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ADDITION AGENT AND METHOD FOR TREATING CAST IRON

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The present invention relates to an agent and method for introducing magnesium into cast iron and more particularly to a special magnesium-containing agent which comprises non-strategic ingredients but has satisfactory addition characteristics when brought in contact with molten cast iron.

Heretofore, the agents which have been used successfully for the purpose of introducing magnesium into molten cast iron have been diluted in magnesium, i. e., these agents have contained about 15% magnesium, and these agents have contained carrier elements of a highly strategic nature in times of national emergency, e. g., nickel, copper, etc. Prior agents having relatively higher magnesium contents than the foregoing and/or having substantially no content of strategic metal carrier elements have produced too violent addition reactions when added to molten cast iron. A problem has existed in the art to provide a magnesium-containing addition agent, adapted for the purpose of introducing magnesium into cast iron melts, which would have commercially feasible characteristics when added to molten cast iron and which would not contain strategic metal carrier elements. Although attempts were made to overcome the foregoing difficulties and other difficulties, 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 magnesium can be introduced into molten cast iron by means of a special briquetted agent containing magnesium but devoid of strategic metal carrier elements.

It is an object of the present invention to provide a magnesium-containing agent adapted to introduce magnesium into molten cast iron.

Another object of the invention is to provide a magnesium-containing agent produced from inexpensive, readily-available materials and devoid of strategically important carrier metals.

The invention also contemplates providing a process for producing magnesium-containing cast iron utilizing a magnesium-containing agent having commercially satisfactory addition characteristics but devoid of strategic metals.

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

Generally speaking, the present invention contemplates a briquetted agent, adapted for the introduction of magnesium into molten cast iron, which contains about 15% to about 50% magnesium particles with the balance essentially finely divided carbon and a small amount of binder sufficient to provide solidity in the agent.

The invention also contemplates the process comprising establishing a bath of molten cast iron and treating said bath with the special magnesium-containing agent provided by the invention to desulfurize said bath and/or to introduce into said bath a small but effective amount up to about 0.3% or 0.4% magnesium to produce compacted graphite, especially spheroidal graphite. The thus-treated bath may then be cast in an inoculated

condition to produce magnesium-containing cast iron castings having improved properties, as compared to similar castings devoid of magnesium, and having a structure containing compacted, including spheroidal, graphite. The aforementioned bath may also be used for other purposes, e. g., as a source of low-sulfur hot metal, to make white iron castings, etc. The process contemplated by the invention enables the introduction of magnesium into molten cast iron from an agent containing magnesium in metallic form without encountering explosive results such as is the cast when metallic magnesium alone is added to molten cast iron. The process and agent contemplated by the invention have the further advantage that no strategic metal carrier elements are required to accomplish introduction of magnesium into molten cast iron.

The proportion of magnesium in the briquetted agent is critical because when the magnesium content of the briquette exceeds about 50% the briquettes tend to break apart when added to molten cast iron and to produce an excessively violent addition reaction. On the other hand, when the magnesium content of the briquette falls below about 15% the bulkiness of the addition required to give the desired retained magnesium content in cast iron becomes excessive and the efficiency of magnesium introduction from the briquette into molten iron is excessively lowered. Agents containing magnesium particles within the range of about 15% to about 50% generally will contain about 40% to about 80% of carbon particles.

The particle sizes of the magnesium and carbon employed to produce the briquette provided by the invention are also critical. Thus, when magnesium particles coarser than about 60-mesh size are used, the resulting briquettes produce violent reactions when added to molten cast iron. The magnesium particles should not be finer than about 200 mesh as otherwise excessive losses of magnesium are encountered upon addition of the briquettes to molten cast iron. Accordingly, divided magnesium having a particle size of about 60 to about 200 mesh is used. The carbon used has a fine particle size of about 200 mesh or finer to facilitate coating the magnesium particles used and to contribute low reactivity to the briquettes when added to molten iron.

