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(54) CARBONITRIDING OR CEMENTATION STEEL AND METHOD OF PRODUCING PARTS WITH SAID STEEL

CARBONITRIER- ODER EINSATZSTAHL UND VERFAHREN ZUR HERSTELLUNG VON TEILEN MIT DEM STAHL

ACIER DE CEMENTATION ET DE CARBONITRURATION ET PROCESSUS DE FABRICATION DE PIECES A PARTIR DUDIT ACIER

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EP 1 876 255 B1

Description

OBJECT OF THE INVENTION

[0001] The present invention relates to a carburized or carbonitrided steel material and to the process of obtaining parts from this material.

[0002] An object of the invention is a carburized or carbonitrided steel having a composition such that it allows increasing its hardenability and minimizing deformations when an area of its surface is subjected to a hardening treatment by carburizing or carbonitriding followed by quenching in a non-severe medium.

[0003] Another object of the invention is the process of obtaining a mechanical part from this starting steel.

BACKGROUND OF THE INVENTION

[0004] Carburizing represents one of the most common surface thermal treatments conducted with metallic materials and is particularly applicable in automotive parts in transmission elements such as steering and the gear box. The large amount of frictions generated during their operation mean that the surfaces of these parts must be hard and have a high resistance to wear, in addition to incorporating a tenacious core to resist mechanical shocks occurring during service. To achieve these properties, parts manufactured with carburized steel are normally used.

[0005] Carburized steels have a carbon content between 0.15% and 0.30% by weight and alloy elements such as manganese, chromium, nickel and molybdenum, among others, which aid in obtaining the final features required of the parts. The carburized steels most commonly used in manufacturing components intended for the automotive industry are steels alloyed with Cr, MnCr, MoCr, NiCr, CrNi, NiCrMo, CrNiMo.

[0006] To increase the surface hardness of the part, the steel is subjected to a carburizing process increasing the C content in its surface layer until reaching values comprised between 0.8 and 1 % C. The carburizing process is carried out at a high temperature in a controlled gas atmosphere. After the carburizing process, the periphery of the part may be relatively soft despite the high C content and the core may show brittleness due to having a coarse structure, so it is therefore necessary to then subject the part to a quenching process.

[0007] The parts are cooled in the quenching process from the carburizing temperature to room temperature at a cooling rate ensuring the transformation of the austenite in the final structure required by the steel.

[0008] Among the known carburizing and quenching techniques, low pressure carburizing combined with a quenching in which oil is substituted with a high pressure gas is being implemented, thus improving the surface quality and reducing deformation of the parts.

[0009] Cooling with gas means that the temperature gradients in the part are more homogenous than those that are reached using oil, which implies a reduction of deformations caused by heat. However, the gas used as a quenching fluid may have a lower cooling capacity than oil, which implies that the obtained steel part will have a lower strength.

[0010] The pressure of the gas is increased to increase the cooling capacity thereof, however excess pressure may cause a higher number of final deformations in the parts.

[0011] Invention patent EP 0 890 653 relates to a process of manufacturing carburized or carbonitrided steel parts and to the steel for manufacturing said part. This steel is conceived to obtain a high degree of hardness in the surface of the part obtained after the thermal treatment and to improve the mechanical features of the core, aiming to prevent deformations that may lead to the part being rejected or to the need to carry out supplementary machining. According to said invention, a specific composition of the starting steel is proposed in which C is found at a by weight percentage between 0.2 and 0.26 and other components including, among others, Si, P, S, Mn, Cr, Ni, Mo, Al, Cu, Ti.

[0012] Also, the patent application EP 0 725 156 A discloses a process for manufacturing a component made of a weldable steel having a high tensile strength and a good ductility. A specific composition of the starting steel is proposed which comprises, by weight, from 0.15 to 0.35% of C and other components including, among others, Si, Al, Mn, Ni, Cr, W, Mo, V and Nb. On the other hand, the patent application ES 2 013 007 A relates to a steel intended for manufacturing highly stressed structural members with high demands for ductility and fatigue resistance; said steel having a carbon content adjusted for the purpose for which it is to be used and molybdenum as the only intentional alloying additive. More in particular, the steel has a carbon content suitably lying within the interval 0.10 to 1.15% and a molybdenum content suitably lying within the interval 0.2 to 1.0%. The content of other alloying materials normally used, such as Si, Mn, Cr, Ni, V and W is limited to the smallest normal level for the industrial manufacturing process applicable to the steel. That is, these other alloying materials shall be present in quantities not greater than the typical ones for residual contents for the industrial manufacturing process being used for the steel in question.

