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3,033,676

NICKEL-CONTAINING INOCULANT

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No Drawing. Filed July 8, 1960, Ser. No. 41,489

Claims priority, application Great Britain July 10, 1959

9 Claims. (Cl. 75-130)

The present invention relates to an addition alloy and, more particularly, to an addition alloy for use in the graphitizing inoculation of cast iron.

In order to promote the graphitization of cast iron, it is a common practice to add an inoculant to the molten iron before casting, that is to say, a material which increases the tendency of the iron to cast gray rather than white and which also causes the graphite in the solidified iron to be in a desirable form. It is desired that the graphite be flake graphite type A and have random distribution. The inoculants most commonly used are ferrosilicon and calcium silicide. Although ferrosilicon, which is a ferroalloy containing, e.g., 50% to 85% silicon, the balance essentially iron, has been commercially used as a graphitizing inoculant in the foundry industry, the industry has been searching for a graphitizing inoculant which will be more effective in reducing chill in foundry gray irons and which would remain effective in the liquid iron over a longer period of time than the usual commercial inoculants presently available. Although many attempts have been made to overcome the foregoing difficulties and other disadvantages, none, as far as I am aware, was entirely successful when carried into practice commercially on an industrial scale.

It has now been discovered that a particular alloy composition containing specially associated and coordinated amounts of ingredients acts in an improved manner as a graphitizing inoculant for the production of foundry gray irons having controlled physical properties and graphite structures.

It is an object of the present invention to provide an addition alloy producing improved effects as a graphitizing inoculant in the treatment of foundry gray irons.

Another object of the invention is to provide an improved method for the graphitizing inoculation of molten cast iron along with or subsequent to the addition thereof of a graphite-spheroidizing agent such as magnesium or cerium to produce ductile iron castings (i.e., spheroidal graphite cast irons) having controlled properties and graphite structures.

The invention also contemplates providing a method for the production of improved foundry gray irons having improved graphite distribution and having controlled chilling tendencies.

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

According to this invention, an inoculant for the purpose of producing controlled graphitizing inoculation of foundry cast irons is an alloy containing from 0.1% to 60% nickel or iron or both, from 0.1% to 5% magnesium, from 0.1% to 10% aluminum, from 0.1% to 10% calcium and 15% to 99.6% silicon. Preferably, the alloy contains nickel rather than iron as the former element is superior to iron as a carrier for the active elements. Advantageously, the ranges of the constituents are nickel or iron from 10% to 25%, magnesium from 1% to 4%, aluminum from 1% to 4% and calcium from 1% to 4%, and 63% to 87% silicon.

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A very suitable alloy contains 2% magnesium, 2% aluminum, 2% calcium, 15% nickel and 79% silicon. Other suitable alloys are as follows:

Percent Mg	Percent Al	Percent Ca	Percent Ni	Percent Si
3 3	3 0.1	3 3	10 15	Bal. Bal.

The inoculants according to the invention give good chill reduction. Thus, thin sections or corners of castings which may tend to solidify white can be kept soft and machinable. In this respect, the inoculant is superior to high grade ferrosilicon, e.g., a commercial alloy containing about 76% silicon and about 2% calcium and 2% aluminium and the remainder essentially iron.

The inoculants according to the invention also cause the graphite to be in a desirable form and so to impart good mechanical properties to the iron and in this respect, also, the new inoculant gives results superior to those which can be obtained from irons inoculated with high grade ferrosilicon.

The superiority of the inoculation effect induced by the new inoculant in treating molten iron is maintained over that which is produced by ferrosilicon for times as long as twenty minutes after treatment. Thus, it follows that molten iron treated with the new alloy will at any specified time be in a better condition for casting than iron that has been treated with ferrosilicon.

