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HEAT AND SHOCK RESISTING CAST IRON

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Our invention relates to iron castings which in use are exposed to repeated heating and cooling which set up severe local stresses in the castings and tend to cause breakages or to deform the castings. For uses such as grate and furnace bars or other installations in which the iron is subjected to repeated heating and cooling, cast iron or malleable iron castings are largely used. Cast iron, when it contains large quantities of cementite, is extremely apt to crack under severe service conditions, or when it contains pearlite and large flakes of graphite is so brittle as likewise to crack, while malleable iron, because of large quantities of ferrite, readily warps and distorts out of shape.

We have found that iron castings of normal compositions used for conversion into malleable iron when properly annealed so as to be substantially free from cementite and containing a relatively high amount of temper carbon and a balanced amount of ferrite and pearlite, are sufficiently stiff to resist deformation under extremely arduous conditions of intense localized heating and frequent cooling, and sufficiently ductile to withstand shocks. Such material is more resistant to destruction by abrasive wear than are the cast or malleable iron materials aforesaid.

We have found that iron castings containing, after being cast, from 2% to 3.5% of carbon, and silicon, manganese, phosphorus and sulphur in the percentages usual in iron intended for use in malleable iron castings and in which the carbon is practicaly all in the form of cementite, give excellent results after being subjected to the following heat treatment.

The castings are treated at an elevated temperature of, for example, between 1500° and 1700° F., but necessarily above the lower critical point commonly called A_1, until practically all the cementite is destroyed. Such heat treatment may be continued from twenty to eighty hours, depending on the length of time required to break down the cementite. Alternatively the castings may be annealed as in the malleabileizing process and then be reheated, preferably to between 1500° and 1700° F., until equilibrium between graphitic and agraphitic carbon is attained. The hot castings, substantially free from cementite, may then be cooled slowly (at not slower than 10° F. per hour) through an interval below A_1 to produce the desired structure. Alternatively the castings may be cooled from the high heat at any conveniently rapid rate to slightly below 1400° F., and maintained at a nearly constant temperature somewhat under—for example, at 1300° F.—for a period of about ten hours before final cooling. Obviously the time or rate of cooling will be a function of the composition of the metal.

When cast iron containing 2.75% carbon practically all combined as cementite has been treated as described above, a typical specimen of our resulting product will contain substantially 2.00% of temper or graphitic carbon and .50% agraphitic, approximately .25% having been lost through oxidation. Results will be impaired if the casting when cooled contains more than the eutectoid composition, which is approximately .83% combined carbon, as the excess over .83% would be in the form of free or pro-eutectoid cementite. Normally the combined carbon is between .30 and .75 and is usualy about .50%, while the silicon usually ranges between .60% and .80%.

When cooled at a slow rate (but not slower than 10° F. per hour) from about 1400° F., we have found that in the resulting structure the carbon is present in graphitic nodules surrounded by areas of ferrite and pearlite.

A characteristic formation of material as shown in micrographs comprises nodules of carbon surrounded by comparatively large areas of ferrite, which in turn are surrounded by either continuous or separated areas of pearlite. We have found, however, that in cooling from above 1400° F. some ferrite is apt to separate out and that in the resulting product the characteristic formation referred to above does not always appear, although the areas of ferrite and pearlite are sufficiently distributed to produce a satisfactory material.

Additions of small percentages of chromium, tin, selenium, tellurium, antimony or boron, abnormal ratios of manganese and sulphur, in which either is present in an amount substantially more than required for combination with the other, will retard the formation of graphitic carbon and ferrite for a given cooling rate, and also serve to stabilize the pearlite, while the presence of high silicon, titanium, aluminum, zirconium or uranium will increase the rate of formation of graphitic carbon and ferrite. Variations in the composition by additions of the elements just referred to will require corresponding changes in the cooling rate or vice versa, to produce satisfactory results.

Our improved material is particularly effective when used for grate and furnace bars, stoker links, and in other installations in which the material is subjected repeatedly to high temperatures, repeated shocks, or severe abrasion. When

used in sintering machines in which the grate bars are subjected at times to rather intense localized heating due to the sintering material burning through in spots, which sets up very severe local stresses, grate bars embodying our invention have a life of several times that of either cast iron or malleable iron bars, due to stiffness, which prevents warping, and their ductility, which prevents cracking.

The terms and expressions which we have employed are used as terms of description and not of limitation, and we have no intention, in the use of such terms and expressions, of excluding any equivalents of the features shown and described, or portions thereof, but recognize that various modifications are possible within the scope of the invention claimed.

What we claim is:

1. A grate bar comprising an iron casting substantially free from cementite, and having the major portion of its carbon in the form of nodules of graphite, the dominant portion of the casting being formed of substantial areas of both ferrite and pearlite, the casting being sufficiently stiff to resist deformation at a moderate heat and being sufficently ductile to prevent cracking under heating stresses.

2. A grate bar comprising an iron casting substantially free from cementite, having the major portion of its carbon in the form of nodules of graphite, areas of ferrite surrounding the nodules of graphite, areas of pearlite surrounding the areas of ferrite, the casting being sufficiently stiff to resist deformation at a moderate heat and being sufficiently ductile to prevent cracking under heating stresses.

3. A granular ferrous metal including grains of free ferrite, graphitic carbon and iron carbide the latter being distributed between the grains of ferrite and about the graphitic carbon.

4. The process of treating malleableized cast iron which comprises successive heating and cooling thereof to derive therefrom a structure containing free carbon ferrite, and iron carbide; the heating being carried above the critical temperature but below the melting point to cause the formation of iron carbide and the cooling being effected at a rate not less than 10° F. per hour to enable the retention of iron carbide together with free carbon and ferrite.

5. The process of treating malleableized cast iron which includes heating the same above the critical temperature but below the melting point to cause the formation of iron carbide, and subsequently so cooling the iron at a rate of not less than 10° F. per hour as to prevent the complete destruction of iron carbide without interfering with the formation of ferrite.

6. A furnace element comprising an iron casting substantially free from cementite and having the major portion of its carbon in the form of nodules of graphite, the dominant portion of the casting being formed of substantial areas of both ferrite and pearlite, the casting being sufficiently stiff to resist deformation at a moderate heat and being sufficiently ductile to prevent cracking under heating stresses.

7. A furnace element comprising an iron casting substantially free from cementite, having the major portion of its carbon in the form of nodules of graphite, areas of ferrite surrounding the nodules of graphite, areas of pearlite surrounding the areas of ferrite, the casting being sufficiently stiff to resist deformation at a moderate heat and being sufficiently ductile to prevent cracking under heating stresses.

8. A stoker element comprising an iron casting substantially free from cementite, and having the major portion of its carbon in the form of nodules of graphite, the dominant portion of the casting being formed of substantial areas of both ferrite and pearlite, the casting being sufficiently stiff to resist deformation at a moderate heat and being sufficiently ductile to prevent cracking under heating stresses.

9. A stoker element comprising an iron casting substantially free from cementite, having the major portion of its carbon in the form of nodules of graphite, areas of ferrite surrounding the nodules of graphite, areas of pearlite surrounding the areas of ferrite, the casting being sufficiently stiff to resist deformation at a moderate heat and being sufficiently ductile to prevent cracking under heating stresses.

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