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PROCESS FOR THE TRANSFORMATION ANNEALING OF STEELS

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The invention relates to a process for the transformation annealing of hypereutectoid and ledeburitic steels, irrespective of whether they contain alloy elements in addition to carbon, that is to say, irrespective of whether they are to be regarded as alloyed or unalloyed. These steels include, for example, high-speed steels, low-alloy and high-alloy tool steels, structural steels of many varied types and stainless and acid-resisting steels, in so far as these are hardenable, that is to say, steels containing chromium and only a relatively small proportion of nickel, molybdenum or the like.

The aforesaid types of steels are present in various forms for the purposes of transformation annealing. They may be in the form of rods, tubes or sheets, and it is furthermore possible that they may have to be subjected to the treatment in the form of wound wire rings. Moreover, they may exist in the form of forgings. By far the commonest form is that of the rod or the tube.

The heat treatment of these relatively varied steels has hitherto had to be carried out in a series of different processes. The consequence of this is that in a precious steel works the individual products must be divided into a large number of groups for separate treatment, the number of the said groups depending upon the composition of the steel to be treated, and the form in which it is present, that is to say, upon whether it is in the form of sheets, tubes or rods, while regard must also be had to the dimensions and the nature of the furnaces available for this work. As is well known, the annealing has hitherto generally been carried out in car type bottom annealing furnaces or in semi-muffle or muffle furnaces, in more or less large stacks. Each stack passes through the annealing stages of heating it, maintaining it at the required temperature and cooling it. The furnace must participate in all the temperature variations and it has therefore been proposed to employ furnaces of the type which allows the stack to be successively fed to zones heated at different temperatures. Processes in which material is annealed in stacks are attended by the known disadvantages that uniform temperature conditions do not exist throughout the stack, because the outside of the stack reaches higher temperatures than the interior and vice versa. Above all, some of the parts lag considerably in the variations of temperature. In order to obviate these difficulties, it has already been proposed to feed the individual workpieces continuously or step-by-step through the individual heating zones of appropriately constructed furnaces.

While the method of continuous and progressive heating, in particular of individual workpieces, affords advantages both with regard to quality and with regard to the time factor as compared with pure annealing in stacks, the heating times are nevertheless still relatively long and in addition this method is generally practicable only when there are large quantities of similar material to be annealed, which is not generally the case. Generally, the materials differ greatly from one another and the groups of material require individual treatment.

I have found that it is possible by applying a preliminary treatment which is identical for all the aforesaid alloyed and unalloyed steels, not only to effect a substantial shortening of the heating times, but also to effect the

annealing of all the aforesaid groups of steels with only a small difference in their after-treatment. The process according to the invention resides in that the material to be annealed is first heated to temperatures between 800° C. and 880° C. Preferably, a temperature of about 840° C. is commonly applied to all steels whether they be hypereutectoid or ledeburitic, this temperature being maintained for one to two hours. After this treatment, the material ot be annealed is cooled at any desired rate to a temperature lower than 700° C. preferably to a temperature of about 650° C. Lowering of the temperature to less than 600° C. in this stage only results in the disadvantage of heat losses.

As soon as the material under treatment has reached this temperature, it is heated to the actual annealing temperature. This annealing temperature must be maintained for one to three hours.

The annealing temperature which must actually be maintained depends upon the composition of the material concerned. A particular advantage of the process according to the invention has been found to reside in that two different temperature levels are generally sufficient in this stage of the treatment.

Unalloyed and low-alloyed hypereutectoid steels are heated in this stage at 740° C.–760° C., preferably at 750° C. For more highly alloyed hypereutectoid steels and for ledeburitic steels, a temperature of 780° C.–800° C. must be maintained. In special cases, however, for example in the case of highly alloyed high-speed steels or highly alloyed tool steel containing about 2% of carbon and 12% of chromium, a temperature of up to 850° C. is expediently applied in this stage of the treatment.

If the aforesaid heating times and heating temperatures, applied to the appropriate steel qualities, are observed, this type of treatment is sufficient in all cases to produce the desired structure formation and annealing hardness.

This treatment is followed by the cooling, which is uniform for all types of steels, and is effected at any desired rapidity to about 720° C. and then slowly down through the temperature range from 720° C. to 680° C. Cooling may be in accordance with a constant temperature curve or may proceed in temperature steps, for example by maintaining the material at successive stages of 720° C., 700° C. or the like. Regardless of the manner in which the temperature is controlled during the cooling, the material must be cooled from about 720° C. to about 680° C. in about two to four hours.

