difficult one to overcome.

It has now been discovered that magnesium can be incorporated controllably and successfully into cast iron melts by means of a special magnesium-containing addition agent and that cast iron castings containing graphite in a spheroidal form can be produced through the treatment of cast iron melts with the addition agent.

It is an object of the present invention to provide a new article of manufacture comprising a magnesium-containing addition agent particularly adapted to the treatment of cast iron melts to improve the castings produced from such melts.

Another object of the invention is to provide an improved process for producing cast iron containing spheroidal graphite which comprises the treatment of molten cast iron baths with the special magnesium-containing addition agent provided by the invention.

The invention also contemplates providing an improved process for producing magnesium-treated cast iron containing spheroidal graphite wherein the introduction of magnesium and the inoculation of the cast iron are carried out simultaneously.

It is a further object of the invention to provide a magnesium-containing agent which enables high recovery of contained magnesium in a cast iron melt and quiet addition of magnesium when said agent is added to a cast iron melt.

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Other objects and advantages will become apparent from the following description.

Generally speaking, the present invention contemplates a magnesium-containing addition agent comprising a special alloy of nickel, magnesium and silicon and containing controlled amounts of the constituents, to wit: about 30%, i. e., 25%, to about 50% silicon, about 12% to about 20% magnesium, up to about 12% iron, and the balance essentially nickel. The invention further contemplates an improved process for treating molten ferrous baths, particularly molten cast iron baths, with the new addition agent provided by the invention to incorporate magnesium in said baths, to reduce the sulfur content thereof, and to provide gray cast iron castings containing a small but effective amount up to about 0.3% or 0.4% magnesium and containing graphite in a compacted or even in a spheroidal form.

In its preferred embodiments, the agent provided by the invention contains about 14% to about 20% magnesium, about 25% to about 30% silicon, and the balance essentially nickel. Very good results are obtained when the magnesium content is about 17% to about 20%. For example, a very satisfactory agent comprises an alloy containing about 18% magnesium, about 28% silicon, about 8% iron and the balance essentially nickel.

As pointed out hereinbefore, the addition of magnesium to molten cast iron baths in the past has been attended by an explosive reaction and by the burning and consequent loss of by far the greater amount of magnesium added to the molten cast iron bath. The foregoing preferred compositions possess the unexpected advantage as compared to other alloys of equivalent density and magnesium level that, when added to molten cast iron baths, quiet introduction of magnesium is promoted and high recovery of contained magnesium in the cast iron is achieved. As a further advantage, small amounts of the special alloy can be employed for the purpose of introducing magnesium into cast iron.

The preferred alloys defined hereinbefore represent practical compositions useful for introducing magnesium into cast iron. With nickel and silicon proportioned as set forth hereinbefore, the magnesium range of about 14% to about 20% gives very good results and it has been found that at magnesium contents higher than about 20% the addition reactions become violent, with spattering of metal and consequent high losses of magnesium, while at magnesium contents lower than about 14% the size of the ladle addi-

tion required becomes too great. In addition to nickel, magnesium and silicon, the alloys may also contain up to about 12% iron, e. g., 0.01% to 12%, up to about 2% copper, e. g., 0.01% to 2%, up to about 1% cobalt, e. g., 0.01% to 1%, up to about 1% manganese, e. g., 0.01% to 1%, up to about 0.5% aluminum, etc. While the foregoing percentages are preferred, it has been pointed out in our parent application U. S. Serial No. 787,420, now U. S. Patent No. 2,485,760, that the addition alloys may contain not only nickel, magnesium and silicon but also manganese, copper and/or iron and that various amounts of these latter elements may be present in larger amounts than the foregoing preferred percentages. The nickel content of the alloy, however, must always be at least about 40%. Likewise, as pointed out hereinbefore, the magnesium content of the alloy must be about 12% to about 20% and the silicon content of the alloy must be about 25% to about 50%. The essential characteristics of the addition alloy are imparted by the presence of these amounts of nickel, magnesium and silicon. In addition to the foregoing, the agent provided by the invention may contain small amounts of incidental impurities, e. g., phosphorus, sulfur and titanium. These impurities do not materially affect the properties of the alloy and must not exceed a total of about 0.5%.