[0013] The properties of the parts obtained by the described thermal treatments can be optimized by means of using a starting steel such as the one proposed by the invention described below.

DESCRIPTION OF THE INVENTION

[0014] The present invention proposes a carburized or carbonitrided steel used as a starting material that can be subjected to a hardening treatment by carburizing or carbonitriding and subsequent quenching, conceived with a chemical composition which increases the hardenability of this type of steels and which also allows using non-severe quenching means for the purpose of minimizing final deformations of the part obtained by means of this treatment.

[0015] A carburized or carbonitrided steel is described in which the result of

[0016] several researches have unexpectedly confirmed that the addition of vanadium in contents of less than 0.15% by weight causes an optimal increase in hardenability in steels having a certain chemical composition.

[0017] The inventors have verified a synergistic effect occurring in parts made of steel alloyed with CrMn with uncommon contents of said elements in carburized steels, to which the indicated amount of vanadium are added, which are subjected to a hardening treatment by carburizing or carbonitriding followed by quenching. These parts having a novel chemical composition have improved features in terms of greater hardenability and fewer deformations, in addition to obtaining a steel with a higher metallurgical quality and with a repetitive and uniform response to the thermal quenching treatment.

[0018] Vanadium is used in higher percentages to improve the resistance to wear in other steels such as tool steels, but not in carburized or carbonitrided steels at the indicated concentrations and with the proposed combination of elements.

[0019] The starting steel part the surface of which is partially subjected to a carburizing or carbonitriding treatment has the following percentage chemical composition by weight:

$0.15\% \leq C \leq 0.27\%$
$0.50\% \leq Mn < 1.00\%$
$1.10\% \leq Cr \leq 2.00\%$
$0.00\% \leq Mo < 0:08\%$
$0.03\% \leq V \leq 0.50\%$

as well as possibly having one or several elements: up to 0.0050% Ca, up to 0.15% Bi, up to 0.20% Pb, up to 0.02% Te, up to 0.04% Se, the remaining elements being residual elements resulting from the manufacturing process.

[0020] The effect of each of said alloy elements in the process of manufacturing the steel in its response to thermal treatments and in properties such as hardness and hardenability, is known by metallurgical experts and is described in the literature on the subject.

[0021] The steel may additionally incorporate at least one of the following elements or a combination thereof:

$0.05\% \leq Si \leq 0.50\%$
$P \leq 0.030\%$
$S \leq 1.000\%$
$0.10\% \leq Ni \leq 0.50\%$
$0.00\% Cu \leq 0.35\%$
$0.005\% \leq Al \leq 0.050\%$
$0.005\% \leq Ti \leq 0.050\%$
$0.0040\% \leq N \leq 0.0200\%$

[0022] A preferred percentage composition of the starting steel part by weight is as follows:

$0.18\% \leq C \leq 0.26\%$
$0.80\% \leq Mn < 1.00\%$
$1.30\% \leq Cr \leq 1.70\%$
$0.00\% \leq Mo < 0.08\%$
$0.03\% \leq V \leq 0.15\%$

[0023] For this preferred solution it additionally comprises at least one of the following elements or a combination thereof:

$0.05\% \leq Si \leq 0.50\%$
$P \leq 0.030\%$
$0.020\% \leq S \leq 0.090\%$
$0.10\% \leq Ni \leq 0.50\%$
$0.00\% Cu \leq 0.35\%$

0.005% ≤ Al ≤ 0.050%
0.005% ≤ Ti ≤ 0.050%
0.0040% ≤ N ≤ 0.0200%

[0024] The described combination allows obtaining a homogenous microstructure and achieves that the mechanical features of the obtained parts are of similar ranges for quenching means having a different severity, such as gas under different pressures for example.

[0025] The process of manufacturing a steel part shall occur according to the following steps:

- selecting a steel material,
- manufacturing a part with the steel material by means of forging or machining,
- carburizing or carbonitriding treatment of at least one part of the surface of the part,
- quenching,
- tempering or stress relief,

in which the selected steel has the general composition or the preferred composition described above.