It will be apparent that the total times of treatment are thus substantially reduced as compared with those of all the known processes, and that in general only two different treatment temperatures are necessary in the actual annealing stage for the purpose of adaption to the different qualities of steel.

The process according to the invention may be carried out in a particularly advantageous manner by progressively passing the steel material to be annealed through an annealing furnace, the temperature of which can be regulated in zones. In such a furnace, the individual zones can be adjusted to and maintained at exactly predetermined temperatures. The material to be annealed is passed through this furnace at such a speed that the heating-up, maintenance and cooling times are positively obtained. No disadvantage occurs if the material to be annealed, for example a rod, is excessively long in relation to such a temperature zone of the furnace. The result of the heat treatment is not affected if the steel material, or unit of material, to be annealed is moved constantly forwards and lies simultaneously in two or more treatment zones.

The advantages afforded by the process according to the

invention will hereinafter be explained with reference to a number of examples.

It will be assumed that it is desired to subject a hypereutectoid roller bearing steel containing about 1% of carbon, 1.5% of chromium and the usual proportions of silicon, manganese and the usual impurities to a transformation annealing.

In the known stack annealing, tubes or rods of this material are treated together in stack units, usually of about 10 tons. The annealing times amount on an average to about 48 hours. The whole stack is heated up for about 20 hours, to reach a temperature of 800° C. This temperature is maintained for 10 hours, whereafter cooling to 720° C. is effected in about 4 hours and this temperature is maintained for 8 to 10 hours. 6 hours must thereafter be expended in reaching a temperature of about 600° C. to 650° C. before the stack can be withdrawn from the furnace.

The necessary time could be reduced to about 20 hours by passing the material continuously through the furnace.

If, on the other hand, the process according to the invention is adopted, the total treatment time is reduced to 8 to 12 hours. For this hypereutectoid steel, an annealing temperature of 780° C.–800° C. must be maintained for about 3 hours.

A steel having the same chromium content, but containing 1.5% of carbon can be treated in a similar manner. A steel, the composition of which lies at the boundary between that of a hypereutectoid steel and that of a ledeburitic steel and which contains 0.4% of carbon and 13% of chromium, may be treated in a similar manner.

Ledeburitic steels, such for example as a high-speed steel containing 18% of tungsten, 4% of chromium, and 1.5% of vanadium or high-speed steel having a low content of materials in short supply and containing 3% of molybdenum, 3% of tungsten, 3% of vanadium and 4% of chromium are also capable of being treated in the same manner, as also is a ledeburitic steel containing 4% of chromium, 1% of molybdenum, 4% of vanadium and 12% of tungsten. If the usual processes are applied, annealing times of 45 hours and more are necessary with these steels, a particular temperature in the 760° C.–860° C. range having to be maintained for each composition, that is to say, there will be a large number or different groups to be subjected to the annealing.

It will be seen from these examples that the process is applicable to steels of very different compositions, and even unalloyed hypereutectoid steels, for example a steel containing 1% of carbon and the usual minor proportions of manganese and silicon, can be treated in this manner if heated to and maintained at an actual annealing temperature of 740° C.–760° C., preferably 750° C.

The process according to the invention, particularly when applied to hypereutectoid steels, affords the advantageous result that the carbides are given a particularly fine and uniform grain size. This is due to the first heating and cooling treatment, which removes the unfavourable influences of the antecedents of the material, and to the short annealing times. In addition, it is possible to vary the actual carbide grain size by suitable choice of the annealing temperature within the aforesaid limits.

In the case of high-speed turning steels, the additional advantage is obtained that the danger of decarburization is substantially avoided owing to the short times of treatment.

The process according to the invention is not comparable to a heat treatment fluctuating around the upper transformation point, which is usual with hypereutectoid steels for the recrystallisation, primarily of the basic mass, that is to say, of the ferrite grain. On the other hand, the process has the object of transforming the carbides, this transformation being initiated by a heating to temperatures between 800° C. and 880° C. prior to the actual annealing.

