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ALLOY WHITE CAST IRON

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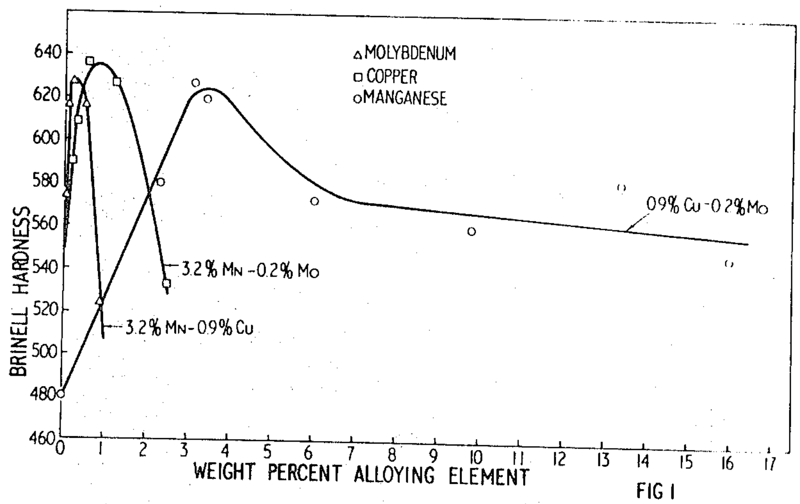

FIG I

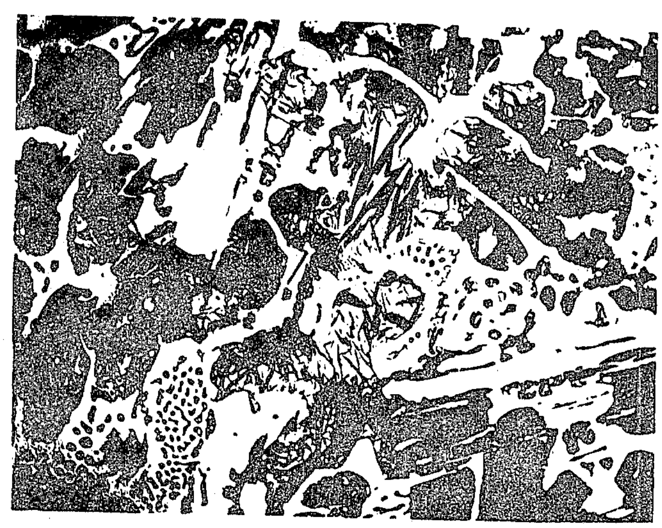

FIG. 2

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ALLOY WHITE CAST IRON

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Claims priority, application Great Britain, Sept. 20, 1965, 40,027/65
Int. Cl. C22c *37/00*
U.S. Cl. 148—35 9 Claims

ABSTRACT OF THE DISCLOSURE

A manganese-copper molybdenum alloy white cast iron has a substantially uniformly distributed martensitic structure and a high and uniform hardness in excess of 500 Brinell and a high resistance to abrasion and impact. A preferred range of alloying components includes between 2.5 and 5% manganese, between about 2% and about 4% carbon, up to about 2% silicon and at least one of the group consisting of 0 to 2.5% copper and 0 to 1% molybdenum wherein the total amount of copper plus molybdenum is not less than 0.1%, the balance being essentially iron and incidental impurities commonly found in cast iron.

This application is a continuation-in-part of our earlier application Ser. No. 575,461, filed Aug. 26, 1966, now abandoned.

This invention relates to manganese-copper-molybdenium white cast iron, and more particularly to manganese-copper molybdenum white cast irons having a high hardness, abrasion resistance, and resistance to impact.

Broadly speaking the present invention is one in which manganese is an essential constituent in the ranges appearing hereafter. However, the alloy has improved properties if manganese is present with either copper or molybdenum.

Materials previously used in applications where resistance to wear and abrasion is required include unalloyed white cast iron, alloy white cast irons having nickel and chromium as the main alloying constituents, and steel, both plain and alloyed. However, these materials suffered from a number of drawbacks. Firstly, they frequently lacked the satisfactory combination of strength, hardness, toughness and abrasion resistance necessary, for example, in such applications as grinding media, mill liners and similar applications or these alloys were expensive to use due to the cost of the alloying constituents.

The need for an alloy possessing the characteristics of toughness, strength, hardness and abrasion resistance and which is also more economical to produce than similar prior art alloys is very clearly apparent.

According to the present invention there is provided an alloy white cast iron having a substantially uniformly distributed martensitic structure and containing between about 1.5% and about 16% manganese; between about 2% and about 4% carbon, from 0 to about 2% of silicon, and at least one of the group consisting of 0 to 2.5% copper and 0 to 1% molybdenum wherein the total amount of copper plus molybdenum is not less than 0.1%, the balance being essentially iron and incidental impurities commonly found in cast iron, said alloy having a high and uniform hardness in excess of 500 Brinell and high resistance to abrasion and impact. These impurities include phosphorus and sulphur as are commonly found in cast iron (the percentage content of phosphorus may vary typically from 0.01 to 0.2 and of sulphur from 0.01 to 0.3), and also tramp elements which are unavoidably introduced into the alloying furnace or cupola with scrap metal.

