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ROYSEL J. COWAN, OF TOLEDO, OHIO, ASSIGNOR TO THE SURFACE COMBUSTION CO., INCORPORATED, OF TOLEDO, OHIO, A CORPORATION OF NEW YORK

PROCESS OF ANNEALING GRAY IRON

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This invention relates to a process of annealing gray iron and has for its object the production of annealed castings of a high degree of machinability at a much more rapid rate than has heretofore been considered possible.

According to the usual method of annealing iron castings, the iron is raised to a temperature above that at which the change of combined carbon into graphite begins. After holding at this temperature for some time, the temperature is lowered very slowly to well below the point where the chemical reactions cease, after which the iron may be cooled rapidly.

As commonly practiced, the iron is held at temperatures varying from 1400 to 1650° F. for periods of time varying from twenty minutes to twenty-four hours—the longer time being coupled with the lower temperature. The heat treatment at these temperatures is designed to bring about the graphitization of the metallographic constituent known as cementite, this being the constituent that causes the material to be hard and which is present in all gray irons in varying proportions, depending on the chemical analysis or composition of the material or upon the rate at which it has been cooled, or both.

When present above a certain amount, cementite causes difficult machinability but annealing aids machinability by bringing about a series of reactions known as graphitization, whereby the hard cementite is changed into the soft elements, iron and carbon.

If the chemical analysis of the material is such as to bring about the formation of a large amount of cementite so that thin sections of the metal are white in appearance, this undesirable condition may be corrected by a proper annealing, whereby the cementite is graphitized.

If the gray iron has been cast in a metal mold or against an iron chill, certain sections of the casting may be white from the presence of excess cementite and this condition may be corrected by a proper annealing whereby the cementite is graphitized.

Any combination of these two variables, viz: chemical composition and rapid cooling from the melted state, may produce undesirable amounts of the hard constituent cementite, which can be removed by graphitization.

The constitution of gray iron as observed under the microscope may be described as follows:

When the carbon content of the iron is 0.85± % a distinct constituent is found, known as pearlite which is an aggregate made up of definite proportions of cementite and ferrite. If more carbon is present than will exactly form this aggregate (pearlite), the excess will separate out as hard free cementite. When the iron cools from the molten state, in addition to the graphite or free carbon which separates out at a temperature close to the melting point, there will always be found varying amounts of pearlite and excess cementite, the exact amount depending upon the chemical analysis of the material, the speed of solidification, or both.

When the temperature of this gray iron is raised, after being cast, as during annealing, a definite temperature will be reached above which a number of changes will take place. One important change is in the percentage of carbon found in that entity which when cold is known as pearlite. Above this temperature pearlite assumes a different structure because the carbon of which it is formed goes into solution in the iron. This solid solution of carbon and iron is of variable composition and varies in hardness when cooled rapidly, in proportion to the amount of carbon it contains. The amount of carbon it contains in each case being dependent upon the temperature to which it has been raised so that the higher the temperature, the greater will be the amount of carbon dissolved and the harder the metal will be when cooled

quickly. The carbon that is dissolved comes either from the solution of excess cementite or from graphite itself.

Another change that takes place above this critical temperature is that which has to do with the excess cementite present. When the metal is held at any one temperature above the point where the chemical reactions begin, the excess cementite is graphitized until the carbon is reduced to a point where it equals the carbon concentration of the solid solution at that temperature, at which point the graphitization reaction stops.

Now I have found that if the metal is held at any given temperature above the critical temperature long enough to cause the graphitizing reactions to once stop, it requires very slow cooling from this temperature down to the critical temperature to get this reaction started again and to carry it to completion. During this slow cooling both the carbon present as excess cementite and that present in the pearlite structure may be completely graphitized as is commonly done in the manufacture of malleable iron. Failure to appreciate these facts is believed to explain the relatively long periods of heating at a given temperature and the relatively slow cooling from such temperature heretofore considered necessary in order to obtain properly annealed castings.

According to my invention the metal is not held at any given temperature for a period long enough to allow the graphitizing reactions to stop but on the contrary I begin the cooling of the metal while the graphitizing reactions are still going on and allow the cooling to proceed at any convenient rate as by quenching in air.

Graphitization proceeds very rapidly with increase of temperature so that gray iron will reach the point where graphitization will stop after only a few minutes at a high temperature,—for instance, for over five minutes at 1650° F. This same condition is reached at a lower temperature as for example 1450° F. after the metal has been held at this temperature for more than one hour.

