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CONVERSION OF IRON-CARBON ALLOYS INTO PRODUCTS OF SHEETED AND OTHER SHAPES

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This invention relates in general to the treatment of cast iron-carbon alloys, particularly white cast iron, for the obtaining of products in sheeted or other shapes with tensile strength and machinability, corrosion resistance, etc. as good or better than customary in malleable iron.

For the manufacture of malleable iron castings, it has been customary to subject the white iron castings, which contain carbon in the combined form, i. e. cementite and pearlite, and which makes the metal hard and brittle, to a suitable heating or annealing treatment, thereby changing the combined carbon to an amorphous free carbon in the form of "temper-carbon", the metal becoming ductile, and known as "malleable cast iron". The annealing treatment usually consists in slowly heating the castings to a temperature of about 1500° F., maintaining them at this temperature for about fifty hours, and then cooling them very slowly. This annealing treatment changes the character of the casting from one having a white silvery crystalline fracture, in which no graphite flakes are visible to the naked eye, to one having a dark gray, soft, velvety appearing fracture, in which the carbon has been precipitated or segregated into rounded masses, leaving little or no carbon combined with the iron. This change takes place at a temperature as low as 1250° F., but occurs more effectively at a temperature of 1350° F. The ordinary commercial temperature range for the treatment is from about 1250° F. to about 1600° F. This change in character of the metal is accompanied by a considerable increase in strength and ductility of the castings, as a result of which they are better able to withstand shock than gray iron castings. Malleable iron castings are accordingly extensively used for agricultural implements, automobiles, railroads, pipe fittings, and hardware.

The manufacture of malleable iron castings is, however, very costly, as compared with the manufacture of similar articles by stamping and other fabricating methods, and is moreover attended with difficulties which are not encountered in ordinary stamping practice. In the manufacture of malleable iron castings for automobile brake drums, for example, only the most highly skilled foundries can be relied upon to produce sound castings, with a minimum of rejections. Due to shifting of the patterns in the mold, the sections of the castings are usually heavier than desired in the finished brake drum, and the excess metal is then required to be removed by slow and expensive machining operations. Moreover, certain defects in the castings, which become visible only after machining, such as porosity, shrinks and cold shuts, result in rejections in addition to those resulting from the initial casting operations.

It is among the objects of this invention accordingly, to provide advantageous processes for directly working iron-carbon alloys, such as white iron castings, preferably by rolling, and subsequently annealing on the order of malleabilizing, or by malleabilizing and subsequently rolling, and in either case obtaining products of marked ductility, tensile strength, resistance to corrosion, etc., as contrasted with the initial cast iron. A further object is the production of such modified metal in the form of sheets, strip, bars, tubes, and other shapes, suitable for use as such, or for stamping or fabrication into other products. Other objects and advantages will appear as the description proceeds.

To the accomplishment of the foregoing and related ends, said invention, then, comprises the features hereinafter fully described, and particularly pointed out in the claims, the following description setting forth in detail certain illustrative embodiments of the invention, these being indicative, however, of but a few of the various ways in which the principle of the invention may be applied.

In accordance with my invention, a melt is prepared and is cast into ingots, slabs, or forms as desired. For the composition of the melt some latitude is permissible; however, in general, it is desirable that the carbon be in the amount of from about 1.50 to about 4.00 per cent, silicon from about 0.45 to about 1.75 per cent, manganese below 1 per cent, phosphorus not exceeding 0.225 per cent and desirably under 0.05 per cent and sulphur desirably not exceeding 0.05 per cent. Optionally also, I may add alloying metals, as for instance molybdenum in amounts up to 1 per cent, 0.5 per cent giving in general excellent results; copper in amounts up to 0.6 per cent, etc.

The form and dimensions of the molds may, of course, vary in accordance with the particular further purpose in view. For instance, for strip mill and universal mill work, it is desirable to cast in slabs of about 3 inches thickness, the width being dependent upon the width of ultimate sheet product desired, for instance 12 to 36 inches. For sheet mill rolling slabs of approximately ¾ inch thickness are desirable.

If the ingots or slabs are to be rolled without being previously malleabilized, I prefer where possible, to roll them before they have cooled down to an appreciable extent. For this purpose, they may be placed in a soaking pit or furnace wherein they are maintained at a temperature suitable for rolling, i. e., from about 1600° F. to about 2100° F. By rolling the ingots or slabs before they have cooled below about 1800° F., primary graphitization or malleabilization is avoided, and reheating between passes is avoided.

