(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 031 631 A2

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
30.08.2000 Bulletin 2000/35

(51) Int Cl.7: **C21D 1/32**, C21D 1/78

(21) Application number: **00850027.4**

(22) Date of filing: **14.02.2000**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **22.02.1999 SE 9900598**

(71) Applicant: **Ovako Steel AB**
813 82 Hofors (SE)

(72) Inventors:
- **Lund, Thore**
  813 33 Hofors (SE)
- **Larsson, Staffan**
  731 52 Köping (SE)
- **Ölund, Patrik**
  813 31 Hofors (SE)

(74) Representative: **Westman, P. Börje I.**
SKF Group Headquarters
Innovation & Patents
S-415 50 Göteborg (SE)

(54) **A method of spheroidizing annealing of hypo-eutectoid low alloy steel**

(57) Method of spheroidizing annealing of hypo-eutectoid low alloy steel, wherein a hot rolled steel typical comprising ferrite and a high carbon phase such as pearlite or martensitic/bainitic microstructural constituents

- a) is heated to a temperature between A1 and A3 until austenitic domains with higher carbon content than the base composition has been created,
- b) the temperature is lowered and held under A1 to enable the austenite to transform into ferrite and carbides,
- c) the temperature is held under A1 until a desired degree of spheroidizing of the carbide is obtained.

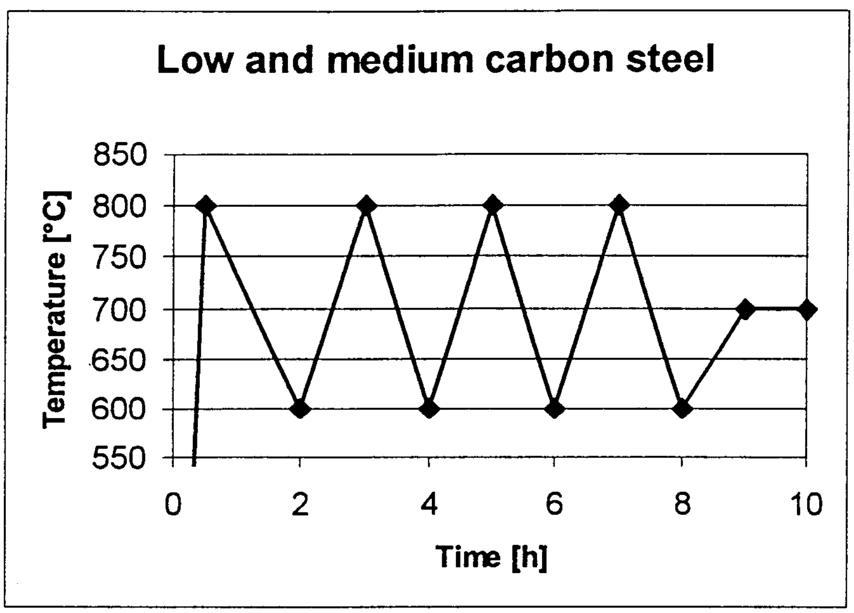

Fig. 1

EP 1 031 631 A2

Description

Field of invention

[0001] The present invention relates to a method of spheroidizing annealing of hypo-eutectoid low alloy steel, and more specifically to a method of heat treatment of hypo-eutectoid low alloy steel for obtaining a desired amount of spherical carbides in a ferritic matrix in order to enhance the cold forming characteristics of the steel.

Background

[0002] Today, low and medium carbon steels are normally delivered having a mixed structure comprising perlite and ferrite, sometimes bainite and/or martensite, tempered or not. This may lead to problems in machining and/or cold deformation. In turning processes this is experienced as heavy wear of the tools and in cold deforming processes unwanted cracks in the treated objects occur. The two conventional heat treatment methods currently used for softening steels do not result in spheroidisation of low or medium carbon steel.

[0003] Spherodizing annealing of high carbon steel is one of the conventional heat treatment methods giving a perlite structure, and the other is tempering at about 700°C of low carbon steel, which gives perlite and non-spherical carbides.

[0004] Further, the sulphur addition used today to enhance workability, results in manganese sulphides, which increase the risk of fatigue failure at high loads. In continuous casting the problems are even worse, and the sulphur may result in segregations and sulphide stringers.

[0005] Thus, it is desirable to obtain good workability without sulphur addition, since the loads on many components produced today tend to increase rather than decrease.

The invention

[0006] The object of the invention is to provide a method for spheroidizing annealing of hypo-eutectoid low alloy steel resulting in improved cold forming characteristics and machinability.

[0007] This is achieved with the method according to the present invention, wherein a hot rolled steel typical comprising ferrite and a high carbon phase such as pearlite or martensitic/bainitic microstructural constituents

-a) is heated to a temperature between A1 and A3 until austenitic domains with higher carbon content than the base composition has been created,
-b) the temperature is lowered and held under A1 to enable the austenite to transform into ferrite and carbides,
-c) the temperature is held under A1 until a desired degree of spheroidizing of the carbide is obtained.

