Patented Mar. 5, 1940 2,192,645

UNITED STATES PATENT OFFICE

2,192,645

FERROUS METAL

Carl F. Lauenstein and Clarence J. Brinkworth, Indianapolis, Ind., assignors to Link-Belt Company, Chicago, Ill., a corporation of Illinois

No Drawing. Original application June 7, 1935, Serial No. 25,418. Divided and this application January 10, 1938, Serial No. 184,341

7 Claims. (Cl. 148—31)

This invention relates to a ferrous alloy and to the process of producing and heat treating said alloy.

It has for one object to provide an alloy which in one form is generally similar to white cast iron but which has increased wear resistant properties. It may also have increased hardness. Another object is to provide a method of making the alloy. A still further object is to provide a method of heat treating the alloy to increase its hardness and to increase its abrasion resistant qualities.

Other objects will appear from time to time in the specification and claims.

Ordinary white cast iron is well known to have moderately good wear resistant qualities. The material of the present invention has better wear resistant qualities than those of white cast iron.

An average chemical analysis of commercial white cast iron is as follows:

	Per cent
Carbon	2.35
Silicon	.95
Manganese	.30
Sulphur	.06
Phosphorus	.16

The balance of the metal is substantially iron.

While the analysis above given is an average analysis, of white cast iron, and while the analysis of white cast iron may vary considerable, in a general way white cast iron has a composition within the limits .5% to 2.0% silicon; .18% to .70% manganese; 1.5% to 3.5% carbon; .05% to .3% phosphorus; up to about .2% sulphur and the balance iron.

Structurally, white cast iron consists of grains of pearlite or sorbitic pearlite embedded in a cementite matrix the mass of metal including the above materials listed in the analysis. Ordinarily the hardness of white cast iron varies from 350 to 420 Brinell.

The material of the present invention has basically analysis typical of white cast iron, but has alloying materials in addition. For example, it may contain one or more of the metals below listed:

	Per cent
Chromium	.5 to 4.0
Manganese	.50 to 6.00
Molybdenum	.30 to 4.00
Vanadium	.20 to 3.00

While carbon is normally present in the analysis of white cast iron, for certain purposes the alloy of the present invention has added to it carbon above that normally present in the metal in quantities varying from .05 per cent to 1.5 per cent, so that carbon, in additional quantities, when added to that normally present in the iron, is to be considered as an alloying substance in addition to the four above listed, and the alloy of the present invention thus comprises a metal having an analysis basically that of white cast iron to which has been added an additional quantity of carbon with or without a suitable quantity of chromium, manganese, molybdenum or vanadium, or suitable quantities of any number of these alloying substances.

One manner of producing the metal is to melt the iron in the usual way, in an air furnace, cupola, electric furnace or any other suitable furnace. The charge consists of sprue, pig iron and scrap, according to the usual well known methods of producing such material. After it has been melted and refined to the point where it is ready for pouring the desired alloy or alloys, generally in the form of ferrochromium, ferromanganese, ferromolybdenum or ferrovanadium, are added and the iron is poured into the molds. If carbon is to be added above that normally present in the metal, while it may be added in any suitable form, for most purposes it is convenient to add it as coke. The alloying material, instead of being added to the melted metal may, where it is desirable, be charged into the melting furnace with the other elements of the charge.

As one example of an alloying material chromium may be added, usually in quantities from .5% to 4.0% and further carbon may be added in addition to that already present in the metal in quantities from .05% to 1.5%. Generally if chromium is to be added it is added in the form of ferrochromium within the proportions indicated.

An alloy made according to our invention and containing 1.5% chromium and 2.7% carbon, but with an analysis otherwise substantially that outlined above, will have an increased Brinell hardness of from 420 to 470. It is thus harder than ordinary white cast iron and its abrasion resistant qualities are substantially increased. For certain purposes this alloy, without further treatment, is usable since it is distinctly superior both in hardness and in abrasion resistant qualities to ordinary white cast iron.

Where it is desired to increase the abrasion resistant qualities above that just indicated in the untreated metal, a special heat treatment is given. This heat treatment in general includes

the heating of alloy white cast iron to a point above the critical temperature and then quenching it.

A typical heat treatment of the alloy metal includes the following steps:

(1) The alloy iron is heated to a temperature between 1450° and 1650°, preferably to approximately 1550°;

(2) The metal is held at this temperature for about one-half hour;

(3) It is then quenched in oil.

