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HARDENABLE CAST IRON

Frederick G. Sefing, Cranford, N. J., assignor to The International Nickel Company, Inc., New York, N. Y., a corporation of Delaware

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The present invention relates to the production of special hardened gray cast iron compositions and castings made thereof characterized by high hardness and by high resistance to the effects of corrosion, abrasion and wear.

It has now been discovered that a special alloy gray cast iron composition can be softened to a satisfactory hardness level for machining and is thereafter, in cooperation with a special thermal treatment, hardened to a high hardness level of at least 450 Brinell.

It is an object of the present invention to provide alloy gray cast iron castings which can be machined and which thereafter can be hardened to a high hardness level of at least about 450 Brinell.

Another object of the invention is to provide a hardened gray cast iron resistant to the corrosive effects of salty, acidic or basic environments.

The invention also contemplates providing a hardened gray cast iron resistant to the deleterious action of abrasives and resistant to metal-to-metal wear.

It is a further object of the invention to provide a special thermal hardening treatment cooperating with a special alloy gray cast iron composition to produce a high hardness level therein of at least about 450 Brinell.

Broadly stated, the invention comprises a special hardened nickel-copper alloy gray cast iron characterized by a hardness of about 450 Brinell or more and a special process for the production of said hardened alloy gray cast iron. The special hardened alloy gray cast iron provided by the invention contains about 2.25% to about 3.25% total carbon, about 7% to about 10% nickel, about 3% to about 4.5% copper, about 1% to about 4% chromium, about 1.5% to about 3% silicon, about 0.3% to about 1% manganese, and the balance essentially iron, said balance being at least about 73% iron.

The special alloy cast iron composition provided by the invention is hardened to a hardness level of at least about 450 Brinell or higher, e. g., about 500 Brinell, by a thermal treatment which comprises heating castings made of said cast iron at temperatures of about 1000° F. to about 1050° F. for time periods up to about 24 hours, e. g., about 8 to about 15 hours. Hardness values up to about 575 Brinell in the special compositions are produced in accordance with the invention.

In carrying the invention into practice, it is preferred to employ alloy cast iron compositions containing about 2.5% to about 3% total carbon,

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about 7.5% to about 9% nickel, about 3.5% to about 4% copper, about 2% to about 2.5% chromium, about 1.75% to about 2.25% silicon, up to about 0.8% manganese, and the balance essentially iron. The aforesaid preferred hardened alloy gray cast iron compositions are characterized by a hardness of about 525 Brinell or more and by improved corrosion resistance.

The temperature range set forth hereinbefore in which the thermal hardening treatment is carried out is critical as it has been found that when the thermal hardening temperature exceeds about 1050° F. hardness values of 450 Brinell or more cannot be achieved whereas at thermal hardening temperatures below about 1000 F. thermal hardening proceeds so slowly as to be commercially impractical. It is preferred that thermal hardening be carried out within the range of about 1015° F. to about 1035° F. and it has been found that very satisfactory results are obtained when the hardening temperature is about 1020° F. to about 1025° F. Very satisfactory results have been obtained with thermal treatments conducted for about 12 hours in the preferred treating range of about 1020° to about 1025° F. Castings containing less than about 12% copper plus nickel and/or more than about 2.5% chromium have been found frequently to be undesirably hard and/or to have a non-uniform hardness in the as-cast condition, with the result that such castings are machinable only with difficulty. It is desirable therefore, before machining such castings, to heat said castings to a temperature of about 1600° to about 1800° F., e. g., 1700° F., and to thereafter rapidly cool said castings, e. g., to oil quench said castings. The aforesaid rapid cooling or quenching is carried out at a rate of not less than about 325° F. per second (at 1300° F.) and the temperatureture of the castings is reduced below about 900° F., but not substantially below atmospheric temperatures, by means of the rapid cooling treatment. The rapid cooling treatment or quench can be carried out with little danger of cracking the castings. The quenching treatment is desirable to overcome the effect of possible production variables and to insure that the cast compositions provided by the process embodying the invention will have a uniform machinable hardness level within a range of about 160 to about 250 Brinell, e. g., a hardness level of about 225 Brinell. In those castings having a satisfactory machinable hardness in the as-cast condition, the aforesaid quenching treatment is not essential to insure hardening to a satis-

factory hardness level upon subsequent heat treatment.

The special process contemplated by the invention thus provides alloy gray cast iron castings which may be thermally softened to a satisfactory machinable hardness level and which may be hardened after any required machining to the high hardness level of 450 Brinell or higher. A further advantage provided by the invention resides in the fact that very little discoloration or oxidation of machined surfaces on the castings is encountered during the thermal hardening treatment. It is preferred that the castings be rapidly cooled, i. e., cooled at a rate at least about as fast as air cooling, after the aforesaid thermal hardening treatment to insure the aforesaid high hardness level in the hardened castings. The castings are cooled to a temperature below about 600° F., e. g., to atmospheric temperature or lower. An expansion of about 0.002 to about 0.004 inch per inch usually occurs during the thermal hardening treatment.