It is very important to maintain the constituents of the alloy within the foregoing ranges in order to obtain the improved results contemplated in accordance with the present invention. Thus, in order to produce gray iron castings containing graphite in a desirable form, i.e., castings in which the graphite is flake graphite type A with random distribution, and in order to maintain the inoculating power of the alloy, the aluminum content of the alloy should be at least 0.10% and not greater than 10%, the magnesium content should be at least 0.10% and not greater than 5%, the calcium content should be at least 0.1% and not more than 10%, the nickel or iron content should be at least about 0.1% to about 60% and from 15% to 99.6% silicon. The aluminum content of the alloy should not exceed about 10% as certain undesirable effects, e.g., pinholing, may be encountered in the resulting castings. In some cases, aluminum may be omitted from the alloys although the inoculating effect of such alloys is concomitantly reduced. The magnesium content of the alloys does not exceed about 5%, as increasing quantities of magnesium may cause the alloys to become undesirably reactive in contact with molten iron. The alloys should be substantially devoid of metals such as zirconium and manganese as such metals detrimentally affect the alloys.

In general, the addition alloy provided in accordance with the invention may be used in amounts of about .125% to about 1.00% in the treatment of molten cast iron for the purpose of effecting the graphitizing inoculation. In employing the advantageous alloys provided in accordance with the invention, amounts of about 0.25% to about 0.75% thereof may be used for effecting graphitizing inoculation of molten cast iron baths.

For the purpose of giving those skilled in the art a

better understanding of the invention, the following illustrative examples are given:

Example I

Several molten cast iron baths containing about 3% carbon, about 1% silicon, about 1% manganese, about 0.08% sulfur, about 0.04% phosphorus, and the balance essentially iron were treated at about 1400° C. with 0.5% of an alloy containing about 3% magnesium, 3% aluminum, 3% calcium, 15% nickel and 76% silicon while another portion of each melt was treated with 0.5% of a commercial ferrosilicon alloy containing 76% silicon and about 2% calcium and 2% aluminum the remainder essentially iron.

Samples of metal from the thus-treated melt were poured to produce Keel blocks having a cross section of about 1 square inch. Tensile test specimens were machined from the castings and tested and the following results were obtained:

Melt No.	Type of Addition Used	Ultimate Tensile Strength of Treated Iron (t.s.i.)
1.-----	{(a) New alloy.-----	16.7
	{(b) Ferrosilicon.-----	14.4
2.-----	{(a) New alloy.-----	17.0
	{(b) Ferrosilicon.-----	14.6
3.-----	{(a) New alloy.-----	15.2
	{(b) Ferrosilicon.-----	13.5

In each test it is seen that treatment with the new alloy gave a better iron.

Example II

Further melts of similar composition were treated with 0.3% of the new alloy as given in Example I or 0.3% of a ferrosilicon alloy containing 76% silicon and about 2% calcium and 2% aluminum the remainder essentially iron. In each case test castings were produced by withdrawing metal from the melt at various intervals and chill test blocks were cast. The following results were obtained:

Melt No.	Addition Used	Depth of chill in inches obtained after stated times in minutes				
		0.5	5.0	8.0	10.0	12.0
1.-----	0.3% New alloy.-----	0.25	0.625	0.750	0.875	1.00
2.-----	0.3% Ferrosilicon.-----	0.375	1.250	1.375	1.375	1.50

A comparison of the results obtained in accordance with the present invention as shown in Examples I and II hereinbefore demonstrates that (1) irons having a superior strength may be produced by treatment with the new alloy and (2) the superiority of iron treated with the new alloy, especially as regards reduction of chill, is maintained for a significant amount of time so that at any specified time molten iron treated with the new alloy will be in a better condition for casting than iron that has been treated with ferrosilicon.

In the production of cast iron containing spheroidal graphite, magnesium in alloy form is commonly added to the molten iron before casting. In this invention, the proportion of magnesium introduced when normal amounts of inoculant are added is not enough for more than a trace of magnesium to remain in the iron as cast and the graphite formed will be in the form of flakes. However, with the use of greater amounts of the inoculant, particularly when the magnesium content is high, the graphite may be spheroidal in the iron as cast, the castings being free from eutectic carbide. Of course, the new inoculant can be added to molten cast iron suitable for the production of spheroidal graphite cast iron along with or subsequent to the introduction therein of a graphite-spheroidizing agent such as magnesium or cerium and

high-quality spheroidal graphite castings can be made from the thus-inoculated metal.