Where it is not feasible to thus soak the ingots or slabs for rolling, they should be cooled or chilled as quickly as possible to prevent precipitation of graphitic carbon, and this may be accomplished by positive chilling with exposure to circulating air, as distinguished from mere passive cooling down as heretofore practiced. When these ingots or slabs are to be worked or rolled, they are first heated to a suitable temperature 1200° F.–2100° F. and most desirably about 1600° F.–2000° F. It is advisable to roll above 1200° F., on account of greater plasticity and economy in rolling at the higher temperatures. Where reheating between passes is necessary on account of the size of the piece, etc., reheating temperatures to about 1500° F.–2000° F. are usually preferable, although slightly lower temperatures give good results. With a ¾ inch white cast iron slab as the starting material, and heating to about 1500° F., I have satisfactorily rolled down to a thickness for instance of 0.16 inch in six passes. It is advisable in heating, not to heat too long and cause precipitation of carbon. Rapid heating is desirable, and it is preferable to preheat or soak, for instance with twin furnaces. The slabs may be preheated or soaked in one section to 1200° F. or 1250° F. as the maximum, and may be kept at such temperature until removed to the higher temperature furnace, in which rapid heating up to about 1500° F.–2000° F. which then requires a relatively short time, may be effected, and the slab fed to the rolls.

After the iron is worked or rolled down as desired, it is subjected to a heating or annealing, somewhat on the order of malleabilizing. Desirably, this heating is carried on with the temperature around 1500° to 1550° F. for a period of time depending upon the thickness of the material, and then the temperature may be slowly lowered to about 1200° F., whereupon it is desirable to then cool rapidly by removing from the fire and air-chilling. This gives a better control of the grain-size of the ferrite and also makes possible obtaining of a more rounded character in the temper-carbon grains.

By adding molybdenum to the melt initially, I have found that the annealing or malleabilizing treatment proceeds much more rapidly, and the time may be cut down accordingly. For instance, with stock otherwise requiring about 100 hours' heating, with the incorporation of 0.25 per cent of molybdenum in the melt, a heating time of about 36 hours is sufficient to obtain the desired properties.

Instead of working or rolling the metal before malleabilizing, such working or rolling may be carried out after malleabilizing.

In such case, the ingots, slabs or other forms are first malleabilized by heating to a temperature within the range 1250° F. to 1600° F. and preferably around 1500° F. to 1550° F., for a period of time depending upon the thickness of the material, then slowly lowering the temperature to about 1200° F., and thereafter cooling rapidly by removing from the fire and air-chilling. This gives a better control of the grain size of the ferrite and makes possible obtaining of a more rounded character in the temper-carbon.

The ingots, slabs or other forms thus malleabilized, are then reheated for working or rolling, being first heated to a suitable temperature, 1000° F.–2000° F., and most desirably about 1000° F.–1600° F. Upon examining a section of the metal under the microscope after rolling, it will be observed that the metal resembles wrought iron in appearance, that is to say, the black rounded masses of temper-carbon have been elongated in the direction of rolling and flattened in the same manner that the slag inclusions in wrought iron appear elongated and flattened. The ferrite grains also appear distorted, as in wrought iron.

Sheets and other stock produced by either of the methods which have been outlined can be employed for fabricating if desired, or can be further finished by cold-rolling. A final annealing at a temperature above 1200° F. is advantageous after cold working.

Following such annealing treatment, the products are in a condition in which they can be readily stamped or otherwise fabricated into various articles, including a great number which have heretofore been made chiefly in the form of malleable iron castings.

Sheet stock rolled and annealed in accordance with my process has a superior resistance to corrosion as compared with sheet steel, and lends itself particularly to usage in exposed locations. If desired, galvanizing or tinning, etc., may also be applied. On account of the properties of my material, nitriding is especially feasible, and as shaped into desired articles, it may be thus hardened or nitrided by heating with ammonia, along known or practical lines.

It will be understood that various products, in addition to those stated, may be made from the iron-carbon alloy slabs or ingots and that various articles, in addition to those described, may be made from such products. In making tubes, for example, the roller sheets may be slit into strips (skelp), which are shaped into cylindrical form, welded and annealed; or the slabs or ingots may be rolled directly into skelp, which may be shaped into cylindrical form while hot, welded by well known electric welding processes and annealed, the annealing in either case being optional.

While certain temperature ranges for working or rolling have been specifically set forth, it will be understood that the rolling may be conducted at temperatures other than those set forth. In general, the working or rolling may be carried out at a temperature above that at which rolling is difficult, due to the hardening of the material, but below that at which the metal loses its malleability, due to overheating.

While the term "malleable iron" has been applied to products such as pure or puddled iron, and soft or mild steels, which are admittedly malleable in various degrees and in a greater degree than "malleable cast iron", such designation is entirely improper in the metallurgy of ferrous products, and it is therefore desired to particularly point out that the term "malleable iron" as used and contemplated in the specification and claims is intended to mean "malleable cast iron", which is a product only slightly malleable at ordinary temperatures, but is tougher than the cast iron from which it is made. The term "malleable", as employed in this connection is intended to designate a relative condition between cast iron, which is practically devoid of malleability and "malleable cast iron".