After the heat treatment just outlined the hardness of the metal is between 750 and 800 Brinell. Should it be desired to reduce the brittleness and strains of the quenched material, the metal may then be drawn.

A microscopic study of the metal shows that after the heat treatment the material consists largely of grains of martensite embedded in cementite. It is very hard and is less brittle than the original white iron before treatment.

The cementite of the alloyed metal without the heat treatment, due to the higher carbon and alloy content, is harder than the cementite of ordinary white iron. Chemically cementite is Fe_3C, or iron carbide. In the alloyed metal of this invention the chromium forms with the iron and carbon a double carbide of iron and chromium which is harder than the ordinary unalloyed iron carbide.

Also, due to the fact that the carbon in the iron has been increased by the addition of coke or some other source, there is present in the body of metal more carbon available for carbide or cementite formation, and there is thus a larger amount of cementite or hard constituent present in the metal than is ordinarily present in white cast iron.

In the alloy of this invention, before heat treatment, the pearlite or sorbitic pearlite is substantially the same as that of ordinary white iron except that it contains a portion of the alloying element. As a result of the heat treatment at temperatures above the critical temperature, and the quenching, this pearlite is transformed to martensite which is the hardest form of iron carbide, and because of the chromium present in the alloy this martensite is harder than the typical or unalloyed martensite.

The material resulting from the alloying and the heat treatment consists of alloy cementite and alloy martensite, both harder than unalloyed cementite and unalloyed martensite, and the relative amount of the cementite area with respect to that normally present in white cast iron has been increased by increasing the carbon content. The result is an extremely hard and wear resistant metal.

The properties of this metal are such that the usual annealing cycle applied to white iron to graphitize it and to form malleable iron does not affect it, and thus in the cast form the alloyed and heat treated metal of this invention will not be annealed if passed through the normal malleableizing cycle and a prolonged heating, followed by a slow cooling, does not materially alter the relative proportions or physical properties of the constituents. This feature is of advantage because it makes possible the use of inserts of the hard material of the present invention in chain links and other parts otherwise made of ordinary white cast iron. Thus a composite unit may be made with wearing parts of metal of the present invention or other parts of cast iron and the composite unit may be subjected to an annealing or malleableizing treatment and after this treatment the white cast iron parts are found to be properly malleableized while the harder inserts are to all intents and purposes unchanged in their chemical composition and in their physical properties and this composite unit, after the malleableizing cycle, may be given other suitable heat treatments still without changing the chemical constituents and the physical properties of the hard insert made according to the analysis and the process of the present invention.

It has been stated above that the metal of the present invention may involve an alloy such as chromium, and may also involve carbon with the chromium. It is to be understood that any of the alloying substances mentioned may be associated in a single metal. Thus the metal might have all, or one of them, or any number of them, ordinarily within the proportions indicated, and a metal having any of the alloys or all of them or any number of them may be used without subsequent heat treatment where extreme hardness and extreme abrasion resistant qualities are not necessary, or any such metal may be heat treated where it is desirable to increase the hardness and the abrasion resistant qualities. The invention thus contemplates among other features the production of an iron alloy metal which, while having generally the analysis of white cast iron, has added to it one or more alloying substances in addition to those normally present in the iron, and which metal may or may not be heat treated subsequent to its formation. It is to be noted that carbon and manganese are ordinarily present in white cast iron and when reference is made herein to the addition of carbon and manganese to the metal, it is meant that carbon or manganese, or both, are added in addition to the carbon or manganese normally present in white cast iron.

The invention also includes the method of heat treating the alloy metal, whatever its analysis, as above pointed out, as well as the steps of that method.

The alloying substances above set out, which are added to the white cast iron to produce the metal of the present invention, have an important property in common, namely, that when alloyed with iron they form carbides and for that reason they may be referred to as of "the carbide forming group of alloys." When alloyed with iron it is found that each of them forms an iron carbide and whether or not it is present elsewhere in the mass of metal, it is present in combination with carbon and in the form of iron carbide within the metal.