What I claim is:

1. A process for the transformation annealing of a steel selected from the group consisting of hypereutectoid and ledeburitic steels, by progressively passing the steel through a furnace the temperature of which is zonally regulated, which comprises the steps of (1) heating the steel to a temperature between 800° C. and 880° C. and maintaining the steel at that temperature for a period of from the order of from 1 to 2 hours; (2) cooling the steel at any desired rate to a temperature below 700° C. but not substantially below 600° C.; (3) immediately reheating the steel to an annealing temperature between 740° C. and 800° C. and maintaining the steel at said annealing temperature for a period of the order of from 1 to 3 hours, and wherein said annealing temperature is selected from the lower part of said temperature range for the unalloyed and low alloyed hypereutectoid steels and in the upper part of said temperature range for high alloyed steels; (4) cooling the steel at any desired rate to a temperature about 720° C.; and thereafter cooling said steel through the temperature range of from 720° C. to 680° C. during a period of time of the order of from 2 to 4 hours.

2. The process of claim 1, wherein said steel is an unalloyed hypereutectoid steel and said annealing temperature is between 740° C. and 760° C.

3. The process of claim 1, wherein said steel is a lower alloyed hypereutectoid steel, and said annealing temperature is between 740° C. and 760° C.

4. The process of claim 1, wherein said steel is a high alloyed steel and said annealing temperature is between 780° C. and 800° C.

5. Process for the transformation annealing of a highly alloyed high-speed steel according to claim 1 in which the re-heating is to an annealing temperature of up to 850° C.

6. Process for the transformation annealing of a highly alloyed tool steel according to claim 1 in which the re-heating is to an annealing temperature of up to 850° C.

7. A process for the transformation annealing of a steel selected from the group consisting of hypereutectoid and ledeburitic steels, by progressively passing the steel through a furnace the temperatrue of which is zonally regulated, which comprises the steps of (1) heating the steel to a temperature between 800° C. and 880° C. and maintaining said temperature for a period of from the order of 1 to 2 hours; (2) cooling the steel at any desired rate to a temperature lower than 70° C. but not substantially lower than 600° C.; (3) immediately re-heating said steel to an annealing temperature between 740° C. and 800° C. and maintaining the steel at said annealing temperature for a period of the order of from 1 to 3 hours, the annealing temperature being selected from the lower part of said range for the unalloyed and low alloyed hypereutectoid steels and in the upper part of said temperature range for highly alloyed steels; (4) cooling the steel to a temperature of about 680° C., said cooling being carried out in two steps, the first step comprising cooling the steel to 740° C. at a rate faster than the rate of cooling in the second stage, said second stage comprising cooling the steel through the temperature range from 720° C. to 680° C. at a rate between 10° and 20° per hour.

8. A process for the simultaneous transformation annealing of a plurality of steels selected from one of the groups consisting of (*a*) unalloyed and low-alloyed hypereutectoid steels and (*b*) highly alloyed hypereutectoid and ledeburitic steels, by progressively passing said steels through a furnace the temperature of which is zonally regulated, which comprises the steps of (1) heating said steels to a temperature between 800° C. and 880° C. and maintaining said steels at that temperature for a period of from the order of from 1 to 2 hours; (2) cooling said steels at any desired rate to a temperature below 700° C. but not substantially below 600° C.; (3)

immediately reheating said steels to an annealing temperature between 740° C. and 800° C., and maintaining said steel at said annealing temperature for a period of the order of from 1 to 3 hours, and wherein said annealing temperature is selecetd in the lower part of said temperature range for the unalloyed and low alloyed hypereutectoid steels and in the upper part of said temperature range for high alloyed steels; (4) cooling said steels at any desired rate to a temperature about 720° C.; and thereafter cooling said steels through the temperature range of from 720° C. to 680° C. during a period of time of the order of from 2 to 4 hours.

9. A process for the transformation annealing of a plurality of steels selected from the group consisting of hypereutectoid and ledeburitic steels, by progressively passing said steels through a furnace the temperature of which is zonally regulated, which comprises the steps of (1) heating said steels to a temperature between 800° C. and 880° C. and maintaining said temperature for a period of time of from the order of 1 to 2 hours; (2) cooling said steels at any desired rate to a temperature lower than 700° C. but not substantially lower than 600° C.; (3) immediately reheating said steels to an annealing temperature between 740° C. and 800° C. and maintaining said steels at said annealing temperature for

a period of the order of from 1 to 3 hours, the annealing temperature being selected from the lower part of said range for the unalloyed and low alloyed hypereutectoid steels and in the upper part of said temperature range for highly alloyed steels; (4) cooling said steels to a temperature of about 680° C., said cooling being carried out in two steps, the first step comprising cooling said steels to 720° C. at a rate faster than the rate of cooling in the second stage, said second stage comprising cooling said steels through the temperature range of from 720° C. to 680° C. at a rate between 10° and 20° per hour.

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