The agent provided by the invention is adapted to the treatment of cast iron baths for the general improvement thereof, e. g., for deoxidation, desulfurization, etc., leading to the production of improved properties in castings made from said baths. Improved properties are obtained when iron-base melts, including cast iron melts, are treated with about 0.8% to about 3% of the magnesium-containing agent provided by the invention.

Magnesium retained in cast iron has been found to have by itself a very powerful whitening or carbide-stabilizing effect which is usually undesirable in gray iron castings. Accordingly, in the production of magnesium-containing gray cast iron, it has usually been necessary heretofore in the great majority of cases to inoculate magnesium-containing cast iron baths before casting and to cast the baths in an inoculated condition to insure that the resulting castings would be graphitic. A feature of the process embodying the present invention is that magnesium introduction and inoculation are accomplished simultaneously. This feature has many practical advantages including the fact that the process embodying the invention provides an improved method for producing cast iron containing spheroidal graphite wherein only the single addition to the cast iron bath is required. Of course, other inoculating additions such as ferrosilicon, nickel silicide, calcium silicide, etc., can be employed along with or subsequently to the addition to a cast iron bath of the agent provided by the invention. When inoculants such as the foregoing are employed (in addition to the agent provided by the invention) in the treatment of cast iron melts, amounts of from about 0.2% to about 1% by weight of the bath may be employed. When an improved inoculating effect is desired in the addition agent contemplated by the invention, it is preferred that calcium up to about 1% be incorporated in said agents, e. g., 0.25% to about 1%. In addition, cast iron castings having thin sections, e. g., below about 0.5 inch in thickness, produced from magnesium-containing gray cast iron according to the process embodying the present invention will have a lower hardness than similar castings produced by processes employing other magnesium-containing addition agents, e. g., nickel-magnesium alloys, copper-magnesium alloys, etc.

Cast iron baths which may be treated according to the process embodying the invention are eutectiferous iron-carbon alloy baths usually containing about 1.7% to about 5% carbon and up to about 5.5% or 6% silicon with the balance essentially iron, said balance usually being 85% or 87% or more iron. The aforesaid baths are those which will produce gray iron castings when cast in an inoculated condition. Preferably, the baths to be treated according to the process embodying the invention contain about 2% to about 4.5% carbon or about 2.5% to 4% carbon. The silicon content of the bath to be treated is such that the final silicon content of castings made according to the process embodying the invention will be about 1.5% to about 4.5%. The molten cast iron compositions to be treated may contain the common alloying elements in the amounts usually found in cast iron, e. g., the cast iron compositions may contain up to about 36% nickel, up to about 0.6% molybdenum, up to about 1% chromium, up to about 2.5% manganese, etc. In order to realize the preferred effects obtainable through the introduction of magnesium into cast iron, the copper content is kept below about 2%. The cast iron bath to be treated is preferably practically devoid of subversive amounts of tin, lead, antimony, bismuth, arsenic, selenium and tellurium, etc., as these elements have been found to be subversive to the desired effects of magnesium on the graphite form. The impurities phosphorus and sulfur may be present in the usual amounts found in various grades of commercial cast iron. Thus, the bath to be treated may contain up to 0.5% or more phosphorus, although it is preferred that the phosphorus content be below about 0.15%, e. g., about 0.02% to 0.06%. Similarly, the sulfur content may be as high as 0.3% or more, e. g., 0.05% to 0.3%, although it is preferred that the sulfur content be below 0.15%, e. g., 0.03% to 0.1%.

In the preferred process provided by the present invention wherein gray cast iron containing a small but effective amount of magnesium to produce graphite in a substantially compacted form is produced through the addition to a cast iron melt of the magnesium-containing agent provided by the invention, the bath contains about 3.4% to about 4% carbon, about 0.1% to about 0.4% manganese, about 0.03% to about 0.1% sulfur, about 0.02% to about 0.12% phosphorus, at least about 1.25% silicon, and the balance essentially iron. Castings made by adding to the aforesaid bath the amounts of addition agent contemplated by the invention will contain about 2% to about 2.5% silicon. When a cast iron bath of the foregoing composition is employed, no additional inoculating agents are required to produce magnesium-containing gray cast iron other than the agent provided by the invention.

