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METHOD FOR MAKING IMPROVED GRAY CAST IRON AND PRODUCT PRODUCED THEREBY

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The present invention relates to gray cast irons having improved properties and containing graphite in a spheroidal form and, more particularly, to gray cast irons containing a combination of elements to control the graphite in a spheroidal form and to a method for producing such cast irons.

It is an object of the present invention to provide a gray cast iron having an improved combination of mechanical and physical properties and containing graphite in a spheroidal form.

It is a further object of the present invention to provide gray cast iron containing spheroidal graphite even in the presence of elements which detrimentally affect the formation of spheroidal graphite in cast iron, and a method for producing such a cast iron.

Other objects and advantages of the invention will be made apparent to those skilled in the art from the following description.

Broadly stated, the present invention is directed to gray cast irons containing a small but effective amount, e. g., about 0.01% up to about 0.5%, of thorium to control the occurrence of uncombined carbon or graphite therein in a compacted, especially a spheroidal, form. Usually the thorium content of the cast iron is about 0.1% to about 0.25%.

It is known that the properties of gray cast iron are much improved if some or all of the graphite is present not as flake but in the form of compact, soft, gray-colored, rounded particles or as conglomerates or groups of such particles, as described in detail in U. S. Patent No. 2,485,760. In the invention described in that specification this form of graphite, referred to as the spheroidal form, is produced by adding magnesium, usually in the form of an alloy, to the molten iron in such an amount and in such a manner as to leave a small but effective amount up to about 0.5% magnesium in the casting.

The present invention is based on the discovery that the graphite can be rendered spheroidal by means of thorium. According to the invention, therefore, thorium is added to molten iron which will cast gray. The proportion of the graphite which is spheroidal in the iron as cast depends on the amount of thorium added and, moreover, the amount of thorium addition required to render a given proportion of the graphite spheroidal depends on the initial sulfur content of the molten metal (increasing with that content), the way in which the thorium is added, and the temperature of the molten metal at the time of the addition.

Preferably, thorium retained in gray cast iron is used in small amounts in conjunction with effective amounts of magnesium to cooperate with said magnesium in the production of compacted, including spheroidal, graphite structures in cast iron and to overcome the effects of certain detrimental elements which when present in cast iron interfere with the effect of magnesium in causing the occurrence of graphite in a spheroidal form.

Although, as indicated above, thorium can be used instead of magnesium to develop spheroidal graphite in cast iron, its price generally renders its use less economic in comparison with magnesium. It can, however, be used with very great advantage as a supplement to magnesium. As has been explained in U. S. Patent No. 2,485,760, the advantageous effect of magnesium can be offset by very small amounts of certain subversive elements. Titanium is an element which, though harmless in the small amounts in which it is usually present, is detrimental in larger amounts. Now it is found that the bad effect of a detrimental element can itself be offset by the addition of a very small amount of thorium before, or (preferably) after or with the magnesium.

In gray cast irons containing a combination of magnesium and thorium to provide a compacting or spheroidizing effect upon the graphite present in the cast iron, magnesium is employed in a small but effective amount up to 0.5%, e. g., about 0.04% up to about 0.1%, and thorium is employed in a small but effective amount up to 0.1%, e. g., about 0.01% up to about 0.06%. The foregoing combinations of magnesium and thorium provide an appreciable effect in compacting or spheroidizing graphite present in the cast iron and provide greatly improved properties in the cast iron, which normally would have contained ordinary flake graphite, even in the presence of substantial amounts of other subversive elements which detrimentally affect the graphite structure which can be produced in the iron by magnesium alone. For example, substantially spheroidal graphite structures are produced in cast irons containing the aforementioned combinations of magnesium and thorium even in the presence of tin in amounts up to about 0.1%, lead in amounts up to about 0.02%, antimony in amounts up to about 0.1%, bismuth in amounts up to about 0.02%, arsenic in amounts up to about 0.1%, thallium in amounts up to about 0.02%, titanium in amounts up to about 0.3%, etc.

When thorium is used by itself or in conjunction with magnesium to produce spheroidal graphite cast iron, it is preferred that the cast iron melt have a low sulfur content when the thorium is added, usually below about 0.04%, e. g., about 0.01% to 0.02%, so that the sulfur content of the iron casting is low. Thus, if the cast iron melt is initially relatively high in sulfur, it can be treated before the thorium addition to reduce the sulfur to a low value.