In carrying the invention into practice, it is preferred to employ a briquetted agent containing about 20% to about 40% magnesium particles, with the balance essentially powdered carbon including an amount of binder sufficient to provide solidity in the briquette. Such preferred agents generally will contain about 50% to about 75% of carbon particles. Briquettes containing the preferred amounts of magnesium provide a particularly satisfactory recovery of contained magnesium in molten iron when added to said molten iron, together with favorable addition characteristics.

The briquettes contemplated by the invention can be produced by a method comprising intimately mixing the powdered ingredients together with a suitable binder, e. g., dextrin; pressing the mixed ingredients into suitable shapes, e. g., by means of an extrusion press, briquetting machine, etc.; and baking the shapes at a relatively low temperature, e. g., about 200° to about 400° F. Briquettes produced in this manner and having compositions within the foregoing ranges have the desirable attribute that they tend to retain their shape when brought into contact with molten cast iron and release contained magnesium gradually without attendant violent addition reactions.

For the purpose of giving those skilled in the art a better understanding of the process embodying the invention, the following illustrative examples are given:

Example I

Magnesium-carbon briquettes about ⅛ inch diameter and having random lengths of about ⅛ inch to ¾ inch were prepared using about 18% of 100-mesh magnesium powder, about 73% of 200-mesh carbon powder and about 9% dextrin binder. A gray cast iron bath containing about 3.5% carbon, about 3.2% silicon, about 0.03% sulfur, about 0.4% manganese, with the balance essentially iron, was prepared. Briquettes were added to the cast iron bath in an amount sufficient to add 1% magnesium thereto, the thus-treated bath was inoculated with about 0.5% silicon as ferrosilicon and metal from the bath was cast in sand to produce castings containing about 0.075% magnesium. These castings contained spheroidal graphite, had a hardness of about 203 BHN, and when tested transversely over 12-inch centers had a deflection of 0.57 inch before breaking at a load of 8150 pounds.

Example II

Magnesium-carbon briquettes similar in size to those used in Example I were pressed from a mix comprising about 28% 100-mesh magnesium powder, about 65% 200-mesh carbon powder and about 7% dextrin binder. Sufficient of these briquettes were added to a gray cast iron bath containing about 3.6% carbon, about 1.5% silicon, about 0.03% sulfur, about 0.4% manganese, with the balance essentially iron, to comprise a 1% magnesium addition to the bath; the thus-treated bath was inoculated with about 0.7% silicon as ferrosilicon and metal from the bath was cast in sand to produce castings including a 1.2-inch diameter casting containing about 0.05% magnesium. This casting contained spheroidal graphite, had a hardness of about 228 BHN, and when tested transversely over 12-inch centers had a deflection of about 1 inch before breaking at a load of 9940 pounds.

Example III

Magnesium-carbon briquettes similar to those used in Example II were added in similar amount to a gray cast iron bath containing about 3.6% carbon, about 2.4% silicon, about 0.03% sulfur, about 0.4% manganese, with the balance essentially iron. The thus-treated bath was then inoculated with about 0.5% silicon as ferrosilicon and metal from the bath was then cast to produce castings containing about 0.025% magnesium and containing spheroidal graphite. A 1.2-inch diameter sand-cast bar produced in this manner had a hardness of about 187 BHN and, when tested transversely over 12-inch centers, had a deflection of about 1.11 inches before breaking at a load of about 8290 pounds.

Example IV

Magnesium-carbon briquettes similar in size to those used in Examples I, II and III were pressed from a mix comprising about 37% 100-mesh magnesium powder, about 56% 200-mesh carbon powder and about 7% dextrin binder. Sufficient of these briquettes were added to a gray cast iron bath containing about 3.5% carbon, about 1.5% silicon, about 0.03% sulfur, about 0.4% manganese, with the balance essentially iron, to provide about a 1% magnesium addition to the bath; the thus-treated bath was inoculated with about 0.5% silicon as ferrosilicon and metal from the bath was then cast in sand to produce castings containing about 0.032% magnesium. These castings contained spheroidal graphite, had a hardness of about 223 BHN, a tensile strength of about 79,000 pounds per square inch, an elongation of about 14%; and had, in 1.2-inch diameter bars, a transverse strength of about 9440 pounds and a deflection of about 0.9 inch over 12-inch centers.