[0026] The obtained steel minimizes deformations, therefore it would allow eliminating finishing operations which would be carried out after the tempering operation (be it grinding, straightening or others) with the subsequent savings involved.

EMBODIMENTS OF THE INVENTION

Example 1

[0027] By way of example and to illustrate the hardenability increase occurring as a result of the addition of vanadium to the composition of a carburized or carbonitrided steel parts have been manufactured the percentage chemical compositions by weight of which are as follows:

	C	Mn	Si	P	S	Cr	Ni	Mo	V	Cu	Al
A1	0,19	0,93	0,24	0,013	0,033	0,95	0,22	0,19	0,00	0,19	0,020
A2	0,19	0,92	0,25	0,015	0,030	0,95	0,23	0,18	**0,10**	0,21	0,022
B1	0,21	0,74	0,25	0,015	0,027	1,16	0,15	0,03	0,00	0,19	0,022
B2	0,21	0,73	0,26	0,015	0,029	1,14	0,16	0,01	**0,05**	0,20	0,028
C1	0,20	0,85	0,24	0,016	0,023	0,54	0,51	0,18	0,01	0,22	0,025
C2	0,20	0,84	0,25	0,014	0,022	0,55	0,49	0,18	**0,10**	0,20	0,025
D1	0,22	0,93	0,25	0,014	0,03	1,44	0,23	0,05	0,00	0,19	0,030
D2	0,22	0,90	0,24	0,011	0,029	1,43	0,23	0,04	**0,07**	0,20	0,027
E1	0,27	1,25	0,26	0,016	0,027	1,00	0,15	0,03	0,01	0,21	0,024
E2	0,27	1,26	0,27	0,019	0,027	1,03	0,12	0,02	**0,12**	0,22	0,022

Table 1

[0028] Steels A1, B1, C1, D1 and E1 have low vanadium contents and steels A2, B2, C2, D2 and E2 are manufactured with a similar chemical composition and a vanadium content according to the range proposed by the invention.

[0029] The hardenability curves of the steels considered have been obtained according to the Jominy test which is usually carried out at the industrial level on steels which are manufactured with a hardenability requirement. Said test consists of machining a test piece having certain dimensions, heating it up to a temperature at which the steel is austenized and cooling it at one end with a cold water jet. Then the hardness is measured at two opposite generators of the test piece and is represented against the distance to the hardened end. The structural transformations taking place in the steel with different coolings is thus known according to the hardness value obtained at each point.

[0030] The Jominy curves obtained for the steels of the example are detailed in the following table:

Table 2

HRc	A1	B1	C1	D1	E1	A2	B2	C2	D2	E2
J1.5	44.5	45.6	44.7	46.7	49.8	44.4	44.9	44.6	46.4	50.1
J3	44.0	44.5	43.8	46.4	49.3	44.1	44.7	41.8	46.0	49.3
J5	39.9	38.9	37.9	44.9	48.7	41.4	42.6	34.6	45.6	48.2
J7	35.2	33.5	31.5	42.4	46.2	37.9	37.6	30.1	44.4	46.5
J9	32.0	30.2	27.6	39.9	43.1	34.0	34.2	27.0	43.2	44.0
J11	30.0	28.2	25.2	37.9	40.3	31.6	31.8	25.1	41.8	41.2
J13	28.6	26.8	23.7	36.3	38.3	29.2	30.2	24.1	40.4	39.9
J15	27.5	25.6	22.5	35.0	36.8	27.8	28.9	23.0	38.5	38.5
J20	25.6	23.1	20.3	32.7	34.2	26.3	26.9	21.5	36.3	35.0
J25	24.3	21.1	18.7	31.1	32.7	25.1	25.1	19.6	34.9	33.9
J30	22.3	19.2	17.3	29.9	31.8	23.6	23.6	18.8	33.2	32.9
J40	19.8	16.2	15.3	28.2	30.6	22.1	21.6	17.1	31.9	31.2
J50	18.4	14.1	13.8	26.6	29.2	22.0	18.1	16.6	31.2	28.9

[0031] When comparing the Jominy curves of steels A1 with A2, B1 with B2, C1 with C2, D1 with D2 and E1 with E2, it is verified that steels B2 and D2, with chemical compositions and vanadium content within the range proposed by the invention, have hardenability curves with hardness values exceeding those obtained for steels B1 and D1, which do not contain vanadium. This hardenability increase effect by the addition of vanadium is not observed in the Jominy curves of steels A2, C2 and E2, the chemical composition of which is outside the range proposed by the invention.

