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METHOD OF PRODUCTION OF CAST-IRON PARTS WITH A HIGH COEFFICIENT OF THERMAL EXPANSION

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ABSTRACT OF THE DISCLOSURE

A method of treating cast-iron parts of an alloy consisting essentially of 1.4 to 4% carbon, 1.5 to 3% silicon, 0.1 to 2% manganese and the balance iron which comprises heating the parts to a temperature between about 825 and 1100° C. followed by immersing the parts in a fluid medium maintained at a temperature between about 400 and about 600° C. and thereafter transferring said parts to a furnace heated to a temperature between 200° and about 450° C., and finally cooling in air.

The present invention has for its object a method of manufacture of parts of cast-iron having a high thermal coefficient of expansion, characterized by the production of cast parts of an alloy composed of 1.4 to 4% of carbon, 1.5 to 3% of silicon, 0.1 to 2% of manganese and impurities in usually negligible traces, the remainder being iron, and by an austenization and homogenization heating after casting followed by a hardening in stages in a fluid medium, this hardening being effected at a temperature comprised between 350 and 450° C. for a definite time corresponding to a limited transformation, permitting a stable austenite to subsist after cooling.

For reasons related to the size of the parts to be cast or to the heat treatment chosen for these parts, it is occasionally possible to effect small additions of at least one of the following elements, comprised within the limits of concentration indicated below:

	Percent
Cu	0.2–2
Ni	0.3–3
Mo	0.05–1
Al	0.05–3
P	0.02–1
Cr	0.1–1

The aluminium may also be added in addition to the silicon or it may be partly substituted for it, the action of these two elements on the bainitic transformation being similar.

The austenization and homogenization treatment may be carried out equally well on a foundry part which has not yet cooled after solidification and on a foundry part which is completely cooled and then re-heated to the appropriate temperature, which is comprised between 825 and 1100° C., the usual duration of such heating being from one minute to two hours at the final temperature.

The hardening in stages is effected for example by means of emmersion in a bath of salt or molten metal, or again by means of a period inside a furnace or a fluid medium containing in suspension a powdered material, known as a "fluidized powdered medium," the usual duration of a heating of this kind is 10 to 200 minutes for an isothermic bath. In accordance with the results obtained within the scope of the invention, there is produced a separation of small plates made of ferrite and epsilon hexagonal carbide, also known by the name of Hofer carbide, while the austenite becomes richer in carbon and more stable. The period in a furnace or immersion in a bath is followed by cooling in calm air or hardening in oil or water at the ambient temperature.

In addition, it should be noted that the period of immersion of the parts in the isothermic hardening bath is critical. It has in fact been discovered, within the framework of the study which terminated in the invention, that hardening in a medium having a temperature comprised between 350 and 450° C., produces successively two transformations, generally fairly clearly separated in time. The first is that which leads to the separation of small plates constituted by ferrite and epsilon hexagonal carbide while the austenite becomes richer in carbon and becomes more stable, and the second results in the transformation of this austenite to ferrite containing epsilon carbide and to new iron carbide. It is for this reason that, according to the invention, the parts must be withdrawn from the isothermic bath before this second transformation takes place.

In addition, the more or less hetergenous structure of a foundry part may contain a little martensite alongside the desired austenite, this martensite appearing in regions of the part in which the concentration of added elements limits the formation of a stable austenite.

In this case, if it is desired to avoid the excessive hardness which results for a cast-iron, this being liable to render its machining difficult or to be a cause of fragility of the cast-iron, a letting-down of the martensite is effected under conditions which keep the austenite stable (an example of this is given later in this text). This letting-down of temper can also be effected in order to ensure the dimensional stability of parts which may have to work at a temperature higher than the ambient temperature.

After the above-described treatment, a cast-iron of a composition according to the invention contains between 15% and 70% of stable austenite between −50° and +300° C., the mean thermal coefficient of expansion between 20° and 200° C. of this type of cast-iron being of the order of 13×10^{-6} to 16.5×10^{-6} per degree centigrade, as against 11.7×10^{-6} per degree centigrade for a cast-iron of current type.

In connection with the hardening according to the invention, it should be noted that it is the part treated which reaches the temperature comprised between the limits of 350° to 450° C., and not necessarily the fluidized medium, the bath or the atmosphere of the hardening furnace above-mentioned, the hardening being carried out when so desired during the course of cooling after the pouring of the part.

According to the composition of the alloy, the thickness and the shape of the parts, and the method of hardening, the period of immersion in the isothermal hardening bath may vary. It can of course be readily determined experimentally by micrography, thermomagnetic analysis, diffraction of X-rays, dilatometry or any appropriate means which are not within the scope of the invention. The duration of this isothermal treatment may vary from a few minutes to several hours.

Relatively thin parts or parts of lightly alloyed cast-iron will for example be plunged after austenization into a metallic bath or a salt bath heated to between 600 and 400° C. for a period of time from a few seconds to a few minutes, 5 seconds to 6 minutes for example, this first phase of the cooling being essentially intended to prevent the perlitic transformation of the cast-iron and to keep it in the austenitic phase. The parts are then transferred for 20 to 200 minutes to a furnace heated to between 450° C. and 200° C., the temperature being progressively lower as the mass of the parts increases.