[0008] According to one embodiment of the invention, a) and b) are repeated at least twice. This will decrease the material grain size and thus increase the diffusion rate and reduce the diffusion distances of alloying elements. This could be necessary in order to successfully anneal a hypo-eutectoide steel with a low amount of carbide forming elements.

Brief description of the drawings

[0009] Fig. 1 illustrates one embodiment of the spheroidizing annealing method according to the invention for low and medium carbon steels (Ovako 234, 0.2 wt. % C).

[0010] Fig. 2 illustrates second embodiment of the method according to the invention, for low and medium carbon steel (Ovako 593, 0.5 wt.% C, 157, 245, och 255, 0.2 wt.% C.

[0011] Fig. 3 illustrates a third embodiment of the method according to the invention for low and medium carbon steels (Ovako 593, 0.5 wt.% C) 157, 245 and 255, 0.2 wt.% C.

The invention

[0012] Today hot rolling of products is common. These products are then delivered non-treated, tempered, toughened or treated in an isothermal heat treatment furnace.

[0013] Products produced and delivered to a customer can be divided into three different categories related to the final treatment before delivery:

1. Not treated:

- Hot rolling at about 1150°C - cooling down to 20°C - to customer.

2. Tempered and hardened:

- Hot rolling at about 1150°C - cooling down to 20°C - tempering at about 650°C - to customer (tempered);
- Hot rolling at about 1150°C - cooling down to 20°C - austenitization at about 900°C - quenching (water/oil) + tempering at about 650°C - to customer (toughened)

3. Treated in isothermal heat treatment furnace:

- Hot rolling at about 1150°C - cooling dowm to approximately 650°C -holding time 1 hour at about 650°C - to customer.

[0014] To the best of our knowledge no supplier today offer shperoidized structures when it comes to low and/or medium carbon steels. For these types of steels three embodiments of the method according to the invention have been illustrated, i.e. heating to or holding isothermally at a temperature between A1 and A3 until austenitic domains with higher carbon content than the base composition has been created, thereafter lowering the temperature to and holding it underneath A1 to enable the austenite to transform into ferrite and carbides, and holding the temperature underneath A1 until a desired degree of spheroidizing of the carbides is obtained.

Examples

Example 1

[0015] Two different steel grades were treated, Ovako 157 with about 0.2 wt.% C, and Ovako 057 with about 0.5 wt.% C.
The respective steels were normalized 4 times by raising the temperature to between A1 and A3, for these steels about 790°C, and then lowering the temperature to below A1, in this case about 600°C, then holding the temperature at about 690°C until the desired degree of spheroidization was obtained, resulting in a structure not containing any perlite. Four or more normalisations results in a grain refining giving a large amount of grain boundaries which will increase the amount of high energetic nucleation sites for the austenite. An increased number and thus reduced size of austenitic domains will decrease the diffusion distances for alloying element making the desired spheroidization possible.
high-energy grain formation sites, making posible 100 % spheroidization with very small, spherioidal grains thanks to a successive grain refining with only small amounts of carbon having to diffuse each time.
[0016] A graph illustrating the method is shown in Fig. 1.

Example 2

[0017] The steel grade Ovako 234 with about 0.2 wt. % C was treated with the method according to the invention, by raising the temperature to between A1 and A3, in this case about 740°C, and maintaining the temperature for a prolonged time, lowering the temperature to underneath A1 and then holding the temperature until the desired degree of spheroidization has been obtained.
[0018] A graph illustrating this embodiment of the method is shown in Fig. 2.

Example 3

[0019] The following steel grades were tested: Ovako 593 with about 0.5 wt.% C, and Ovako 157, 245, and 255 with about 0.2 wt.% C. The temperature was increased to between A1 and A3, in this case about 740°C, this temperature was maintained for about one hour, then lowered to well below A1, i.e. about 600°C, and then increased again to about 670°C and maintained there until the desired degree of spheroidization was obtained.
[0020] In all three embodiments of the method according to the invention 100 % spheroidization was obtained. The effect of lowering the temperature to a minimum value as in example 3, did not give any significant improvment of the characteristics of the resulting material to be delivered to the customer.

Claims

1. Method of spheroidizing annealing of hypo-eutectoid low alloy steel, wherein a hot rolled steel typical comprising ferrite and a high carbon phase such as pearlite or martensitic/bainitic microstructural constituents

   - a) is heated to a temperature between A1 and A3 until austenitic domains with higher carbon content than the base composition has been created,
   - b) the temperature is lowered and held under A1 to enable the austenite to transform into ferrite and carbides,
   - c) the temperature is held under A1 until a desired degree of spheroidizing of the carbide is obtained.