Example 2

[0032] An example is described below which illustrates the reduction of deformation while at the same time ensuring optimal hardness of parts subjected to hardening treatments by carburizing or carbonitriding followed by quenching with gas, in which a steel is used having the preferred compositional features corresponding to the starting steel forming the object of this invention.

[0033] Parts having a particular geometry with a dimension sensitive to deformations have been manufactured from a series of steels having a different composition. The percentage composition by weight of the starting steels is shown in the following table, in which it can be verified that steel E has a chemical composition within the preferred range proposed by the invention.

Table 3

	C	Mn	Si	P	S	Cr	Ni	Mo	V	Cu	Al
A CrMo	0.19	0.92	0.24	0.013	0.033	0.95	0.22	0.19	0.01	0.19	0.020
B CrMn	0.21	0.74	0.25	0.015	0.027	1.16	0.15	0.03	0.00	0.19	0.022
C CrNiMo	0.20	0.85	0.24	0.016	0.023	0.54	0.51	0.18	0.01	0.22	0.025
D MnCr	0.20	1.26	0.28	0.016	0.026	1.17	0.18	0.04	0.01	0.16	0.020
E CrMnV	0.20	0.95	0.25	0.015	0.028	1.45	0.22	0.05	0.06	0.19	0.028

[0034] The parts manufactured with these steels are subjected to a low pressure industrial carburizing process at a temperature of 980°C and to subsequent quenching with gas at pressures of 5 bar, 10 bar, 15 bar and 20 bar respectively, followed by stress relief.

[0035] Hardness in the core, where the least severe cooling takes place, of all the parts thus manufactured was measured, the following table showing the obtained values.

Table 4

	Hardness Hv 30 kg				
Gas pressure	A	B	C	D	E
5 bar	<350	<350	<350	350 - 400	>400
10 bar	<350	<350	<350	350 - 400	>400
15 bar	350 - 400	350 - 400	350 - 400	>400	>400
20 bar	>400	>400	>400	>400	>400

[0036] The results of the previous table show that the maximum hardnesses are obtained with the most severe cooling, quenching the parts at a pressure of 20 bar. It is also observed that when the pressure of the quenching gas is reduced in steels A, B, C and D, the obtained hardness values are reduced. In contrast, in steel E object of the invention the hardness values are maintained in similar orders, even with the less severe cooling taking place at 5 bar.

[0037] To obtain the optimal mechanical features in the manufactured parts, steel E could therefore be hardened at the lowest pressure possible, thereby minimizing deformations. However, to obtain hardnesses similar to those of steel E with 5 bar, the other steels would require more severe coolings: steels A, B and C quenching with gas pressures at about 20 bar, and steel D with pressures of at least 15 bar, obtaining parts with deformations exceeding those of the steel of the invention.

[0038] This is reflected in the following table, showing the result of the dimensional control carried out before and after the treatment in the dimension sensitive to being deformed in parts A, B, C, D and E for the different quenching gas pressures and which is expressed as the variation in relation to the initial dimension in percentages.

Table 5

	Dimensional variation %				
Gas pressure	A	B	C	D	E
5 bar	<0.8%	<0.8%	<0.8%	<0.8%	<0.8%
10 bar	<0.8%	<0.8%	<0.8%	0.8-1%	0.8-1%
15 bar	0.8-1%	0.8-1%	0.8-1%	0.8-1%	0.8-1%
20 bar	>1%	>1%	>1%	>1%	>1%

[0039] It is therefore verified in this example that to minimize the deformations obtained in the parts after thermal treatment, it is necessary to use means in the quenching with the lowest quenching severity possible, such as low pressure gases, and steels which ensure obtaining the required features of the component. Steel E, which has the combination of elements within the range object of the invention ensures in the parts manufactured according to the process object of the invention reducing deformations after the treatment and obtaining the required mechanical demands, as well as a homogenous structure in the part and a uniform and repetitive performance of the material.

