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3,146,090

PROCESS OF PRODUCING NODULAR IRON USING GROUP III METAL HYDRIDE

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This invention relates to unique ferrous alloys possessing improved properties, and processes for preparing the same, and, more particularly, to cast iron containing small, but effective, amounts of an addition agent selected from Group III metals of the periodic table.

It is known that the physical characteristics of ferrous metal containing carbon can be improved by forming the graphite in compacted, spheroidal, and nodular shapes. With the graphite in a compacted, or spheroidal, form, the metallic matrix is free of discontinuities, and possesses superior physical properties, particularly improved ductility.

Gray iron has been made more ductile by addition to the molten iron containing graphite-yielding carbon, certain agents, such as cerium, magnesium, calcium, misch metal, and the other materials, in the elemental form, as alloys, as mixtures with inert substances, or as chemical compounds of the desired addition metal. Copending application Serial No. 789,468, filed December 15, 1958, now Patent No. 3,055,756, assigned to the same assignee discloses yttrium as an addition for producing nodular iron.

There are certain disadvantages to each of the above identified addition agents, a few of which can briefly be mentioned as illustrative of the problems involved. Introducing elemental magnesium into molten ferrous metal is hazardous, since its boiling point, 1120° C., is below the melting point of eutectic iron carbon solution, ordinarily maintained around 1500° C. The same disadvantage accompanies the introduction of elemental cerium, or calcium, since their respective boiling points are 1400° C. and 1170° C.

Introducing the foregoing addition agents into a ferrous melt as alloys with metals, or non-metals, or as mixtures with inert materials, has the disadvantage of not only adding sometimes unwanted ingredients to the iron, but also requiring materials which in some instances are costly or are not readily obtainable.

Elemental yttrium addition to molten cast iron is remarkably quiet, compared, for example, with elemental magnesium; however, the heat of solution of yttrium is exothermic and there is noticeable activity in the bath when yttrium is added. Furthermore, elemental metals are expensive to produce, and are sometimes less effective as nodularizers because of their method of manufacture.

It is, therefore, an object of the present invention to provide an improved process for effecting the formation of spheroidal, compacted, or nodular, granules of graphite in cast ferrous metal containing carbon. It is still another object of the invention to improve the physical properties of cast iron. It is yet another object of the invention to provide a process for making spheroidal carbon iron using addition agents which improve the introduction into the ferrous metal. It is still another object of the invention to provide addition agents for the manufacture of spheroidal carbon in iron which allow a high carbon tolerance in the ferrous metal. It is still yet another object of the invention to provide addition agents in a form which are effective for nodularizing. It is a further object of the invention to provide addition agents that increase the time period in which to cast the ferrous metal after addition to the ferrous melt. It is a still

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further object of the invention to provide addition agents in which the nodularizing action can be better controlled. It is a yet further object of the invention to provide nodularizing agents which can be produced at lower costs than in the elemental form. Other objects and advantages of the present invention will be apparent to those skilled in this field from a study of the following description.

Briefly stated, the invention is concerned with addition to molten cast iron mix the hydride of a Group III metal of the periodic table having atomic numbers up to 71.

The composition of the novel ferrous product of the invention, in the absence of addition agents, is that of cast iron, for example, gray iron, or white iron. Generally, the product will contain at least 50% by weight iron and usually at least 90% by weight iron, carbon and silicon in the cast iron range, for example, about 2% to 5% by weight of carbon and about 1% to 5% by weight of silicon. The addition agent retained in the product of the invention is in the range from about 0.05% to about 0.8% usually from about 0.2% to about 0.8% by weight.

It is a discovery of the present invention that the hydride of metals of Group III of the periodic table having atomic numbers up to 71 when added to a molten cast iron mix decompose to release the elemental metals which act as nodularizing agents, produce marked improvements in ductility of the cast product. The decomposition reaction is endothermic and offsets the simultaneous exothermic heat of solution, so that the addition is more quiet than obtained by elemental metals having high boiling points.

The decomposition reaction is as follows:



(in which M is a Group III metal). The released hydrogen burns quietly on the surface of molten bath.

Although the Group III metal hydrides within the above definition are not equally effective, available, or desirable, they include the light and heavy lanthanons, and yttrium. Special preference is given to yttrium.

The Group III metal hydrides may be added singly or in combination. The hydride of yttrium misch metal is a convenient source of the additive.

The micro-structure in one form of product of the invention is obtained in the as-cast condition, with spheroidal, compacted, or nodular graphite and substantially devoid of the flake form. The nodular, or spheroidal, form of carbon is obtained in any matrix which as-cast, without a nodularizing agent, possesses flake graphite, such as gray cast iron. The various matrix constituents and structure can be controlled by well known methods by regulating the ingredients with or without heat treatments to obtain, for instance, pearlite, ferrite, martensite, tempered martensite, acicular transformation product of austenite, or combinations of the foregoing.