My invention may be said to be based on the following facts: that if gray iron is heated to a temperature above that at which the conversion of combined carbon into graphite begins, the metal may be cooled befor the grahpitization reaction is stopped and graphitization will continue as the temperature is lowered to a degree that will produce a metal that is readily machinable; that if gray iron is heated to a temperature above that at which the conversion of combined carbon into graphite begins and is held at this temperature long enough to initiate the graphititizing reactions but not long enough to cause a marked retardation of these reactions, the metal may then be cooled from this point at any convenient rate in air and produce a gray iron of fine quality; that if gray iron is held during the process of annealing at any one temperature above the critical temperature for too long a time, the graphitizing reactions that are the essential part of these annealing operation may be very much retarded and even stopped in extreme cases; that if the heat treatment of gray iron has been such, during the annealing operation that the graphitization reactions have not been greatly retarded by holding for too long a time at any one temperature, the cooling from this maximum temperature used may be done at any convenient rate in air and produce a gray iron of fine quality; that if, during the annealing of gray iron, the heating at any one temperature is discontinued and the temperature lowered before the graphitizing reaction at this temperature is greatly retarded or stopped, it will not be necessary to have a prolonged cooling period in order to produce a gray iron of fine machinability; that if, during the annealing of gray iron, the heating at any one temperature is discontinued and the temperature lowered before the graphitizing reaction at this temperature is greatly retarded or stopped, the iron may be cooled at any convenient rate, as by quenching in air and will produce a gray iron of fine machinability; that when gray iron is to be annealed, the amount of cementite present in the metal as cast, determines the temperature to which the metal must be raised in order to produce a material of fine machinability; this relationship being such that the greater amount of cementite requires the higher temperature for annealing; that a relationship exists between the maximum temperature of annealing, the amount of cementite present in the metal as cast, and the time required to hold at maximum temperature, such that the higher temperatures will require the shorter time and the lower temperatures the longer time.

What is claimed is:

1. In the art of annealing gray iron castings, the steps consisting of heating the iron to a temperature above its critical point, holding said temperature for period sufficient to initiate graphitization, and before the graphitization has stopped, cooling the iron at any conveninet rate.

2. In the art of annealing gray iron castings, the steps consisting of heating the iron to a temperature above its critical point, holding said temperature for period sufficient to initiate graphitization and before the graphitization has stopped, cooling the iron by quenching in the open air.

3. In the art of annealing gray iron castings, the steps of heating the iron to a temperature of 1650° F. as a maximum and by such heating initiating graphitization, holding said temperature for a maximum time in-

terval of five minutes, and thereafter while graphitization is still in progress cooling the iron at any convenient rate.

4. In the art of annealing gray iron castings, the steps of heating the iron to a temperature of 1450° F. as a minimum and by such heating initiating graphitization, holding said temperature for a maximum time interval of one hour, and thereafter while graphitization is still in progress cooling the iron at any convenient rate.

5. In the art of annealing gray iron castings, the steps of heating the iron to a temperature of 1650° F. as a maximum and by such heating initiating graphitization, holding said temperature for a maximum time interval of five minutes, and thereafter while graphitization is still in progress quenching the iron in the open air.

6. In the art of annealing gray iron castings, the steps of heating the iron to a temperature of 1450° F. as a minimum and by such heating initiating graphitization, holding said temperature for a maximum time interval of one hour, and thereafter while graphitization is still in progress quenching the iron in the open air.

7. The method of annealing gray iron castings which consists in raising the temperature to a predetermined point of reaction, maintaining this reaction temperature for such time as will allow the graphitizing reactions to proceed, and thereafter lowering the temperature at any convenient rate as by quenching in air before that point is reached where graphitizing reactions are greatly retarded or stopped because of too long a time at a particular temperature.

8. The method of annealing gray iron castings which are very hard and contain more cementite than usual which condition is caused either by unusual chemical composition, rapid solidification or both, which consists in heating the iron to a maximum temperature of 1650° F., and by such heating initiating graphitization, holding said temperature for a time not to exceed five minutes, and thereafter while graphitization is still in progress lowering the temperature at any convenient rate as by quenching in air.

9. The method of annealing gray iron castings which are soft and contain less cementite than usual due to special chemical composition, very slow cooling or both, which consists in heating the iron to a minimum temperature of 1450° F., and by such heating initiating graphitization, holding said temperature for a time not to exceed one hour, and thereafter while graphitization is still in progress lowering the temperature at any convenient rate as by quenching in air.

10. The method of annealing gray iron castings which consists in heating the iron between a temperature range of 1450° F. as a minimum and 1650° F. as a maximum, and by such heating initiating graphitization, holding said temperature for a period ranging from one hour as a maximum and five minutes as a minimum, the longer period being coupled with the minimum temperature and vice versa, and thereafter while graphitization is still in progress cooling the iron at any convenient rate.

In testimony whereof I affix my signature.

ROYSEL J. COWAN.