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AUSTENITIC CAST IRON

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This invention relates to the treatment of austenitic white cast iron in which the principal alloying element is manganese.

The principal object of the invention is to produce from a white cast iron in which all the carbon is in the combined form as carbide a product which is both austenitic and malleable or tough, and which has a considerable resistance to wear or abrasion.

U. S. application Serial No. 492,948, now U. S. Patent No. 2,435,946, describes a process for the treatment of castings of austenitic manganese cast iron alloys wherein the castings are decarburized in a furnace by an agent which is relatively non-oxidizing to the manganiferous austenite but is decarburizing to the carbon content. According to an embodiment of the invention of the said application, the alloy as cast contained 9% to 25% by weight of manganese, 2% to 6% by weight of carbon, not more than 2% by weight of silicon and not more than 0.15% by weight of phosphorus. If desired, part of the manganese might be replaced by nickel and/or copper to such an extent that the alloy contained up to a total of 24% by weight of nickel and copper, the nickel substituting an equal weight of manganese whilst the copper substitutes approximately half its weight of manganese. Other alloying elements, such as chromium, molybdenum, titanium, tungsten and vanadium, might also be present in the alloy in quantities not exceeding 5% by weight of any one element or 12% by weight in all.

The process in accordance with the aforesaid application Serial No. 492,948 is more particularly suited to the production of castings of relatively thin section as decarburization becomes uneconomical in thick sections owing to the long-time cycle required. If a long-time cycle is not used, then the core of a thick section contains free carbide and is, therefore, of relatively low ductility.

According to the present invention, a process is provided for the treatment of castings of austenitic white cast irons in which manganese is the principal alloying element wherein nickel is included in the composition of the cast iron employed to make said castings and the austenitic white cast iron casting made therefrom is subjected to an annealing treatment, the ratio

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of carbide-stabilizing elements to graphite-promoting elements in the said cast iron being such that an austenitic structure is preserved in the final product but that substantially all the free carbide is graphitized during the annealing treatment to render the austenitic casting malleable. The annealing treatment may be effected in a decarburizing atmosphere or other medium.

The free carbide in the original casting is eliminated almost in its entirety and the casting is converted into a tough, ductile product, the structure being graphite plus austenite with or without a minor amount of martensite. A certain amount of carbon is in solution in the austenite, and if the heat treatment process is of a decarburizing nature, some carbide will be removed from the surface layers. Hence, it must be understood that the phrase "substantially all the free carbide is graphitized" refers to the carbide which either does not remain in solution in the austenite or is not removed from the casting.

The graphitizing of the carbide causes the casting to become malleable or ductile throughout irrespective of its sectional dimensions, within limits, and, therefore, the invention is readily applicable to thick castings required to have wear resistant properties.

The austenitic cast iron employed by the invention has such a composition that it is white in the as cast condition. The composition falls in the range of 2% to 5% by weight of nickel, 9% to 18% by weight of manganese, 3% to 6% by weight of carbon, 1.5% to 4.5% by weight of silicon, and not more than 0.15% by weight of phosphorus. The presence of nickel, in combination with silicon, manganese and carbon, is essential in order to obtain the graphitization of the carbide whilst retaining an austenitic structure. A typical composition is about 3% by weight of nickel, about 10% by weight of manganese, about 2.2% by weight of silicon, about 0.09% by weight of phosphorus and about 3.5% by weight of carbon. The sulfur content of such castings will always be less than about 0.1% since any sulfur which may be present in the raw material from which the original casting is produced is mainly converted into manganese sulfide during the melting process prior to cast-

ing and is eliminated as a slag. It may be desirable to add other graphite-promoting elements, such as copper and aluminum, to the casting, and these may replace part at least of the nickel and/or silicon. Moreover, one or more other alloying elements, such as chromium, molybdenum, tungsten and vanadium, may be present in proportions not exceeding about 2% by weight of any one element and about 5% by weight in all, bearing in mind the necessity for preserving an austenitic structure and the balance between carbide-stabilizing elements and graphite-promoting elements. In general, it is preferred to maintain the amounts of these elements as low as practicable.

The alloy casting is subjected to a heat treatment process between about 850° C. and 1150° C., preferably between about 1000° C. and 1100° C., for a period of more than five hours, and during this treatment substantially all the free carbide will be changed into graphite carbon, except for the amount that remains in solution as austenite, or is removed by any decarburizing action. To preserve the austenitic nature of the material after treatment, it is rapidly cooled by air cooling, air blast cooling, oil quenching or water quenching from a temperature of about 900° C. to 1150° C.