The thorium may most conveniently be added either as a constituent of a powder mixture or as an alloy. Metallic thorium can also be used provided precautions are taken to avoid its loss by oxidation before it can dissolve in the melt. One advantage obtained by the use of thorium is that there is no violent reaction when the addition is made. For example, the thorium may be added as elemental thorium or as an alloy of thorium containing about 20% to about 80% thorium with up to about 80% nickel, up to about 80% copper, up to about 80% aluminium, up to about 80% iron, up to about 60% silicon, and up to about 10% manganese. Examples of satisfactory thorium-containing alloys are alloys containing about 60% thorium and about 40% nickel; about 60% thorium and about 40% copper; about 20% thorium and about 80% aluminium; ferro-silicon-thorium containing about 10% iron, 50% silicon and 40% thorium. Satisfactory powdered mixtures comprise mixtures of about 40% thorium powder with about 60% nickel powder; about 40% thorium powder with about 60% copper powder; and about 40% thorium powder with 60% powdered ferro-silicon. The powdered mixtures can be in the form of briquettes.

In preparing the cast irons containing spheroidal graphite in accordance with the present invention, a charge of

ferrous metal is melted to produce a melt suitable for the production of gray cast iron. The melt is brought to a suitable temperature to dissolve the constituents and is treated with thorium alone or with a combination of magnesium and thorium while the melt is held either in a ladle or other container. The melt is thereafter cast in an inoculated condition. Preferably, a graphitizing inoculant is added along with or after the thorium. The proportion of carbon present as spheroidal graphite in the iron as cast is increased by the addition of an inoculant such as ferro-silicon or other silicon-bearing material after the addition of thorium.

The magnesium can be added in the form of alloys of magnesium with nickel, copper and/or silicon which contain about 10% to about 40% magnesium. The magnesium can be added in the elemental form provided proper precautions and technique are employed. The magnesium and thorium may also be added in the form of an alloy containing both these metals, for instance, an alloy containing 80% of magnesium and 20% of thorium. Satisfactory inoculants include ferro-silicon containing about 75% or more silicon, silicon metal, calcium silicide and proprietary silicon-containing graphitizing materials available to the foundry industry.

For the purpose of giving those skilled in the art a better understanding of the invention, the following illustrative examples are given in which thorium alone was employed as the only graphite-spheroidizing agent:

Example I

A powder mixture containing 40% thorium and 60% nickel was made and added to molten iron of the following analysis: 3.27% carbon, 1.76% silicon, 0.39% manganese, 0.007% sulfur and 0.02% phosphorus. After the addition of thorium the iron was inoculated with silicon (added as ferro-silicon containing 80% silicon) in an amount equal to 0.5% of the molten metal by weight. When the amount of thorium added equalled only 0.1% of the weight of the molten metal, all the graphite in the iron as cast was present as flake. When, however, this amount was increased to 0.2%, about 45% of the graphite was spheroidal and the remainder was rounder and shorter than ordinary flake, i. e., was compacted.

Example II

A molten cast iron bath was prepared which had the following analysis: 3.7% carbon, 2.1% silicon, 0.1% manganese, 0.018% sulfur and 0.02% phosphorus. Separate portions of the melt were treated with additions of 0.5%, 0.75% and 1.25% of a powder mixture containing 40% thorium and 60% nickel. Another portion from the melt was not treated with thorium. Each portion was subsequently inoculated with 0.5% silicon added as ferro-silicon containing 80% silicon and cast into 4-leaf clover block moulds in green sand. The graphite in the iron cast without thorium treatment was present as flake. A proportion of the graphite in each of the irons treated with thorium was spheroidal and the remainder was rounder and shorter than normal flake graphite, i. e., was compacted. Castings made from the portions of iron treated in the foregoing manner were subjected to mechanical tests and the results of these tests are given in the following table:

Thorium Addition, Percent	Retained Thorium, Percent	Mechanical Properties			
		Tensile Strength, p. s. i.	Elong., Percent	Izod Impact, ft. lb.	BHN
None	-------	15,900	------	5	114
0.2	0.02	54,500	3.0	12	164
0.3	0.10	61,400	4.5	15	180
0.5	0.26	65,500	5.0	24	187

In order to illustrate the effect of thorium in overcoming the influence of an element subversive to the effect of magnesium in spheroidizing the graphite of gray cast iron, the following example is given:

Example III

A molten gray iron had the following analysis: 3.27% carbon, 1.76% silicon, 0.39% manganese, 0.007% sulfur, 0.02% phosphorus and 0.14% titanium. This iron was treated with a nickel-magnesium alloy containing 85% nickel and 15% magnesium in an amount equal to 1% of the weight of the molten metal and thereafter inoculated with 0.5% silicon added as ferro-silicon containing 80% silicon. The addition of this amount of the magnesium alloy to an ordinary gray iron melt would render the graphite predominantly spheroidal, but because of the high titanium content only about 5% of the graphite was spheroidal, the remainder being flake. When, however, 0.02% thorium in the form of the powder mixture described above (in the preceding examamples) was added after 1% of the nickel-magnesium alloy but before the inoculation, the proportion of spheroidal graphite increased to 25%, and the remainder of the graphite was shorter and rounder than ordinary flake.