With the preferred nickel content, say about 15%, the inoculant according to the invention can be used to produce good mechanical properties in flake graphite irons having an appropriate base composition.

With a high nickel content, e.g., about 40%, the inoculant may be used to alloy the castings simultaneously with inoculation, for example, in the production of acicular cast iron.

Molten cast iron which may be treated in accordance with the present invention contained about 2% to about 3.8% carbon, about 0.50% to about 4% silicon, about 0.1% to about 1% manganese, about 0.01% to about 0.1% sulfur, about 0.01% to about 0.1% phosphorus, up to about 0.08% magnesium, up to about 35% nickel, up to about 1% copper, up to about 0.5% chromium, up to about 1% molybdenum, with the balance essentially iron. More usually, molten cast irons treated in accordance with the invention will contain about 2.4% to about 3% carbon, about 0.80% to about 1.2% silicon, about 0.4% to about 1% manganese, about 0.02% to about 0.1% sulfur, about 0.02% to about 0.06% phosphorus, up to about 0.08% magnesium, up to about 5% nickel, up to about 1% copper, up to about 0.5% chromium, up to about 1% molybdenum, with the balance essentially iron.

Although the present invention has been described in conjunction with preferred embodiments, it is to be 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. Such modifications and variations are considered to be within the purview and scope of the invention and appended claims.

I claim:

1. A graphitizing inoculant for the treatment of molten cast iron consisting essentially of about 3% magnesium, about 3% aluminum, about 3% calcium, about 15% nickel and 76% silicon.

2. A graphitizing inoculant for the treatment of molten cast iron consisting essentially of about 1% to about 4% magnesium, about 1% to about 4% aluminum, about 1% to about 4% calcium, about 10% to about 25% of metal from the group consisting of nickel and iron and about 63% to about 87% silicon.

3. A graphitizing inoculant for the treatment of molten cast iron consisting essentially of about 1% to 4% magnesium, up to about 4% aluminum, about 1% to 4% calcium, about 10% to 25% of metal from the group consisting of nickel and iron and about 63% to about 88% silicon.

4. The method of effecting the graphitizing inoculation of cast iron which comprises establishing a molten bath of cast iron, incorporating in said bath a small amount of an alloy containing about 3% magnesium, about 3% aluminum, about 3% calcium, about 15% nickel and 76% silicon and casting metal from said bath in the inoculated condition to produce a cast iron product having a microstructure substantially devoid of eutectic carbide and containing graphite in a well-dispersed form.

5. The method of effecting the graphitizing inoculation of cast iron which comprises establishing a molten bath of cast iron, incorporating in said bath a small amount of an alloy containing about 1% to 4% magnesium, up to about 4% aluminum, about 1% to 4% calcium, about 10% to 25% of a metal from the group consisting of nickel and iron and about 63% to about 88% silicon and casting metal from said bath in the inoculated condition to produce a cast iron product having a microstructure substantially devoid of eutectic carbide and containing graphite in a well-dispersed form.

6. A graphitizing inoculant for the treatment of molten cast iron consisting essentially of silicon with about 0.1% to 5% magnesium, about 0.1% to 10% aluminum, about

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0.1% to 10% calcium and about 0.1% to 60% of metal from the group consisting of nickel and iron.

7. A graphitizing inoculant for the treatment of molten cast iron consisting essentially of silicon with about 0.1% to 5% magnesium, up to about 10% aluminum, about 0.1% to 10% calcium and about 0.1% to 60% of metal from the group consisting of nickel and iron.

8. The method for producing gray cast iron having improved strength and substantial freedom from chill which comprises establishing a molten bath of gray cast iron and introducing therein shortly before casting a small amount of graphitizing inoculant consisting essentially of silicon with about 0.1% to 5% magnesium, up to about 10% aluminum, about 0.1% to 10% calcium and about

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0.1% to 60% of metal from the group consisting of nickel and iron and casting metal from the thus treated bath to produce a gray cast iron product.

9. The method according to claim 8 wherein the molten gray cast iron bath is suitable for the production of spheroidal graphite cast iron.

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