For the graphitizing treatment, the casting may be put into a furnace and packed in any inert material, such as sand, or the furnace may be well sealed so as to prevent excessive oxidation. Alternatively, a neutral atmosphere or gas may be inserted into the furnace to prevent oxidation. A further variation of the treatment is to apply a decarburizing process as described in application Serial No. 492,948, and this process will yield a product with a ductile core consisting of graphite and austenite with relatively little residual carbide and an intermediate tough and ductile band of substantially stable austenite which becomes more unstable as it merges into a hard surface layer of martensite. The latter treatment is carried out in a controlled atmosphere furnace, and the gases employed as the decarburizing medium may be at a pressure of from approximately half an atmosphere to two atmospheres. It is difficult to use at the operating temperatures below or exceeding those mentioned above.

In order that those skilled in the art may have a better understanding of the invention, the following illustrative data are given:

Examples

Cast irons containing manganese, nickel, silicon and carbon in the amounts given in the following schedule, the balance being substantially all iron, were cast.

Cast Iron No.	Composition			
	Per Cent Mn	Per Cent Ni	Per Cent Si	Per Cent C
1	10.3	3.2	2.4	3.15
2	9.0	3.9	2.1	3.15
3	8.8	2.8	1.8	3.3

Cast irons No. 1 and No. 3 were cast in section sizes up to 2 inches, while cast iron No. 2 was cast in section sizes up to 1 inch. All the cast irons were austenitic and white, i. e., the excess carbon was in the form of free carbides. Cast iron No. 1 was annealed for about 50 hours at 1050° C. After this treatment, the carbon of the austenitic cast iron was in the graphitic form. Likewise, after treating cast irons No. 2 and No. 3 for 35 to 40 hours and 70 to 80 hours, respectively, at 1050° C., the carbon was graphitized while the austenitic structure was retained. Similar nickel-free cast irons which were austenitic, white and not malleable in the as cast condition did not show signs of graphitization when annealed for periods up to 120 hours at 1075° C.

The present application is in the nature of a continuation-in-part of our prior copending application Serial No. 558,742, filed October 14, 1944, now abandoned.

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 variations and modifications are considered within the purview and scope of the invention and the appended claims.

We claim:

1. A process for producing a malleable casting from an austenitic white cast iron composition in which manganese is the principal alloying element and which contains free carbides in the as cast condition, said process comprising making an austenitic white cast iron casting containing about 2% to 5% nickel in addition to about 9% to 18% manganese, 3% to 6% carbon, 1.5% to 4.5% silicon, not more than 0.15% phosphorus and the balance essentially iron, treating said casting made of said nickel-containing austenitic white cast iron between about 1000° C. and 1100° C. for more than five hours to graphitize substantially all the free carbides while retaining an austenitic matrix structure, and rapidly cooling the thus-treated casting from within the range of about 900° C. to 1150° C.

2. A process for producing a malleable casting from an austenitic white cast iron composition in which manganese is the principal alloying element and which contains free carbides in the as cast condition, said process comprising treating a casting made of an austenitic white cast iron containing about 2% to 5% nickel in addition to about 9% to 18% manganese, 3% to 6% carbon, 1.5% to 4.5% silicon, not more than 0.15% phosphorus and the balance essentially iron between about 850° C. and 1150° C. for more than five hours to graphitize substantially all the free carbides while retaining an austenitic matrix structure, and rapidly cooling the thus-treated casting from within the range of about 900° C. to 1150° C.

3. A process for producing a malleable casting from an austenitic white cast iron composition in which manganese is the principal alloying element and which contains free carbides in the as cast condition, said process comprising treating a casting made of an austenitic white cast iron containing about 2% to 5% nickel in addition to about 9% to 18% manganese, 3% to 6% carbon, 1.5% to 4.5% silicon, not more than 0.15% phosphorus and the balance essentially iron between about 850° C. and 1150° C. in a decarburizing gaseous atmosphere for more than five hours to graphitize substantially all the free carbides, and rapidly cooling the thus-treated casting from within the range of about 900° C. to 1150° C.

4. A casting made of austenitic cast iron in which manganese is present in sufficiently large

amounts to impart an austenitic structure and to tie up the carbon content of nickel-free austenitic manganese cast iron in the form of free carbides, said casting being comprised of a malleable austenitic cast iron containing about 2% to 5% nickel in addition to about 9% to 18% manganese, 3% to 6% carbon, 1.5% to 4.5% silicon, not more than 0.15% phosphorus and the balance essentially iron, said casting having a microstructure comprised of graphite in an austenitic matrix and being substantially devoid of free carbides.

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