The addition of Group III metals also enhances what would otherwise be white iron, in another form of the invention. If heat treatments of the white iron are employed, beneficial results are obtainable which are attributable to the addition. Also, the presence of Group III metals in white iron improves its physical characteristics, in some instances. In the production of malleable iron, the presence of the addition agents shortens the essential heat treatment, or annealing cycle.

The amount of addition agent to be introduced to the bath will depend upon a number of conditions. If too large a quantity is retained in the product, iron carbide will result in the as-cast structure. Too small amounts of addition agent will fail to obtain the optimum nodularizing effect of the carbon. The constituents in the melt,

the temperature of the molten iron, the contemplated delay in casting after introduction of addition agent, the proportion of retained addition agent in the product, and the amount of retained addition agent desired will be factors to be considered. Amounts will, therefore, be such as to obtain in the cast metal retained addition agent in the proportions previously indicated.

In order to further illustrate the invention, the following examples are given. The examples are not, however, intended to limit the scope of the invention:

EXAMPLE I

Into a 50 lb. molten cast iron mix were introduced 3 ozs. of yttrium hydride. The addition proceeded quietly with little disturbance of the molten bath. The molten bath was inoculated with approximately 0.5% silicon as ferro-silicon and cast into a mold. The resulting casting possessed as-cast graphite in spheroidal compacted form.

EXAMPLE II

Into a 50 lb. ladle of molten cast iron mix were introduced 3 ozs. of a composition comprising:

- 1.5 oz. yttrium hydride; and
- 1.5 oz. metallic yttrium.

The addition produced little disturbance of the molten bath. The molten bath was inoculated with approximately 0.5% silicon as ferro-silicon and cast into a mold. The resulting casting possessed as-cast graphite in spheroidal compacted form.

The composition and parties of the castings produced by the above examples are reproduced in the following tables:

Table I

Example No.	Percent Si	Percent Mn	Percent S	Percent P	Percent Y
1	.267	.27	.014	.028	.34
2	.220	.30	.014	.028	.19

Table II

Example No.	Y-Block, inches	T.S.	Y.S.	El.	BHN
1	1/2	64,500	48,000	8.0	156
2	1/2	66,400	44,600	16.6	152
1	1	56,300	43,500	8.0	163
2	1	66,700	43,500	12.0	163

T.S.=Tensile strength in pounds per square inch.
Y.S.=Yield strength in pounds per square inch.
El.=Elongation in two square inches.
BHN=Brinell hardness number.

It will be noted that contrary to what may be expected to be an explosive reaction, the metal hydride addition is surprisingly quiet. A further advantage of the invention is the release in situ of the elemental metal by the decomposition of the hydride in the molten bath. This controls the elemental metal, so that it is in a form effective for nodularizing which may not be the case if produced in elemental form by certain manufacturing tech-

niques. Another advantage is the economic route for the preparation of certain metal hydrides which is less expensive, in certain instances, than preparation of elemental metal.

Other modes of applying the principle of the invention may be employed, change being made as regards the details described, provided the features stated in any of the following claims or the equivalent of such be employed.

We, therefore, particularly point out and distinctly claim as our invention.

What is claimed is:

1. The process for producing iron castings in which graphitic carbon is present in the nodular form and with substantially no separation of flake-like graphitic carbon which comprises the steps of preparing a bath of molten cast iron mix, introducing into said bath a small but effective amount of the hydride of a Group III metal having an endothermic heat of decomposition selected from the class consisting of lanthanons and yttrium, and thereafter casting metal from said bath to produce a casting containing a small but effective amount of addition agent and containing graphite in a compacted form.

2. The process for producing iron castings in which graphitic carbon is present in the as-cast state as agglomerates of nodular form and with substantially no separation of flake-like graphitic carbon which comprises the steps of preparing a bath of molten cast iron mix, introducing into said bath the hydride of a Group III metal having an endothermic heat of decomposition selected from the class consisting of lanthanons and yttrium, in effective amounts ranging from about 0.2% to about 0.8% by weight, and thereafter casting metal from said bath to produce a casting containing a small but effective amount of addition agent and containing graphite in a compacted form.

3. The process of claim 2 wherein said cast iron mix contains from about 2% to about 5% by weight of carbon and from about 1% to about 5% by weight of silicon.

4. The process of claim 1 in which said Group III metal hydride is in the form of yttrium misch metal hydrides.

5. The process of claim 1 in which said Group III metal hydride is yttrium hydride.

6. The process of claim 2 in which said Group III metal hydride is in the form of yttrium misch metal hydrides.

7. The process of claim 2 in which said Group III metal hydride is yttrium hydride.

8. The process of claim 1 in which said Group III metal hydride is a lanthanon hydride.

9. The process of claim 2 in which said Group III metal hydride is a lanthanon hydride.

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