The bainitic transformation of the cast-iron with enrichment of the austenite in carbon, is mainly effected in fact before the parts reach the temperature of the furnace, and it becomes practically stopped by the reduction of temperature resulting from their passage through this furnace.

In the particular case of cast-irons containing molybdenum and nickel, preferably employed for the manufacture of relatively-massive parts, a stabilized austenite can be obtained without passing these parts into the molten bath above-mentioned, intended to prevent perlitic transformation, and the transfer of the parts from the austenization furnace to the medium employed for hardening in stages, a molten salt-bath furnace, for example, may even not be very rapid if a practical advantage is obtained from a slow transfer.

Finally, if it is desired to give a high degree of hardness to certain portions of the parts treated according to the invention, they are subjected to local treatment, either thermal by austenization and rapid temper, or mechanical by cold-rolling.

The alloying and treatment according to the invention are applied with particular advantage to the manufacture of wet jackets of cast-iron, with a high coefficient of expansion, for internal combustion engines in which the crank-case is of aluminum alloy.

In one form of embodiment of this invention, a cast-iron alloyed with nickel and molybdenum comprising with the iron 3.14% C, 2.42% SiO, 31% Mn, 0.014% S, 0.025% P, 1.45% Ni, 0.32 Cr and 0.58% Mo is melted in an induction furnace having a capacity of 200 kg. for example, and is then poured into a ladle in which it is subjected to a small addition, still known as "inoculation" of 0.60% of ferro-silicon at 75%. This cast-iron is then cast by centrifuging at 1300° C. in a metal chill-mould following any desired shape, and it is left to cool down to ordinary temperature.

The castings are then subjected to an austenization treatment for 30 minutes at 925° C. followed by hardening in a salt-bath for 45 minutes at 390° C. and cooling in calm air. The parts are then let-down to 360° C. for 30 minutes so as to avoid fragility due to the martensite formed, and have a hardness of about 340 Brinell, and an average coefficient of expansion of 16×10^{-6} between 20° and 200° C. Their micrographic structure comprises A5 lamellar graphite surrounded by a matrix composed of 50% of bainite and 50% of austenite.

In an alternative form, a cast-iron containing copper and chromium, composed of 3.2% C, 2.5% Si, 0.3% Mn, 1.5% Cu, 0.3 Cr, the remainder being iron, is cast by centrifuging in a chill-mould, and is then cooled after de-moulding. The parts are then heated to 925° C. and hardened in a lead bath at 400° C. for 20 to 60 seconds, and finally removed from this bath and placed while hot in a furnace at 360° C. After having kept them at this temperature for 2 hours, they are then cooled in calm air.

Their hardness is then about 240 Brinell and their coefficient of expansion is 15.5 to 16×10^{-6}.

The treatment described above is applicable to the first form of embodiment.

In another alternative form, a phosphorous cast-iron alloyed with chromium, of known composition applied up to the present to the manufacture of jackets of perlitic structure, is cast by centrifuging in a chill-mould, then heated for austenization to 900° C., and finally hardened in a salt bath at 390° for 45 minutes.

When the cast parts have been cooled down in calm air, they have an approximate hardness of 310 Brinell and a coefficient of expansion of 14.5×10^{-6} instead of about 11.7×10^{-6} when they are subjected to the conventional treatment.

It will of course be understood that the forms of embodiment described above are not limitative, and may be given any desired modifications, without thereby departing from the scope of the invention.

What is claimed is:

1. A method of preparation of cast-iron parts having a high thermal coefficient of expansion, consisting of producing cast parts of an alloy consisting essentially of 1.4 to 4% of carbon, 1.5 to 3% of silicon, 0.1 to 2% of manganese, impurities in usually-negligible traces, and the balance iron, by subjecting said cast-iron parts to a heat treatment comprising heating said parts to a temperature between about 825 and 1100° C. to effect austenization and homogenization of said parts, transferring said cast-iron parts and immersing them in a fluid medium maintained at a temperature between about 400 and about 600° C. for a period of time between about five seconds and about six minutes, thereafter directly transferring said parts to a furnace heated between 200° and about 450° C. for a period of time between 20 and 200 minutes, and finally cooling said parts in calm air.

2. A method as claimed in claim 1, in which said alloy contains small additions of at least one of the following elements, within the limits of concentration stated:

	Percent
Cu	0.2–2
Ni	0.3–3
Mo	0.05–1
Al	0.05–3
P	0.02–1
Cr	0.1–1

in which the aluminium may be added as a complement to the silicon or may be partly substituted therefor.

3. A method as claimed in claim 1, in which said cast-iron parts have a content of stable austenite after treatment of 15 to 70% and the average thermal coefficient of expansion between 20° and 200° C. is 13×10^{-6} to 17×10^{-6} per degree centigrade.

4. A method as claimed in claim 1, in which the treated cast parts are subjected to a tempering treatment which, in the case of local formation of martensite, reduces the brittleness, facilitates machining and ensures the dimensional stability of said parts.

5. A method as claimed in claim 1, in which said treated cast parts are subjected locally to a conventional heat treatment by austenization and rapid quenching.

6. A method as claimed in claim 1 in which said treated cast parts are subjected locally to a conventional mechanical treatment involving localized deformation.

References Cited

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