The term "white cast iron", as used in this application, is intended to designate an iron-carbon alloy which is within the melt analysis set forth in the specification. While it usually contains from about 2.00% to about 3.00% carbon and from about .45% to about 1.75% silicon, it may be more generally defined as an iron-carbon alloy containing more than about 2% carbon which solidifies and cools to ordinary temperatures without the formation of graphite.

This application is a continuation-in-part of applications Serial No. 619,814 filed June 28, 1932, and Serial No. 634,782 filed Sept. 24, 1932.

Other modes of applying the principle of my invention may be employed instead of the one explained, change being made as regards the means and the steps herein disclosed, provided those stated by any oi the following claims or their equivalent be employed.

I therefore particularly point out and distinctly claim as my invention:

1. The method which comprises hot rolling graphitizable white cast iron containing a graphitizing agent.

2. The method which comprises rolling white cast iron containing a graphitizing agent at a temperature above about 1200° F. and then malleabilizing the same.

3. As a new article of manufacture, a product formed by hot rolling graphitizable white cast iron.

4. The method which comprises plastically deforming into products of sheeted and other shapes, at a temperature above about 1200° F., iron-carbon alloys containing more than 2.00% and up to about 4.00% carbon and a graphitizing agent in an amount sufficient to permit the alloys to be graphitized after deformation, and then graphitizing said alloys.

5. The method which comprises hot rolling a ferrous alloy containing more than 2.0% of carbon, and a graphitizing element in an amount sufficient to permit graphitization of the alloy, and thereafter heat treating the alloy within the graphitizing range to precipitate substantially all of the combined carbon as graphite.

6. The method which comprises hot rolling white cast iron containing a graphitizing agent, and thereafter heat treating the same within the graphitizing range to precipitate substantially all of the combined carbon as graphite.

7. The method which comprises hot rolling white cast iron containing a graphitizing agent and then malleabilizing the same.

8. The method which comprises making graphitizable white iron castings, subsequently heating the same to above about 2000° F. and rolling.

9. As a new article of manufacture, a rolled wholly graphitizable iron-carbon alloy containing in excess of 2.00% carbon.

10. The method which comprises hot rolling white cast iron containing more than 2% and up to about 4% carbon and a graphitizing agent in an amount sufficient to permit graphitization of the product after rolling.

11. The method which comprises hot rolling white cast iron containing more than 2% and up to about 4% carbon and a graphitizing agent in an amount sufficient to permit graphitization of the product after rolling, and then graphitizing the rolled product.

12. The method which comprises hot rolling graphitizable white cast iron containing more than 2% and up to about 4% carbon and from about .45% to about 1.75% silicon.

13. The method which comprises hot rolling white cast iron containing more than 2% and up to about 4% carbon, from about .45% to about 1.75% silicon, and less than 1% manganese, and then graphitizing the product of said rolling.

14. As a new article of manufacture, a product formed by hot rolling white cast iron containing more than 2% and up to about 4% carbon and a graphitizing agent in an amount sufficient to permit graphitization of the product after rolling.

15. As a new article of manufacture, a product formed by hot rolling graphitizable white cast iron containing more than 2% and up to about 4% carbon and from about .45% to about 1.75% silicon.

16. As a new article of manufacture, a product formed by hot rolling graphitizable white cast iron containing more than 2% and up to about 4% carbon, from about .45% to about 1.75% silicon, and less than 1% manganese.

17. The method which comprises plastically deforming into products of sheeted and other shapes, at a temperature above about 1200° F., white cast iron containing more than 2% and up to about 4% carbon and a graphitizing agent in an amount sufficient to permit the product to be graphitized after deformation, and then graphitizing said product.

18. The method which comprises hot rolling white cast iron containing more than 2.0% of carbon, and a graphitizing element in an amount sufficient to permit graphitization of the product, and thereafter heat treating the product within the graphitizing range to precipitate substantially all of the combined carbon as graphite.

19. The method of making ferrous articles comprising forming an article by hot working an ingot of an iron-carbon alloy containing not less than about 1.5% of carbon and also containing silicon and molybdenum, as graphitizing elements, and the remainder of the alloy being effectively iron, and heating the article at a temperature above its critical temperature to convert a substantial proportion of its carbon content to the graphitic state.

20. The method which comprises hot rolling a ferrous alloy containing between about 2.1 and 2.5% carbon and about .9% silicon, and thereafter heat treating the alloy within the graphitizing range to precipitate substantially all the combined carbon as graphite.

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