2. Method according to claim 1, wherein steps a) and b) are repeated at least twice.

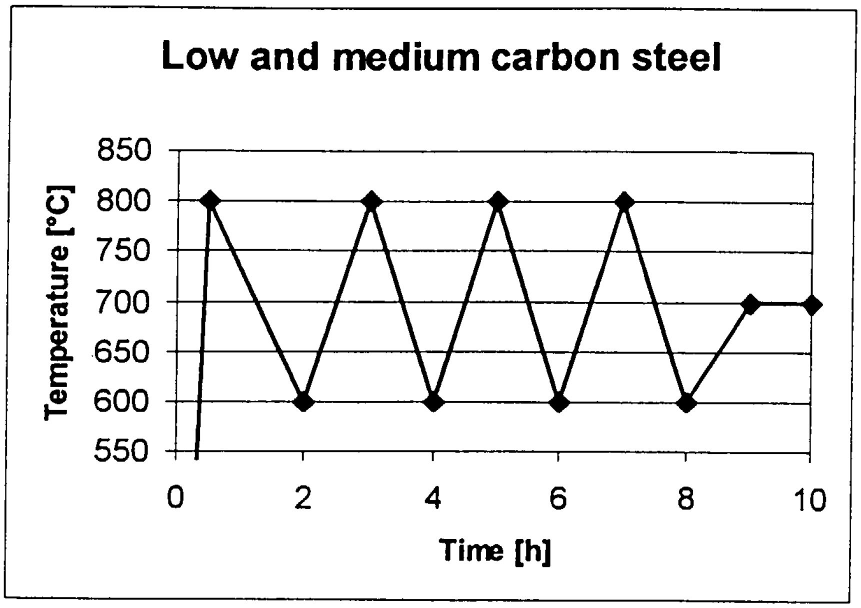
Low and medium carbon steel
Temperature [°C]
850
800
750
700
650
600
550
0
2
4
6
8
10
Time [h]

Fig. 1

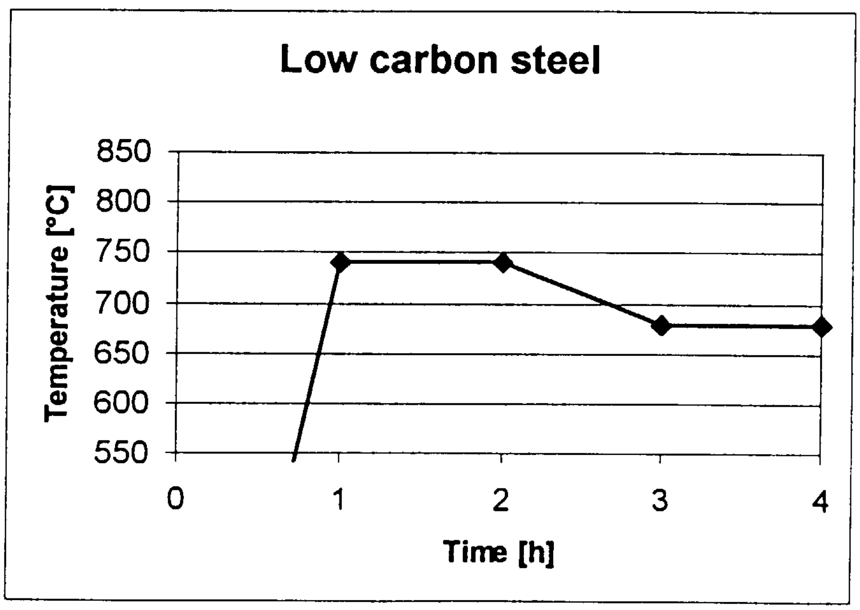
Low carbon steel
Temperature [°C]
850
800
750
700
650
600
550
0
1
2
3
4
Time [h]

Fig. 2

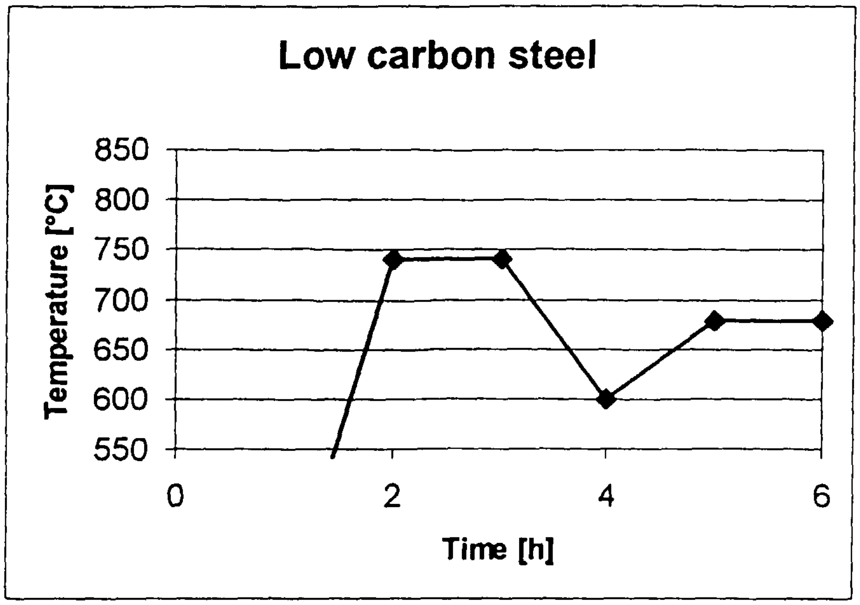
Low carbon steel
850
800
750
700
650
600
550
Temperature [°C]
0
2
4
6
Time [h]

Fig. 3