Example V

Magnesium-carbon briquettes about 2½ inches in diameter by about 1 inch long were prepared using about

37% of 100-mesh magnesium powder, about 56% of 200-mesh carbon powder and about 7% dextrin binder. Sufficient of these briquetes were added to a gray cast iron bath containing about 3.6% carbon, about 1.5% silicon, about 0.03% sulfur, about 0.5% manganese, with the balance essentially iron, to provide a 1% magnesium addition to the bath; the thus-treated bath was inoculated with about 0.5% silicon as ferrosilicon and metal from the bath was cast in sand to produce castings, including a 1.2-inch diameter bar and a keel block, which contained spheroidal graphite and about 0.055% magnesium. The 1.2-inch diameter bar had a hardness of 228 BHN and when tested transversely over 12-inch centers had a deflection of about 0.55 inch before breaking at a load of 8370 pounds. A tensile specimen cut from the keel block had a tensile strength of about 100,000 pounds per square inch and an elongation of about 9%.

Example VI

Magnesium-carbon briquettes similar in size to those used in Example V were pressed from a mix comprising about 46% of 100-mesh magnesium powder, about 47% of 200-mesh carbon powder and about 7% dextrin binder. Sufficient of these briquetes were added to a gray cast iron containing about 3.5% carbon, about 1.7% silicon, about 0.03% sulfur, about 0.4% manganese, with the balance essentially iron, to comprise a 1% magnesium addition to the bath; the thus-treated bath was inoculated with about 0.5% silicon as ferrosilicon and metal from the bath was cast in sand to produce castings, including a 1.2-inch diameter bar and a keel block, which contained spheroidal graphite and about 0.05% magnesium. The 1.2-inch diameter bar had a hardness of 212 BHN and when tested transversely over 12-inch centers had a deflection of about 0.92 inch before breaking at a load of 8730 pounds. A tensile specimen cut from the keel block had a tensile strength of about 73,000 pounds per square inch and an elongation of about 14%.

As previously indicated, binders are employed in the mix used to make the briquetted agents contemplated in accordance with the invention to insure that the briquettes will have the necessary mechanical strength and will retain their shape when added to molten iron. The preferred binders are water-dispersible organic binders which do not oxidize or otherwise react with magnesium and which do not interfere with the function of magnesium in desulfurizing cast iron and/or in controlling the occurrence of graphite in cast iron to a spheroidal form. Binding materials such as dextrin, glue, gum arabic, casein, etc., may be used in amounts of about 5% to 15% by weight of the briquette. For example, about 7% to about 10% dextrin gives satisfactory results. Binders such as cement, sodium silicate, milk of lime, etc., should not be present in substantial amounts because such materials tend to produce briquettes having unsatisfactory addition characteristics. Thus, the resulting briquettes may become excessively hard and release magnesium vapor too slowly into the molten iron. In addition, such briquettes may explode when finally they become thoroughly heated.

Although preferably the agents provided by the invention are essentially comprised of magnesium powder and carbon powder, certain other powdered ingredients having a generally reducing character may be present, for example, up to about 30% of silicon added as itself, as ferrosilicon, as calcium silicide, or in other metallic forms. Such powdered ingredients should have a particle size at least as fine as 60 mesh. The carbon used in compounding the special addition agents contemplated in accordance with the present invention may be in the form of either amorphous carbon or graphite and may be derived from such sources as crushed electrode butts, commercial powders, etc. Such carbon-containing materials as powdered coal and/or coke are less preferred since the sulfur, ash and volatile matter contents thereof may interfere with

proper functioning of the briquetted agent. The magnesium particles used may be in the form of chips and/or millings, in the form of spherical powders or in other powdered form. The briquettes should be practically devoid of the elements lead, titanium, antimony, arsenic, bismuth, tin, selenium tellurium, etc., as these elements are subversive to the effect of magnesium in causing graphite in cast iron to occur in a spheroidal form. Preferably, the briquetted agents are also practically devoid of sulfur.