Claims

1. A carburized or carbonitrided steel consisting, in percentage by weight, of $0.03\% \leq V \leq 0.50\%$,

$0.15\% \leq C \leq 0.27\%$,
$0.50\% \leq Mn < 1.00\%$,
$1.10\% \leq Cr \leq 2.00\%$,
$0.00\% \leq Mo < 0.08\%$,
$0.05\% \leq Si \leq 0.50\%$,
$0.10\% \leq Ni \leq 0.50\%$
$0.00\% \leq Cu \leq 0.35\%$,
$0.005\% \leq Al \leq 0.050\%$.
P s 0.030%,

S ≤ 1.000%,

and optionally at least one of the following components:

up to 0.0050% Ca,
up to 0.15% Bi,
up to 0.20% Pb,
up to 0.02% Te,
up to 0.04% Se;

further optionally, one of the following elements or a combination thereof:

0.005% ≤ Ti ≤ 0.050%,
0.0040% ≤ N ≤ 0.0200%;

the balance being Fe and incidental impurities.

2. A carburized or carbonitrided steel according to claim 1, consisting, in percentage by weight, of:

0.03% ≤ V ≤ 0.50%,
0.15% ≤ C ≤ 0.27%,
0.50% ≤ Mn <1.00%
1.10% ≤ Cr ≤ 2.00%
0.00% ≤ Mo < 0.08%,
0.05% ≤ Si ≤ 0.50%,
0.10% ≤ Ni ≤ 0.50%,
0.00% ≤ Cu ≤ 0.35%
0.005% ≤ Al ≤ 0.050%,
0.005% ≤ Ti ≤ 0.050%,
0.0040% ≤ N ≤ 0.0200%,
P ≤ 0.030%,
S ≤ 1.000%,

optionally having at least one of the following components:

up to 0.0050% Ca,
up to 0.15% Bi,
up to 0.20% Pb,
up to 0.02% Te,
up to 0.04% Se.

the balance being Fe and incidental impurities.

3. A carburized or carbonitrided steel, according to claim 1, consisting, in percentage by weight, of:

0.03% ≤ V ≤ 0.15%,
0.18% ≤ C ≤ 0.26%,
0.80% ≤ Mn <1.00%,
1.30% ≤ Cr ≤ 1.70%,
0.00% ≤ Mo < 0.08%,
0.05% ≤ Si ≤ 0.50%
0.10% ≤ Ni ≤ 0.50%
0.00% ≤ Cu ≤ 0.35%
0.005% ≤ Al ≤ 0.050%

and optionally, at least one of the following components:

P ≤ 0.030%

0.020% ≤ S ≤ 0.090%
0.005% ≤ Ti ≤ 0.050%
0.0040% ≤ N ≤ 0.0200%

the balance being Fe and incidental impurities.

4. A carburized or carbonitrided steel according to claim 3 consisting, in percentage by weight, of:

0.03% ≤ V ≤ 0.15%,
0.18% ≤ C ≤ 0.26%
0.80% ≤ Mn <1.00%
1.30% ≤ Cr ≤ 1.70%
0.00% ≤ Mo < 0.08%
0.05% ≤ Si ≤ 0.50%
P ≤ 0.030%
0.020% ≤ S ≤ 0.090%
0.10% ≤ Ni ≤ 0.50%
0.00% ≤ Cu ≤ 0.35%
0.005% ≤ Al ≤ 0.050%
0.005% ≤ Ti ≤ 0.050%
0.0040% ≤ N ≤ 0.0200%

the balance being Fe and incidental impurities.

5. A process of manufacturing of a steel part occurring according to the steps of:

- selecting a steel material,
- manufacturing a part with the steel material by means of forging or machining,
- carburizing or carbonitriding treatment of at least one part of the surface of the part,
- quenching,
- tempering or stress relief,

characterized in that in the selection step, a steel having the composition described in any of claims 1 to 4 is chosen.

