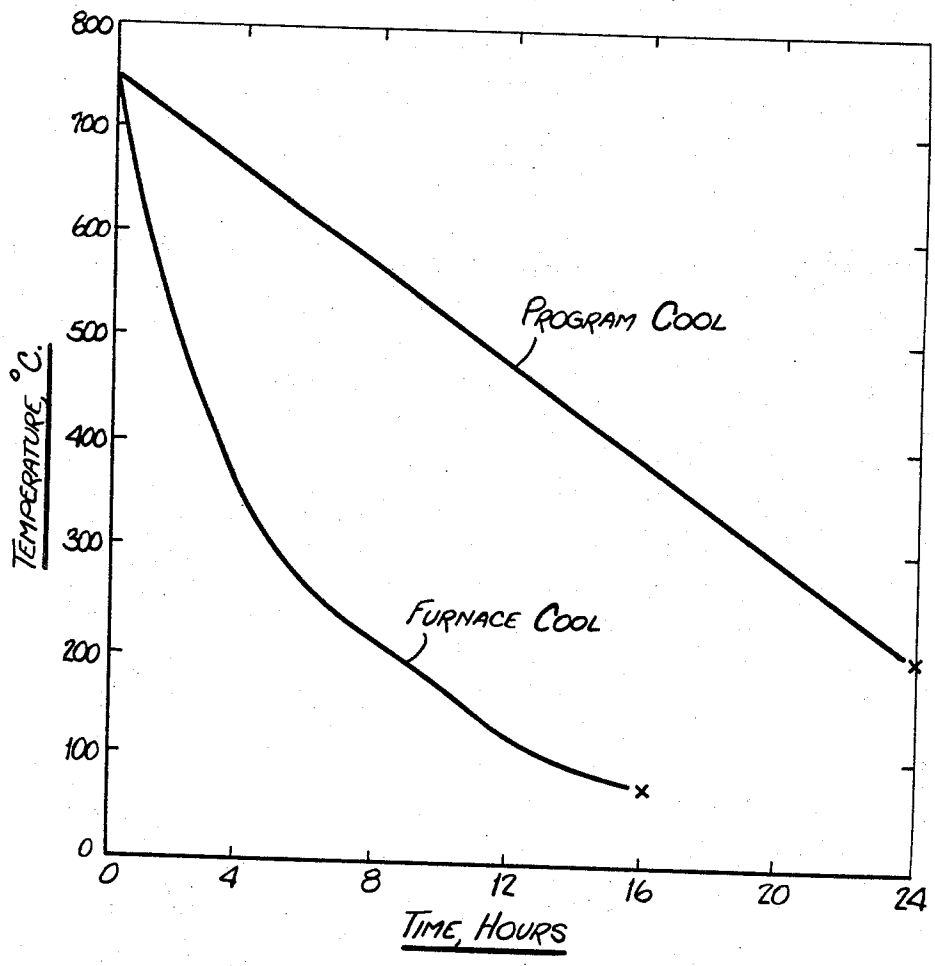
Dec. 3, 1968 R. K. GREENWOOD ET AL 3,414,442

HEAT TREATMENT OF ALLOY CAST IRON

Filed June 10, 1966



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United States Patent Office 3,414,442 Patented Dec. 3, 1968

3,414,442

HEAT TREATMENT OF ALLOY CAST IRON

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Filed June 10, 1966, Ser. No. 556,759
Claims priority, application Great Britain, June 17, 1965, 25,706/65
12 Claims. (Cl. 148—141)

This invention relates to a process for the heat treatment of cast iron and, more particularly, to the heat treatment of alloyed white cast iron to enhance hardness, toughness, and impact fatigue life.

It is generally known that white cast iron alloyed with nickel and chromium has superior resistance to both wear and abrasion. These superior properties are largely due to the presence in the microstructure of massive carbides in a martensitic-austenitic matrix. If, in addition to wear and abrasion resistance, strength, toughness, and impact fatigue life are of importance, it is preferred to use alloyed white cast irons in which the carbide phase is discontinuous rather than those in which the carbide phase is present as a continuous network since a continuous carbide phase provides a continuous path for propagation of fractures. However, the improved strength, toughness, and impact fatigue life of alloyed white cast irons having a discontinuous carbide phase is obtained at some loss in hardness in the iron as-cast.

Heretofore, the art has endeavored to increase the hardness of alloyed cast irons such, for example, as the iron described in U.S. Patent No. 2,662,011, through heat treatment. This heat treatment consisted of heating the iron to a temperature high enough to cause some or all of the austenite in the matrix to transform to martensite or bainite. Such temperatures are generally in excess of 450° C. and, typically, are about 750° C. The cast iron is held at the transformation temperature for about 8 hours and is, thereafter, air-cooled to room temperature.

It has now been discovered that if the rate at which nickel-chromium alloyed white cast iron is cooled from the transformation temperature to at least about 200° C. is carefully controlled, a marked increase in hardness, toughness, and impact fatigue life results.

It is an object of the present invention to provide a process for heat treating cast irons which greatly enhances their hardness, toughness, and impact fatigue life.

Another object of this invention is to provide a process for heat treating an alloyed martensitic white cast iron which greatly enhances hardness, toughness and impact fatigue life.

The invention also contemplates providing an alloyed, white cast iron having greatly enhanced hardness, toughness, and impact fatigue life in the heat treated condition.

Other objects and advantages will become apparent from the following description taken in conjunction with the accompanying drawing in which the figure depicts the time-temperature curves for ball castings 60 millimeters in diameter made of an alloy cast iron cooled in the furnace and cooled at a predetermined, programed rate.