Cast iron baths which may be treated in accordance with the invention are eutectiferous iron-carbon alloy baths usually containing 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. Preferably, the baths to be treated contain about 2% to about 4.5% carbon or about 2.5% to 4% carbon. The silicon content of the baths is such that the final silicon content of the castings made 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., up to about 36% nickel, up to about 0.6% molybdenum, up to about 1% chromium, up to about 2.5% manganese, etc. The impurities phosphorus and sulfur may be present in the usual amounts found in various grades of commercial cast iron.

In essence, the present invention contemplates a cast iron containing the amounts of thorium set forth hereinbefore with the balance essentially a gray cast iron composition, especially one in which the iron is in the alpha form at atmospheric temperatures.

It is recognized that thorium determinations of the order involved herein are difficult to make and are subject to the variations inherent in the analytical procedure employed for determining small amounts of thorium in cast 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. As a new article of manufacture, a gray cast iron containing about 0.04% to about 0.1% magnesium effective to induce the occurrence of graphite in cast iron in a spheroidal form, a detrimental amount of an element subversive to effect of said magnesium and about 0.01% to about 0.06% thorium to counteract the detrimental effect of said subversive element and to provide a cast iron containing more graphite in a spheroidal form than if thorium were absent.

2. As a new article of manufacture, a gray cast iron containing a small but effective amount of magnesium up to about 0.5% to induce the occurrence of graphite in cast iron in a spheroidal form, a detrimental amount of an element subversive to the effect of said magnesium and

a small but effective amount up to about 0.1% thorium to counteract the detrimental effect of said subversive element and to provide a cast iron containing more graphite in a spheroidal form than if thorium were absent.

3. As a new article of manufacture, an iron casting having a gray cast iron composition containing about 0.01% to about 0.06% thorium, up to about 0.5% magnesium and being characterized by the presence of a substantial proportion of graphite in a spheroidal form.

4. As a new article of manufacture, an iron casting having a gray cast iron composition containing a small but effective amount up to about 0.1% thorium, up to about 0.5% magnesium and being characterized by the presence of a substantial proportion of graphite in a spheroidal form.

5. As a new article of manufacture, an iron casting containing less than about 0.04% sulfur and about 0.1% to about 0.25% thorium to induce the occurrence of spheroidal graphite in said casting, with the balance essentially a gray cast iron composition.

6. As a new article of manufacture, an iron casting containing less than about 0.04% sulfur and a small but effective amount up to about 0.5% thorium to induce the occurrence of spheroidal graphite in said casting, with the balance essentially a gray cast iron composition.

7. The method for producing cast iron containing spheroidal graphite which comprises establishing a molten gray cast iron bath containing a detrimental amount of an element subversive to the effect of magnesium in causing the occurrence of spheroidal graphite, incorporating into said bath about 0.04% to about 0.1% magnesium and about 0.01% to about 0.06% thorium, and thereafter casting metal from said bath in an inoculated condition to produce a gray cast iron casting containing graphite in a spheroidal form.

8. The method for producing cast iron containing spheroidal graphite which comprises establishing a molten gray cast iron bath containing a detrimental amount of an element subversive to effect of magnesium in causing the occurrence of spheroidal graphite, incorporating into said bath magnesium in an amount up to about 0.5% and thorium in an effective amount up to about 0.1%, and thereafter casting metal from said bath in an inoculated condition to produce a gray cast iron casting containing graphite in a spheroidal form.

9. The method for producing cast iron containing spheroidal graphite which comprises establishing a bath of molten gray cast iron, incorporating into said bath about 0.1% to about 0.25% thorium and thereafter casting metal from said bath in an inoculated condition to produce a gray cast iron casting containing graphite in a spheroidal form.

10. The method for producing cast iron containing spheroidal graphite which comprises establishing a bath of molten gray cast iron, incorporating into said bath thorium in a small but effective amount up to about 0.5% and thereafter casting metal from said bath in an inoculated condition to produce a gray cast iron casting containing graphite in a spheroidal form.

11. The method for producing cast iron containing spheroidal graphite which comprises establishing a bath of molten iron which has a composition such that it would be a gray cast iron if cast in an inoculated condition and which contains a detrimental amount of an element subversive to the effect of magnesium in causing the occurrence of spheroidal graphite, incorporating into said bath a small but effective amount up to about 0.5% magnesium and a small but effective amount up to about 0.1% thorium such that the incorporation of thorium does not precede the incorporation of magnesium and thereafter casting metal from said bath in an inoculated condition to produce a gray iron casting containing graphite in a spheroidal form.

12. The method for producing cast iron containing spheroidal graphite which comprises establishing a bath of molten iron which has a composition such that it would be a gray cast iron if cast in an inoculated condition and which contains a detrimental amount of an element subversive to the effect of magnesium in causing the occurrence of spheroidal graphite, incorporating into said bath about 0.04% to about 0.1% magnesium, thereafter incorporating into said bath about 0.01% to about 0.06% thorium and casting the thus-treated bath in an inoculated condition to produce a gray iron casting containing graphite in a spheroidal form.

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