We have thus far described a white cast iron alloy which by reason of the alloying material present in it has a hardness and an abrasion resistance greater than that of ordinary white cast iron. We have also described a product produced by our heat treating method as a result of which the alloy white cast iron is given through heat treating a hardness and a degree of abrasion resistance greater than that which it had prior to the heat treatment. The alloy white cast iron without heat treatment has a Brinell hardness of from 420 to 470 and the alloy after heat treatment has a Brinell hardness of between 750 and 800. A further modification of the process produces an alloy of an intermediate degree of hardness greater than that of ordinary sand cast alloy white iron and less than that of the heat treated alloy. This is obtained

by casting the alloy metal against a chilled surface and the metal so cast has a Brinell hardness of from 470 to 520. The alloy thus produced has therefore without additional heat treatment a hardness greater than that of the sand cast alloy. If it is desired, such chill cast metal may be subsequently treated according to the treatment above outlined and its hardness after heat treatment will be approximately the same as that of the heat treated sand cast metal.

Where the expression "quenching" is used, cooling in air, oil, water or other suitable cooling means is meant and the expression is therefore not limited to any specific cooling medium.

This application is a division of our application No. 25,418, filed June 7, 1935, and now Patent No. 2,105,220.

Where in the claims it is specified that the balance of the metal consists of martensite and cementite, it is understood that the metal includes the usual impurities such as silicon, sulphur and phosphorus, which are normally present in white cast iron, as pointed out above. It is understood, also, that the martensite may be true martensite or may be one of the transitional stages of martensite.

We claim:

1. A white cast iron including an alloying metal selected from the carbide forming group of elements consisting of manganese, with the following proportions: .50% to 6.00%; molybdenum, within the following proportions: .30% to 4.00%; vanadium, within the following proportions: .20% to 3.00%; and chromium, within the following proportions: .5% to 4.00%; and the balance of the metal being made up of pearlite and cementite, and being substantially free from ferrite and from graphitic carbon.

2. A white cast iron including an alloying metal selected from the carbide forming group of elements consisting of manganese, within the following proportions: .50% to 6.00%; molybdenum, within the following proportions: .30% to 4.00%; vanadium, within the following proportions: .20% to 3.00%; chromium, within the following proportions: .5% to 4.00%; and carbon in excess of that normally present in white cast iron in quantities varying from .05% to 1.5%, and the balance of the metal being made up of pearlite and cementite, and being substantially free from ferrite and from graphitic carbon.

3. A heat-treated white cast iron including an alloying metal selected from the carbide forming group of elements consisting of manganese, within the following proportions: .50% to 6.00%; molybdenum, within the following proportions: .30% to 4.00%; vanadium, within the following proportions: .20% to 3.00%; and chromium, within the following proportions: .5% to 4.00%; and the balance of the metal being martensite and cementite, and being substantially free from ferrite and from graphitic carbon, the metal having been heated to a point above its critical temperature.

4. A heat-treated white cast iron including an alloying metal selected from the carbide forming group of elements consisting of manganese, within the following proportions: .50% to 6.00%; molybdenum, within the following proportions: .30% to 4.00%; vanadium, within the following proportions: .20% to 3.00%; chromium, within the following proportions: .5% to 4.00%; and carbon in excess of that normally present in white cast iron in quantities varying from .05% to 1.5%, and the balance of the metal being made up of martensite and cementite, and being substantially free from ferrite and from graphitic carbon, the metal having been heated to a point above its critical temperature.

5. A heat-treated white cast iron including an alloying metal of the carbide forming group of elements consisting of manganese, within the following proportions: .50% to 6.00%; molybdenum, within the following proportions: .30% to 4.00%; vanadium, within the following proportions: .20% to 3.00%; and chromium, within the following proportions: .5 to 4.00%; and the balance of the metal being made up of martensite and cementite, and being substantially free from ferrite and from graphitic carbon, the metal having been heated to a point above its critical temperature, cooled and subsequently drawn.

6. A white cast iron including an alloying metal of the carbide forming group of elements consisting of manganese, within the following proportions: .50% to 6.00%; molybdenum, within the following proportions: .30% to 4.00%; vanadium, within the following proportions: .20% to 3.00%; and chromium, within the following proportions: .5% to 4.00%; and the balance of the metal being martensite and cementite, and substantially free from ferrite and graphitic carbon.

7. A white cast iron including an alloying metal selected from the carbide forming group of elements consisting of manganese, within the following proportions: .50% to 6.00%; molybdenum, within the following proportions: .30% to 4.00%; vanadium, within the following proportions: .20% to 3.00%; chromium, within the following proportions: .5% to 4.00%; and carbon in excess of that normally present in white cast iron in quantities varying from .05% to 1.5%, the balance of the metal being martensite and cementite, and substantially free from ferrite and graphitic carbon.

CARL F. LAUENSTEIN.
CLARENCE J. BRINKWORTH.