Generally speaking, the present invention contemplates a heat treatment process in which an alloyed white cast iron having the following composition: about 2.8% to 3.7% carbon, about 0.5% to 3.0% silicon, about 0.2% to 1.5% manganese, about 4% to 8% nickel, about 4% to 15% chromium, and the balance iron with residual impurities, is heated to a temperature at least sufficient to transform some or all of the retained austenite, present in the as-cast condition, to martensite or bainite, e.g., about 450° C. to about 750° C. or about 800° C., maintained at this temperature for a peroid sufficient to transform most of the retained austenite to martensite or bainite, slowly cooled to about 200° C. or lower at a rate not exceeding about 50° C. per hour and, thereafter, cooled at any convenient rate.

After heat treatment, in accordance with this invention, the cast irons normally have a microstructure consisting of a discontinuous carbide phase in a matrix of tempered martensite or bainite with little or no austenite. In addition, cooling in accordance with this invention also serves to avoid internal stresses.

In carrying the invention into practice, it is advantageous to treat an alloyed white cast iron containing about 2.8% to 3.2% carbon, about 1.5% to 2.0% silicon, about 0.4% to 0.6% or 0.8% manganese, about 5.5% to 6.5% nickel, about 7.5% to 9.0% chromium, and the balance iron with residual impurities by heating to about 750° C. to about 800° C. for about 8 hours, cooling to about 200° C. or lower at a rate not exceeding about 30° C. per hour and, thereafter, cooling below about 200° C. at any convenient rate.

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

Example I

An iron containing 3.1% carbon, 1.7% silicon, 0.7% manganese, 5.7% nickel, 7.6% chromium was cast into balls 60 millimeters in diameter, which were then heated to 750° C. for 8 hours. A first group of balls was air cooled to room temperature; a second group of balls was furnace cooled in accordance with the curve identified by the legend, "Furnace Cool," shown in the accompanying figure; a third group of balls was cooled at a programed, uniform rate of about 23° C. per hour in accordance with the invention down to about 200° C. as shown by the curve identified by the legend, "Program Cool," in accordance with the accompanying figure. The first group of balls, air cooled according to the prior art, was found to have a hardness of about 700 DPN, and fractured after an average of about 4000 drops in a test wherein the balls were repeatedly dropped from a height of about 21 feet onto an anvil. The second group of balls, furnace cooled at a cooling rate faster than that contemplated in accordance with the invention, had a hardness of about 700 DPN and fractured after an average of about 5070 drops. The third group of balls, cooled at a controlled rate in accordance with this invention, had a hardness of about 780 DPN and did not fracture after an average of more than 10,000 drops.

The present invention is particularly applicable to the heat treatment of cast iron balls for use in grinding mills.

Although the present invention has been described in conjunction with advantageous 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 modifications and variations are considered to be within the purview and scope of the invention and appended claims.

We claim:

1. A heat treatment process for improving hardness, toughness, and impact fatigue life of alloyed white cast irons comprising about 2.8% to 3.7% carbon, about 0.5% to 3.0% silicon, about 0.2% to 1.5% manganese, about 4% to 8% nickel, about 4% to 15% chromium, balance iron with residual impurities, which comprises:

(a) heating the cast iron to a temperature of about 450° C. to about 800° C. in order to transform the retained austenite present in the as-cast condition;

(b) maintaining this temperature for a period sufficient to transform substantially all the retained austenite;

(c) slowly cooling the cast iron to about 200° C. at a rate not exceeding about 50° C. per hour.

2. A process of heat treating cast irons in accordance with claim 1 wherein the cast iron is cooled at a rate not exceeding about 30° C. per hour.

3. A process for heat treating cast irons in accordance with claim 1, wherein the cast iron is heated to about 750° C. to about 800° C.; maintained at this temperature for about 8 hours; and then cooled to about 200° C. at a rate not exceeding about 50° C. per hour.

4. A process for heat treating cast irons in accordance with claim 3 wherein the cast iron is cooled at a rate not exceeding about 30° C. per hour.

5. A process for heat treating cast irons in accordance with claim 1 wherein the cast iron comprises: about 2.8% to 3.2% carbon, about 1.5% to 2.0% silicon, about 0.4% to 0.8% manganese, about 5.5% to 6.5% nickel, 7.5% to 9.0% chromium, balance iron with residual impurities.

6. The process for heat treating cast irons in accordance with claim 5 in which the manganese content of the cast iron is about 0.4% to 0.6%.

7. A process for heat treating cast irons in accordance with claim 5 wherein the iron is cooled at a rate not exceeding about 30° C. per hour.

8. A process for heat treating cast irons in accordance with claim 5 wherein the iron is heated to about 750° C. to about 800° C.; maintained at this temperature for about 8 hours; and then cooled to about 200° C. at a rate not exceeding about 50° C. per hour.

9. A process for heat treating cast irons in accordance with claim 8 wherein the cast iron is cooled at a rate not exceeding about 30° C. per hour.

10. A process for heat treating cast irons in accordance with claim 1, wherein the cast iron is heated to about 750° C.; maintained at this temperature for about 8 hours; and then cooled to about 200° C. at a rate not exceeding about 50° C. per hour.

11. A process for heat treating cast irons in accordance with claim 10 wherein the cast iron is cooled at a rate not exceeding about 30° C. per hour.

12. A new article of manufacture produced in accordance with the process of claim 8.

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