The briquettes provided in accordance with the present invention may be manufactured in various sizes and shapes, depending largely upon the amount of iron to be treated at a time and upon the briquetting equipment used to produce the briquettes, e. g., rolls, extrusion press, etc. Usually, the larger the quantity of molten iron to be treated at once, the larger should be the briquettes employed. For example, briquettes approximately 3" x 3" x 4" could be used in treating ladles containing about 10,000 pounds or more of molten iron.

It is very important that the ingredients employed to produce the briquettes provided by the invention be thoroughly and intimately mixed before pressing so that the magnesium particles are coated by the carbon particles. When this practice is employed in compounding the briquetted agents contemplated by the invention, the briquettes tend not to disintegrate or give violent magnesium addition reactions but tend to retain their shape when brought in contact with molten cast iron and gradually release magnesium to the melt with commercially feasible magnesium addition reactions.

The magnesium-containing briquettes provided in accordance with the present invention may be added to molten iron in a number of ways. Thus, the briquettes may be thrown upon the surface of the molten iron or may be thrust beneath the surface of the iron by means of a mechanical device which may comprise an inverted can or cup made of metal, refractory, etc. From the quiet addition characteristics observed when these briquettes are in contact with molten iron, it would appear that the briquettes function to permit gasification of the contained magnesium before the molten iron comes in contact therewith. Thus, it is possible to extract the magnesium contained in the briquette while the briquette is in contact with molten iron without substantially changing the original shape of the briquette. In this manner, a skeletal or sponge-like mass having substantially the size and shape of the original briquette is left in contact with the molten iron bath after the magnesium has been extracted from the briquette. In order to accomplish this result, critical proportions of ingredients having the critical particle sizes described hereinbefore must be used and these ingredients must be intimately mixed and pressed so that the magnesium particles are coated with the carbon particles and binder used. When the precautions set forth hereinbefore are observed, a structure is produced in the briquetted agents which permits satisfactory addition of magnesium to molten iron. This desired structure appears to be characterized in that the magnesium particles are substantially isolated from each other by a framework of carbon.

The agent and process provided by the invention provide special advantages in that magnesium appears to be introduced into cast iron in a particularly effective form in carrying out the invention. For example, as pointed out hereinbefore, spheroidal graphite has been produced in cast iron at a retained magnesium level of about 0.025% in accordance with the invention without special conditioning treatment prior to magnesium addition. With special conditioning treatments it is possible to produce spheroidal graphite with as little as 0.01% retained magnesium.

As those skilled in the art know, cast iron is essentially an alloy of iron, carbon and silicon in which the carbon is present in excess of the amount which can be retained in solid solution in austenite at the eutectic temperature. Preferably, the cast iron to be treated with the agents contemplated by the present invention contains at least about 87% iron and is characterized by having iron in the alpha form at atmospheric temperatures. The cast iron preferably contains about 2% to 4.5% carbon and about 1.3% to 5% silicon, for example, about 2.5% to 4% carbon and about 1.5% to about 4.5% silicon. Such cast irons may contain small amounts of alloying elements less than a total of about 8%, e. g., up to about 5% nickel, up to about 1% molybdenum, up to about 1% chromium, etc. Manganese, sulfur and phosphorus normally are not considered alloy additions. Preferably the manganese content of the cast iron is less than about 1%. The bath to be treated may contain up to 0.25% or even 0.5% 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 0.2% or more, e. g., 0.005% to 0.2%, although it is preferred that the sulfur content be below 0.15%, e. g., 0.03% to 0.1%.