FIG. 1 is a graph showing the relationship of alloy hardness to the percentage content by weight of manganese, copper and molybdenum.

FIG. 2 is a photomicrograph of a preferred alloy taken at a magnification of ×500.

After extensive experimentation and the carrying out of tests or numerous alloys, we have found that alloy white cast iron, containing as part of its composition, manganese, copper and molybdenum, provides a desirable combination of strength, hardness, toughness and abrasion resistance when the alloy compositions are held within the given limits, and that the alloy white cast iron can be readily melted in a cupola. Moreover, the new alloy white cast iron provides an economical alternative to the abrasion resistant materials used heretofore.

The microstructure of alloys made according to the invention is comprised of a carbide phase, a pearlite phase and an austenite-martensite phase in various proportions. Apart from the carbide phase it is not necessary that all these phases be present together in the microstructure of the present invention. The proportions of the carbide phase, the pearlite phase and the austenite-martensite phase in the microstructure vary according to the section size of the cast object, the cooling rate of the casting and the precise composition as will readily be appreciated by those skilled in the art. The combined effects of these phases give to the microstructure, and hence to the alloy, the desirable combination of properties already mentioned and enable the alloy to be used where a high resistance to abrasion and impact, as well as a high and uniform hardness throughout the cast object, are necessary.

An example of the invention will now be described with reference to FIG. 1 of the accompanying drawings, which shows the relation of alloy hardness to the percentage content by weight of manganese, copper and molybdenum.

A number of one and one-half inch diameter grinding members, as are commonly used in ore grinding applications, were chill cast with various alloying contents. The hardness of the members was tested and the drawing shows the variation in hardness of such slugs when the manganese, copper and bolybdenum are varied independently, the other constituents of the alloy being held constant within the limits of experimentation. The Rockwell hardness of the members was tested. It may be seen that an equivalent Brinell hardness about 500 may be obtained in an alloy white cast iron over a range of compositions, many of which would be substantially more economical than materials now in common use for alloys requiring superior abrasion and wear resistance.

Before arriving at the preferred embodiment an experimental programme on alloys containing up to 4% copper, up to 16% manganese, up to 0.5% nickel, up to 1% molybdenum and up to 0.1% boron was carried out on a pilot scale. Each alloy was based on a cast iron mixture containing approximately 3% carbon, 0.5% silicon, the remainder iron, all percentages being by weight. All the alloys tested provided to have a high hardness and good abrasion resistance.

However, within the broad range of compositions contemplated by the invention, and set out hereinbefore, a special and preferred alloy having an optimum hardness is obtained. The preferred embodiment contains about 3.2% manganese, 0.9% copper, and 0.20% molybdenum with 2–4% carbon, 0–2% silicon, the balance essentially iron containing small amounts of impurities e.g. phosphorus and sulphur in the amounts commonly found in cast iron and referred to previously. It should be noted that the total amount of copper plus molybdenum should not be less than 0.1%. This preferred alloy would offer very high resistance to abrasion and wear in uses such as grinding of ores.

The following are three examples of many specific compositions which were used in casting alloys in accordance with the present invention:

EXAMPLE I

A truncated cone, of height approximately 2 inches and measuring approximately 1½ inches at the base, cast under normal production conditions at Foundry No. 2, from hot cupola metal of the following composition: 3.19% carbon, 0.56% silicon, 3.54% manganese, 1.05% copper, 0.25% molybdenum, had a uniform hardness of Brinell 618.

EXAMPLE II

A truncated cone, approximately 1½ inches high and 1 inch diameter at the base, cast under normal production conditions at Foundry No. 1, from hot cupola metal of the following composition: 3.19% carbon, 0.76% silicon, 3.20% manganese, 1.34% copper, 0.27% molybdenum, had a uniform hardness of Brinell 640.

EXAMPLE III

A grinding ball of 1½ inches diameter, sand cast, using the "Disamatic" (registered trademark) process at Foundry No. 3 under normal production conditions, from hot cupola metal of the following composition: 3.45% carbon, 0.71% silicon, 3.40% manganese, 1.10% copper, 0.19% molybdenum, had a uniform Brinell hardness of 630.

The structure of the alloys produced by the above examples was characterized by the presence of a substantially uniformly distributed martensitic phase.

The microstructure of the preferred alloy is illustrated in FIG. 2 which is a photomicrograph taken at a magnification of ×500. This photomicrograph shows the distribution of carbide, pearlite retained austenite and martensite of the alloy.

In addition the preferred alloy has an improved strength and toughness when compared to the commonly used nickel-chromium containing white cast irons such as are sold under the trademark Ni-Hard. For example, when tested by repeatedly dropping a 100-lb. weight on 1½-inch chill cast and stress-relieved members from a height of 8 feet, the preferred alloy proved to be significantly tougher than the chromium nickel containing cast irons commonly known as Ni-Hard.