Patentansprüche

1. Einsatzgehärteter oder karbonitrierter Stahl, der in Gew.-% besteht aus:

0,03 % ≤ V ≤ 0,50 %,
0,15% ≤ C ≤ 0,27%,
0,50 % ≤ Mn ≤ 1,00 %,
1,10 % ≤ Cr ≤ 2,00 %,
0,00% ≤ Mo ≤ 0,08 %,
0,05 % ≤ Si ≤ 0,50 %,
0,10 % ≤ Ni ≤ 0,50 %,
0,00 % ≤ Cu ≤ 0,35 %,
0,005 % ≤ Al ≤ 0,050 %,
P ≤ 0,030 %,
S ≤ 1,000 %,

und wahlweise aus wenigstens einem der folgenden Bestandteile:

bis zu 0,0050 % Ca,
bis zu 0,15 % Bi,
bis zu 0,20 % Pb
bis zu 0,02 % Te
bis zu 0,04 % Se;

und des Weiteren wahlweise aus wenigstens einem der folgenden Elemente oder einer Kombination derselben:
0,005 % ≤ Ti ≤ 0,050 %,
0,0040 % ≤ N ≤ 0,0200 %;

wobei der Rest Fe und zufällige Verunreinigungen sind.

2. Einsatzgehärteter oder karbonitrierter Stahl nach Anspruch 1, der in Gew.-% besteht aus:

0,03 % ≤ V ≤ 0,50 %,
0,15% ≤ C ≤ 0,27%,
0,50 % ≤ Mn ≤ 1,00 %,
1,10 % ≤ Cr ≤ 2,00 %,
0,00 % ≤ Mo ≤ 0,08 %,
0,05 % ≤ Si ≤ 0,50 %,
0,10 % ≤ Ni ≤ 0,50 %,
0,00 % ≤ Cu ≤ 0,35 %,
0,005 % ≤ Al ≤ 0,050 %,
0,005 % ≤ Ti ≤ 0,050 %,
0,0040 % ≤ N ≤ 0,0200 %;
P ≤ 0,030 %,
S ≤ 1,000%,

und wahlweise einen der folgenden Bestandteile aufweist:

bis zu 0,0050 % Ca,
bis zu 0,15% Bi,
bis zu 0,20 % Pb
bis zu 0,02 % Te
bis zu 0,04 % Se,

wobei der Rest Fe und zufällige Verunreinigungen sind.

3. Einsatzgehärteter oder karbonitrierter Stahl nach Anspruch 1, der in Gew.-% besteht aus:

0,03% ≤ V ≤ 0,15%,
0,18% ≤ C ≤ 0,26%,
0,80% ≤ Mn < 1,00 %,
1,30% ≤ Cr ≤ 1,70%,
0,00 % ≤ Mo ≤ 0,08 %,
0,05 % ≤ Si ≤ 0,50 %,
0,10 % ≤ Ni ≤ 0,50 %,
0,00 % ≤ Cu ≤ 0,35 %,
0,005 % ≤ Al ≤ 0,050 %,

und wahlweise aus wenigstens einem der folgenden Bestandteile:

P ≤ 0,03 %,
0,020% ≤ S ≤ 0,090%,
0,005% ≤ Ti ≤ 0,050 %,
0,0040 % ≤ N ≤ 0,0200 %;

wobei der Rest Fe und zufällige Verunreinigungen sind.

4. Einsatzgehärteter oder karbonitrierter Stahl nach Anspruch 3, der in Gew.-% besteht aus:

0,03% ≤ V ≤ 0,15%,
0,18% ≤ C ≤ 0,26%,
0,80 % ≤ Mn < 1,00 %,

1,30 % ≤ Cr ≤ 1,70 %,
0,00 % ≤ Mo ≤ 0,08 %,
0,05 % ≤ Si ≤ 0,50 %,
P ≤ 0,030 %,
0,020 % ≤ S ≤ 0,090 %,
0,10 % ≤ Ni ≤ 0,50 %,
0,00 % ≤ Cu ≤ 0,35 %,
0,005 % ≤ Al ≤ 0,050 %,
0,005 % ≤ Ti ≤ 0,050 %,
0,0040 % ≤ N ≤ 0,0200 %;

wobei der Rest Fe und zufällige Verunreinigungen sind.

5. Verfahren zum Herstellen eines Stahlteils, das gemäß den folgenden Schritten abläuft:

- Auswählen eines Stahlmaterials,
- Herstellen eines Teils mit dem Stahlmaterial mittels Schmieden oder spanender Bearbeitung,
- Einsatzhart- oder Karbonitrier-Behandlung wenigstens eines Teils der Oberfläche des Teils,
- Abschrecken,
- Tempern oder Spannungsfreimachen,

dadurch gekennzeichnet, dass beim Schritt des Auswählens ein Stahl mit der in einem der Ansprüche 1 bis 4 beschriebenen Zusammensetzung gewählt wird.

