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PROCESS FOR PRODUCING CAST IRON

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This invention relates to an improved cast iron and a process for producing this improved material. More specifically the invention relates to a cast iron containing graphite in a nodular or pseudo-nodular form.

Nodular cast iron is well known to the art and is distinguished by the spheroidal or nodular form assumed by the free graphite in the cast iron. A specimen in which all of the free graphite is in the nodular form may exhibit a tensile strength of as high as 100,000 p. s. i. and ductility as measured by elongation of up to 15%. These properties are in contrast to those for ordinary gray cast iron, containing graphite in flake form, which has a tensile strength of up to 40,000 p. s. i. and negligible ductility. Properties of strength and ductility range from those of the gray cast iron to the fully nodular cast iron depending in large part upon the extent to which the free graphite has been nodulized. Considerable improvement in tensile strength and ductility is shown by cast iron having a part only of the graphite in nodular form. The same is true for a cast iron in which some or all of the free graphite is in compacted or pseudo-nodular rather than fully nodular form.

According to the prior art nodular cast iron may be produced by treating the molten cast iron with bulk additions of a nodulizing agent so as to impart to the cast iron in the as-cast condition a minimum amount of the nodulizing agent. Among the more common nodulizing agents are magnesium and cerium which are conventionally added to the cast iron by combining suitable alloys of one or both of these elements with molten cast iron. Minimum amounts of the nodulizing agents that must be retained by the cast iron to effect the nodulization of the graphite are prescribed by the art.

It is a principal object of the invention to provide cast iron having a fully nodular graphitic structure. Another object of the invention is to provide a nodular cast iron having a fully nodular graphitic structure and containing smaller quantities of nodulizing agents than the nodular cast irons of the prior art. Still another object of the invention is to provide a cast iron exhibiting improved tensile strength and ductility which contains at least some free graphite in compacted or pseudo-nodular form and which contains amounts of nodulizing agents that are less than those prescribed by the prior art for cast irons having similar physical properties. A further object is to provide a process for producing nodular cast iron which minimizes the amount of nodulizing agent necessary to effect full or partial nodulization of the free graphite in the cast iron. An additional object of the invention is to provide a process for nodulizing cast iron which results in a savings of the amount of nodulizing agents consumed in the treatment of the iron.

These objects are accomplished according to the invention by providing molten cast iron having a sulfur content of less than 0.010% and treating the cast iron with a nodulizing agent. Cast irons resulting from this treatment, when magnesium is used as the nodulizing agent, exhibit a fully nodular graphitic structure with a retained magnesium content of less than 0.01%.

The reduction of the sulfur content of conventional cast irons to below 0.010% presents certain difficulties. These are overcome in the preferred process of the invention by deoxidizing the cast iron before it is desulfurized. This is done conveniently by adding a deoxidizer, for example an alloy of calcium-silicon or aluminum, to the molten iron as it is tapped from the cupola or forehearth. A quantity of deoxidizer equal to about 0.1% of the weight of the metal treated has been found to be satisfactory.

The deoxidation treatment is followed by the desulfurization of the cast iron. Preferably this desulfurization is accomplished by injecting into the molten cast iron a quantity of powdered calcium carbide which is entrained in a stream of an inert gas, for example argon. With the combined deoxidation and desulfurization of the cast iron the sulfur content of the iron is reduced to 0.010% or less and preferably to between 0.005% and 0.010%.

Following the adjustment of the sulfur content of the cast iron, the nodulizing agent is added. Because of the economies in the amount of nodulizing agent required when it is used, an injection technique for introducing the agent is preferred. Bulk additions of the agent have however proved satisfactory. According to the preferred process, the nodulizing agent is reduced to powdered form and carried into the cast iron in a stream of an inert gas. Magnesium and cerium are the more common nodulizing agents. These may be used in any suitable form, as for example elemental magnesium, magnesium-ferrosilicon, misch metal, rare earth oxides, and cerium-magnesium-ferrosilicon. The cast iron is inoculated before casting. The inoculation may be done in a conventional manner by adding lumps of ferrosilicon or other silicon-containing material to the molten iron. Preferably the inoculant is added at the same time the nodulizing agent is injected into the iron by mixing a powdered silicon-containing material with the powdered nodulizing agent. For best results a retained amount of nodulizing agent in the iron of between 0.005% and 0.01% is preferred.

A number of specimens of the cast iron of the invention were analyzed and tested with the results that are set forth in the table below. In each instance the molten cast iron was deoxidized with calcium silicon, and desulfurized with calcium carbide in the preferred manner. The sulfur content prior to the nodulization treatment is given in the table. The nodulization treatment comprised injecting in powdered form an alloy of cerium-magnesium-ferrosilicon. The amounts of cerium and magnesium added to the iron and the amounts of each retained are given in the table. The tensile strength and a brief description of the microstructure of the iron are also included.

Heat No.	Sulfur (Percent)	Added (Percent)		Residual (Percent)		Tensile Strength, p. s. i.	Microstructure, Percent	
		Mg	Ce	Mg	Ce			
1	0.006	0.020	0.001	0.007	0.0006	58,000	[1] 40	[2] 60
2	0.007	0.030	0.0015	0.005	0.0007	72,300	[1] 80	[2] 20
3	0.006	0.030	0.0015	0.006	0.0008	68,800	[1] 80	[2] 20
4	0.006	0.030	0.0015	0.005	0.0007	65,700	[1] 75	[2] 25
5	0.006	0.040	0.002	0.008	0.0009	77,000	[1] 100	------

[1] Nodules.
[2] Compacted flakes.

It will be seen from the table that cast iron having a fully nodular graphitic structure can be produced according to the invention with a retained amount of

nodulizing agent which is less than 0.01%. This fact plus the savings resulting from the use of the preferred injection techniques result in the production of cast iron with quantities of materials that are substantially less than those required by the art.

It should of course be understood that while the injection of the nodulizing agent into the cast iron in a gas stream is preferred, bulk additions give satisfactory results and require no greater amounts of retained nodulizing agents in the cast iron. For example, in one series of tests the amount of nodulizing agent that had to be added as a bulk addition was three times that which had to be added by the injection technique to effect full nodulization. In each instance the residual amount of nodulizing agent in the cast iron was less than 0.01%.

What is claimed is:

1. A process for treating cast iron to promote the formation of free graphite in compacted and nodular form, which process comprises providing a bath of molten cast iron, adding to said cast iron a deoxidizer, entraining powdered calcium carbide in a stream of inert gas, injecting said entrained calcium carbide into said molten cast iron thereby reducing the sulfur content of said cast iron to not more than 0.01%, injecting into the desulfurized cast iron simultaneously an inoculant and nodulizing agent, both in powdered form, said nodulizing agent being added in an amount sufficient to impart to said cast iron in the as-cast condition a retained amount of nodulizing agent equal to not more than 0.01%.

2. A process for treating cast iron to promote the formation of free graphite in compacted and nodular form, which process comprises providing a bath of molten cast iron, adding to said cast iron about 0.1% by weight of cast iron to be treated of one of the deoxidizers in the group consisting of calcium-silicon and aluminum, entraining powdered calcium carbide in a stream of inert gas, injecting said entrained calcium carbide into said molten cast iron thereby reducing the sulfur content of said cast iron to not more than 0.01%, injecting into the desulfurized cast iron simultaneously an inoculant and nodulizing agent, both in powdered form, said nodulizing agent being added in an amount sufficient to impart to said cast iron in the as-cast condition a retained amount of nodulizing agent equal to not more than 0.01%.

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