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. In the process for introducing magnesium into molten cast iron to produce iron castings containing a small but effective amount of retained magnesium, the improvement which comprises introducing said magnesium as a briquetted agent essentially comprising about 20% to about 40% magnesium particles having a particle size of about 60 to about 200 mesh, about 50% to about 75% carbon particles having a particle size at least as fine as about 200 mesh and about 5% to about 15% of a binder to provide solidity in said agent.

2. In the process for introducing magnesium into molten cast iron, the improvement which comprises introducing said magnesium as a briquetted agent essentially comprising about 20% to about 40% magnesium particles having a particle size of about 60 to about 200 mesh, about 50% to about 75% carbon particles having a particle size at least as fine as about 200 mesh and a binder in amount sufficient to provide solidity in said agent.

3. In the process for introducing magnesium into molten cast iron to produce iron castings containing a small but effective amount of retained magnesium, the improvement which comprises contacting molten cast iron with a briquetted agent essentially comprising about 20% to about 40% magnesium particles having a particle size of about 60 to about 200 mesh, about 50% to about 75% carbon particles having a particle size at least as fine as about 200 mesh and a binder in amount sufficient to provide solidity in said agent; and maintaining said agent in contact with said molten iron to extract magnesium from said agent without substantially altering the original shape of said agent.

4. In the process for introducing magnesium into molten cast iron, the improvement which comprises contacting molten cast iron with a briquetted agent essentially comprising about 15% to about 50% magnesium particles having a particle size of about 60 to about 200 mesh, about 40% to about 80% carbon particles having a particle size at least as fine as about 200 mesh and a binder in amount sufficient to provide solidity in said agent; and maintaining said agent in contact with said molten iron to extract magnesium from said agent without substantially altering the original shape of said agent.

5. In the process for introducing magnesium into molten cast iron to produce iron castings containing a small but effective amount of retained magnesium, the improvement which comprises introducing said magnesium as a briquetted agent essentially comprising about 15% to

about 50% magnesium particles having a particle size of about 60 to about 200 mesh, about 40% to about 80% carbon particles having a particle size at least as fine as about 200 mesh and about 5% to about 15% of a water-dispersible organic binder to provide solidity in said agent.

6. In the process for introducing magnesium into molten cast iron, the improvement which comprises introducing said magnesium as a briquetted agent essentially comprising about 15% to about 50% magnesium particles having a particle size of about 60 to about 200 mesh, about 40% to about 80% carbon particles having a particle size at least as fine as about 200 mesh and a binder in amount sufficient to provide solidity in said agent.

7. As a new article of manufacture, a briquetted agent adapted for the introduction of magnesium into molten cast iron which comprises a compacted, intimate mixture of about 20% to about 40% magnesium particles having a particle size of about 60 to about 200 mesh, about 5% to about 15% of a water-dispersible organic binder, and the balance essentially carbon particles having a particle size at least as fine as about 200 mesh, said carbon particles comprising about 50% to about 75% of the agent.

8. As a new article of manufacture, a briquetted agent adapted for the introduction of magnesium into molten cast iron which comprises a compacted, intimate mixture of about 15% to about 50% magnesium particles having a particle size of about 60 to about 200 mesh, about 5% to about 15% of a binder to provide solidity in said agent, and the balance essentially carbon particles having a particle size at least as fine as about 200 mesh, said carbon particles comprising about 40% to about 80% of said agent.

9. As a new article of manufacture, a briquetted agent adapted for the introduction of magnesium into molten cast iron which comprises a compacted, intimate mixture of about 15% to about 50% magnesium particles having a particle size of about 60 to about 200 mesh, up to about 30% powdered silicon, a binder in an amount sufficient to provide solidity in said agent, and the balance essentially carbon particles having a particle size at least as fine as about 200 mesh, said carbon particles comprising about 40% to about 80% of said agent.

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