The amounts of alloying elements in the cast iron compositions contemplated by the invention set forth hereinbefore are critical and the novel results provided by the invention are not achieved unless the aforesaid amounts of alloying elements are employed. Thus, when the carbon content is below about 2.25%, trouble is encountered by way of poor castability, poor machinability and poor metal-to-metal wear resistance. On the other hand, at carbon contents above about 3.25%, it is not practically possible to obtain the high hardness of 450 Brinell contemplated by the thermal treating process provided by the invention. The total content of nickel plus copper in the special alloy cast iron provided by the invention is maintained within the range of about 10% to about 14% because when the total content of these two elements is substantially below about 10%, quenched castings are too hard to be machinable, and when the total content of these two elements is substantially above about 14%, the castings are not thermally hardenable to the high level of 450 Brinell or above, as contemplated according to the process provided by the invention. The chromium content in combination with the total content of nickel plus copper is also a critical factor as it has been found that with the total nickel plus copper contents set forth hereinbefore, castings containing less than about 1% chromium are not hardenable to 450 Brinell and, on the other hand, castings containing more than about 4% chromium are not practically machinable, even after the rapid cooling treatment described hereinbefore. The preferred chromium content of about 2% to about 2.5% insures satisfactory machinable hardness at least after the aforesaid quenching operation and the development of high hardness in the subsequent thermal treatment at about 1000° F. to about 1050° F. The silicon content in combination with the aforesaid nickel, copper and chromium contents is likewise critical as it has been found that when the silicon content is less than about 1.5% both the castability and the hardenability are impaired, whereas when the silicon content exceeds about 3% it is difficult to achieve the machinable hardnesses of less than about 250 Brinell in the as-cast and/or quenched conditions. The special alloy gray cast iron castings provided by the invention contain at least about 1% graphite up to about 2.6% graphite, e. g., the preferred compositions set forth hereinbefore will contain about 1.25% to about 2% graphite. For best response to the thermal hardening treatment, it is preferred to keep the manganese content low, e. g., below about 0.5%.

For the purpose of giving those skilled in the art a better appreciation of the advantages of the invention, the following illustrative example is given:

A gray cast iron casting containing about 2.9% total carbon, about 1.8% silicon, about 8.6% nickel, about 2.1% chromium, and about 3.3% copper was produced. In the as-cast condition, this casting had a hardness of about 385 Brinell. The casting was heated to about 1700° F. and was quenched in oil. The hardness of the quenched casting was about 235 Brinell. The casting was then heated to about 1025° F., was held at the said temperature for about 12 hours, and was air cooled from said temperature to room temperature. After the aforesaid heat treatment, the casting had a hardness of 545 Brinell.

In addition to the alloying elements set forth hereinbefore, the alloy gray cast iron provided by the invention may also contain usual small amounts of incidental impurities and other elements found in gray cast iron and which do not materially affect the properties of the castings provided by the invention. Thus, the castings may contain up to about 0.14% sulfur, up to about 0.5% phosphorus, etc.

Castings contemplated by the invention may be produced by the usual methods and in the usual equipment employed in the production of high quality gray iron castings. Thus, the arc or induction electric furnaces, etc., have been employed successfully in the production of castings contemplated by the invention.

The special hardened alloy gray cast iron compositions provided by the invention having the high hardness described hereinbefore are characterized by a high combination of corrosion resistance, abrasion resistance, metal-to-metal wear resistance and heat resistance. Thus, the special cast iron has been found to be particularly resistant to the corrosive effect of salt water and to have a highly useful resistance to the corrosive effects of both acids and alkalies.

The high combination of corrosion resistance, abrasion resistance and metal-to-metal wear resistance which characterize the hardened alloy cast iron provided by the invention are particularly useful in pump parts and in other equipment handling sour crude oils containing sand or in handling salty crude oils containing sand. Parts for equipment used in handling acid or basic abrasive slurries, e. g., the corrosive slurries found in kraft paper mills, are also advantageously made from the new cast product provided by the invention. In addition, parts for equipment used in handling abrasive materials at elevated temperature are also made with great advantage from the new product.

While the mechanism involved in the present invention is not fully understood theoretically, it is believed that the special thermal treatment at temperatures of about 1000° F. to about1050° F. cooperates with the critical cast iron composition contemplated by the invention to produce a depletion of the carbon content of austenite in the as-cast or as-quenched castings provided according to the invention to produce very finely dispersed carbides and to cause transformation of the carbon-depleted austenite to a hard constituent upon cooling of the castings from the

aforesaid special thermal treating temperature. Whatever the true explanation may be, the facts are that the special compositions cooperate with the thermal treatment under special conditions contemplated by the invention to produce an unexpectedly high hardness in the thermally treated cast iron compositions.

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 understand. Such modifications and variations are considered to be within the purview and scope of the invention and of the appended claims.