Full scale foundry tests have shown that the alloys of the present invention may be chill cast or sand cast using ordinary cupola practice and casting methods. The only melting equipment used so far in these full scale tests has been a cupola which is the cheap commonly used melting unit for cast iron. However, it is obvious that other known melting equipment such as an electric furnace could also be used. Tests to date have been made on chill cast members as well as on sand cast manganese-copper-molybdenum alloys to determine their behaviour from the point of view of the foundryman. Good results were obtained by such tests.

Field tests on ore grinding have shown that chill cast members cast from the preferred alloy, and subsequently stress relieved by heating at 600° F., have excellent resistance to abrasion and impact and are comparable in these respects to the commonly used and more costly nickel-chromium white cast irons.

A number of tests were also conducted on ball mill components approximately 4 x 6 x 28 inches cast from an alloy of the preferred embodiment hereinbefore defined. These components proved to have a high impact resistance as tested by a freely falling weight of 2,700 lbs. from a height of 1 foot and also superior hardness.

Because of its unusual combination of properties, the white cast iron of the present invention will find application in a number of fields in which high hardness, wear

resistance, and abrasion resistance may be beneficially employed. For example, grinding balls, attrition mill plates, rolls, pump parts, mining machinery parts, muller tires, nozzles, etc. can be made from the white cast iron of the present invention.

The improvement and advantages of the present invention are therefore clearly apparent.

We claim:

1. An alloy white cast iron having:

(a) a microstructure comprising a carbide phase, a pearlite phase and an austenite-martensite phase including

(b) a substantially uniformly distributed martensitic structure in the as-cast condition; and

(c) containing between 1.5% and 16% manganese;

(d) between 2% and 4% carbon substantially all of which is present in the combined form as carbide;

(e) from 0 to 2% of silicon; and

(f) at least one of the group consisting of 0 to 2.5% copper and 0 to 1% molybdenum wherein the total amount of copper plus molybdenum is not less than 0.1%, the balance being iron and incidental impurities commonly found in cast iron;

(g) said alloy having a high and uniform hardness in excess of 500 Brinell and high resistance to abrasion and impact.

2. An alloy white cast iron having:

(a) a microstructure comprising a carbide phase, a pearlite phase and an austenite-martensite phase including

(b) a substantially uniformly distributed martensitic structure in the as-cast condition; and

(c) containing between 2.5% and 6% manganese;

(d) between 2% and 4% carbon substantially all of which is present in the combined form as carbide;

(e) from 0 to 1% silicon; and

(f) at least one of the group consisting of 0 to 2.5% copper and 0 to 1% molybdenum wherein the total amount of copper plus molybdenum is not less than 0.1%, the balance being iron and incidental impurities commonly found in cast iron;

(g) said alloy having a high and uniform hardness in excess of 500 Brinell and high resistance to abrasion and impact.

3. An alloy white cast iron having:

(a) a microstructure comprising a carbide phase, a pearlite phase and an austenite-martensite phase including

(b) a substantially uniformly distributed martensitic structure in the as-cast condition; and

(c)containing between 3% and 4% manganese;

(d) between 3% and 4% carbon substantially all of which is present in the combined form as carbide;

(e) 0 to 1% silicon; and

(f) at least one of the group consisting of 0 to 2.5% copper and 0 to 1% molybdenum wherein the total amount of copper plus molybdenum is not less than 0.1%, the ballance being iron and incidental impurities commonly found in cast iron;

(g) said alloy having a high and uniform hardness in excess of 500 Brinell and high resistance to abrasion and impact.

4. The alloy white cast iron according to claim 1 wherein the copper is present in positive amounts up to 1.40% and the molybdenum is present in positive amounts up to 0.4%.

5. The alloy white cast iron according to claim 2 wherein the copper is present in positive amounts up to 1.40% and the molybdenum is present in positive amounts up to 0.4%.

6. The alloy white cast iron according to claim 3 wherein the copper is present in positive amounts up to 1.40% and the molybdenum is present in positive amounts up to 0.4%.

7. An alloy white cast iron having:
(a) a microstructure comprising a carbide phase, a pearlite phase, and an austenite-martensite phase including
(b) a substantially uniformly distributed martensitic structure in the as-cast condtion; and
(c) containing about 3.2% manganese;
(d) between 3 and 4% carbon substantially all of which is present in the combined form as carbide;
(e) from 0 to 1% silicon; and
(f) about 0.9% copper, and about 0.2% molybdenum, the balance being iron and incidental impurities;
(g) said alloy having a high and uniform hardness in excess of 500 Brinell and high resistance to abrasion and impact.

8. The white cast iron alloy according to claim 1 wherein said alloy is chill cast.

9. The white cast iron alloy according to claim 7 wherein said alloy is chill cast.

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