For the purpose of giving those skilled in the art a better understanding of the invention, the following illustrative example is given:

A gray cast iron melt containing about 4% carbon, about 0.35% manganese, about 0.06% phosphorus and about 0.04% sulfur was established and the temperature of the bath was adjusted to permit successful casting. To a portion of said bath held in a ladle, a 1.5% addition of

an agent containing about 18% magnesium, about 27% silicon, about 47% nickel and about 8% iron was made. The thus-treated metal was then cast. In 1-inch keel sections, the castings had hardness values of 215 to 230 Brinell, tensile strengths of 87,000 to 92,000 pounds per square inch and elongations of 5% to 7.5% in the as-cast condition.

The proportion of the magnesium content of a given addition alloy which will be introduced into a particular iron-base bath depends upon a number of factors. Thus, the temperature of the bath is an important factor as it has been found that the magnesium recovery from a given addition alloy is reduced at a very marked rate when the temperature of the bath is elevated. A preferred bath temperature to be employed in the addition of the alloy provided by the invention, particularly in the treatment of the preferred bath composition set forth hereinbefore containing about 3.4% to about 4% carbon, is about 2700° to about 2760° F. As magnesium has been found to be a powerful desulfurizer even under acid conditions and in the absence of a slag, the sulfur content of the bath is also a factor. When magnesium is introduced into a sulfur-containing cast iron melt, the sulfur content will be reduced and magnesium will be consumed in the resulting reaction. Generally speaking, when sufficient magnesium is introduced into a cast iron containing more than about 0.02% sulfur (e. g., 0.03% to 0.1% or more) to produce a retained magnesium content of 0.03% or more, the sulfur content will be reduced below about 0.02%. Practically speaking, about one part by weight of magnesium must be introduced into the bath for each part by weight of sulfur removed. The technique employed in adding the addition agent provided by the invention to the cast iron bath will also effect the magnesium recovery. It has been found that satisfactory results have been obtained when the addition agent provided by the invention is added to the molten stream of hot metal flowing into a ladle or other container. It has been found that magnesium recovery is usually greater when additions are made on a large scale as in a commercial foundry than when additions are made on a small scale, e. g., on a laboratory scale.

The magnesium addition agent provided by the invention can be prepared by a method which comprises melting down nickel and ferro-silicon (e. g., an alloy containing about 75% silicon, balance essentially iron), introducing magnesium into the resulting bath, and casting the metal from said bath.

This application is a continuation-in-part of our co-pending U. S. application Serial No. 787,420, filed November 21, 1947, now U. S. Patent No. 2,485,760.

Although the present invention has been described in conjunction with preferred embodiments, it is understood that modifications and

variations may be resorted to without departing from the spirit and scope of the invention, as those skilled in the art will readily understand. Variations and modifications apparent to those skilled in the art are considered to be within the purview and scope of the invention and appended claims.

We claim:

1. As a new article of manufacture, an addition agent adapted for the treatment of cast iron baths to desulfurize said baths and to improve the quality of castings made therefrom, and comprising an alloy containing about 18% magnesium, about 28% silicon, up to about 8% iron, and the balance essentially nickel.

2. As a new article of manufacture, an addition agent adapted for the treatment of cast iron baths to desulfurize said baths and to improve the quality of castings made therefrom, and comprising an alloy containing about 17% to about 20% magnesium, about 25% to about 30% silicon, up to about 12% iron, and the balance essentially nickel.

3. As a new article of manufacture, an addition agent particularly adapted for the treatment of cast iron melts and comprising an alloy containing about 14% to about 20% magnesium, about 25% to about 30% silicon, up to about 12% iron, calcium up to about 1%, and the balance essentially nickel.

4. As a new article of manufacture, an addition agent comprising an alloy containing about 30% to about 50% silicon, about 12% to about 20% magnesium, up to about 12% iron, up to about 1% calcium, and the balance essentially nickel, with the nickel constituting at least about 40% of the alloy.

5. As a new article of manufacture, an addition agent for the treatment of molten cast iron and comprising an alloy containing about 12% to 20% magnesium, about 25% to 50% silicon, up to about 12% iron, and the balance consisting essentially of nickel and constituting at least about 40% of the alloy.

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