I claim:

1. The improved process for producing a hard, wear-resistant, corrosion-resistant alloy gray cast iron casting which comprises producing an alloy gray cast iron casting containing about 2.5% to about 3% carbon, about 7.5% to about 9% nickel, about 3.5% to about 4% copper, about 2% to about 2.5% chromium, about 1.75% to 2.25% silicon, and the balance essentially iron, heating said casting to a temperature of about 1600° F. to about 1800° F., rapidly cooling said heated casting to a temperature below about 900° F. to soften said casting to a machinable hardness level of about 180 to about 250 Brinell, and thereafter subjecting said casting to a thermal treatment at a temperature of about 1020° to about 1025° F. for about 8 to about 15 hours to harden said casting and to produce a wear-resistant, corrosion-resistant alloy gray iron casting having a hardness of at least about 450 Brinell.

2. The improved process for producing a hard, wear-resistant, corrosion-resistant alloy gray cast iron which comprises thermally treating a gray cast iron casting containing about 2.25% to about 3.25% carbon, about 7% to about 10% nickel, about 3% to about 4.5% copper, the sum of said nickel and said copper contents being about 10% to about 14%, about 2% to about 2.5% chromium, about 1.5% to about 3% silicon, and the balance essentially iron, at a temperature of about 1015° F. to about 1035° F. for about 8 to about 24 hours and thereafter rapidly cooling said casting to a temperature below about 600° F.

3. In the process for producing a hard, wear-resistant, corrosion-resistant alloy gray cast iron casting, the improvement which comprises thermally treating a gray cast iron casting containing about 2.25% to 3.25% carbon, about 7% to about 10% nickel, about 3% to about 4.5% copper, the sum of said nickel and said copper contents being about 10% to about 14%, about 1% to about 4% chromium, about 1.5% to about 3% silicon, about 0.3% to about 1% manganese, and the balance essentially iron, at a temperature of about 1000° to about 1050° F. for a time period up to about 24 hours.

4. As a new article of manufacture, a thermally hardened alloy gray cast iron casting containing about 2.25% to 3.25% carbon, about 7% to about 10% nickel, about 3% to about 4.5% copper, the sum of said nickel and said copper contents being about 10% to about 14%, about 1% to about 4% chromium, about 1.5% to about 3% silicon, about 0.3% to about 1% manganese, and the balance essentially iron, said casting being characterized by a hardness of at least about 450 Brinell.

5. As a new article of manufacture, an alloy gray cast iron casting containing about 2.5% to about 3% carbon, about 7.5% to about 9% nickel, about 3.5% to about 4% copper, about 2% to about 2.5% chromium, about 1.75% to about 2.25% silicon, up to about 0.8% manganese, and the balance essentially iron, said casting being characterized by a low machinable hardness at least after a heating to a temperature of about 1600° F. to about 1800° F., followed by a rapid cooling to a temperature below about 900° F., but not substantially below atmospheric temperature; and being characterized by a high hardness of about 525 Brinell after a subsequent thermal treatment at about 1000° to about 1050° F. for about 8 to about 15 hours.

6. As a new article of manufacture, an alloy gray cast iron casting containing about 2.25% to about 3.25% carbon, about 7% to about 10% nickel, about 3% to about 4.5% copper, the sum of the nickel and copper contents being about 10% to about 14%, about 1% to about 4% chromium, about 1.5% to about 3% silicon, about 0.3% to about 1% manganese and the balance essentially iron, said cast iron having been hardened to a hardness of at least about 450 Brinell by a process comprising the successive steps of heating to a temperature of about 1700° F., rapid cooling to a temperature below about 900° F., heating to a temperature of about 1000° F. to about 1050° F. for a time period up to about 24 hours, and rapid cooling to a temperature below about 600° F.

7. In the process for producing a hard, wear-resistant, corrosion-resistant alloy gray cast iron casting, the improvement which comprises thermally treating a gray cast iron casting containing about 2.5% to about 3% carbon, about 7.5% to about 9% nickel, about 3.5% to about 4% copper, about 2% to about 2.5% chromium, about 1.75% to about 2.25% silicon and the balance essentially iron, at a temperature of about 1000° to about 1050° F. for a time period of about 8 to about 24 hours.

8. The process for producing a hard, wear-resistant, corrosion-resistant alloy gray cast iron which comprises heating to a temperature of about 1600° to about 1800° F. a gray cast iron casting containing about 2.25% to about 3.25% carbon, about 7% to about 10% nickel, about 3% to about 4.5% copper, the sum of said nickel and copper contents being about 10% to about 14%, about 1% to about 4% chromium, about 1.5% to about 3% silicon, about 0.3% to about 1% manganese and the balance essentially iron, rapidly cooling said heated casting to a temperature below about 900° F. to soften said casting to a machinable hardness level, and thereafter subjecting said casting to a thermal treatment at a temperature of about 1015° to about 1035° F. for about 8 to about 24 hours.

FREDERICK G. SEFING.

REFERENCES CITED

The following references are of record in the file of this patent:

FOREIGN PATENTS

Number	Country	Date
279,415	Great Britain	Jan. 29, 1949