Revendications

1. Acier cémenté ou carbonitruré composé en pourcentage pondéral de :

0.03 % ≤ V ≤ 0.50%
0.15% ≤ C ≤ 0.27%
0.50%≤ Mn ≤ 1.00%
1.10% ≤ Cr ≤ 2.00%
0.00% ≤ Mo < 0.08%
0.05 % ≤ Si ≤ 0.50%
0.10% ≤ Ni ≤ 0.50%
0.00 % ≤ Cu ≤ 0.35%
0.005 % ≤ Al ≤ 0.050 %
P ≤ 0.030 %
S ≤ 1.000 %

et le cas échéant d'au moins l'un des composés suivants :

jusqu'à 0.0050 % Ca,
jusqu'à 0.15 % Bi,
jusqu'à 0.20 % Pb,
jusqu'à 0.02 % Te,
jusqu'à 0.04 % Se ;

et en outre et le cas échéant de l'un des éléments suivants ou d'une combinaison de ces éléments :

0.005 % ≤ Tl ≤ 0.050 %
0.0040 % ≤ N ≤ 0.0200 %

le reliquat étant du fer et des impuretés secondaires.

2. Acier cémenté ou carbonitruré conforme à la revendication 1, composé en pourcentage pondéral de :

0.03 % ≤ V ≤ 0.50%
0.15% ≤ C ≤ 0.27%
0.50% ≤ Mn ≤ 1.00%
1.10% ≤ Cr ≤ 2.00%
0.00% ≤ Mo ≤ 0.08%
0.05% ≤ Si ≤ 0.50%
0.10% ≤ Ni ≤ 0.50%
0.00 % ≤ Cu ≤ 0.35%
0.005 % ≤ Al ≤ 0.050 %
0.005 % ≤ Ti ≤ 0.050 %
0.0040 % ≤ N ≤ 0.0200 %
P ≤ 0.030 %
S ≤ 1.000 %

et le cas échéant d'au moins l'un des composés suivants :

jusqu'à 0.0050 % Ca,
jusqu'à 0.15 % Bi,
jusqu'à 0.20 % Pb,
jusqu'à 0.02 % Te,
jusqu'à 0.04 % Se ;
le reliquat étant du fer et des impuretés secondaires.

3. Acier cémenté ou carbonitruré conforme à la revendication 1, composé en pourcentage pondéral de :

0.03 % ≤ V ≤ 0.15%
0.18% ≤ C ≤ 0.26%
0.80% ≤ Mn ≤ 1.00%
1.30% ≤ Cr ≤ 1.70%
0.00 % ≤ Mo < 0.08 %
0.05% ≤ Si ≤ 0.50%
0.10% ≤ Ni ≤ 0.50%
0.00% ≤ Cu ≤ 0.35%
0.005 % ≤ Al ≤ 0.050 %

et le cas échéant d'au moins l'un des composés suivants :

P ≤ 0.030 %
0.020 % ≤ S ≤ 0.090%
0.005 % ≤ Ti ≤ 0.050 %
0.0040 % ≤ N ≤ 0.0200 %

le reliquat étant du fer et des impuretés secondaires.

4. Acier cémenté ou carbonitruré conforme à la revendication 3, composé en pourcentage pondéral de :

0.03 % ≤ V ≤ 0.15%
0.18% ≤ C ≤ 0.26%
0.80% ≤ Mn < 1.00%
1.30% ≤ Cr ≤ 1.70%
0.00% ≤ Mo < 0.08%
0.05% ≤ Si ≤ 0.50%
P ≤ 0.030 %
0.020 % ≤ S ≤ 0.090%
0.10% ≤ Ni ≤ 0.50%
0.00% ≤ Cu ≤ 0.35%
0.005 % ≤ Al ≤ 0.050 %
0.005 % ≤ Ti ≤ 0.050 %

$0.0040\ \% \leq N \leq 0.0200\ \%$

le reliquat étant du fer et des impuretés secondaires.

5. Procédé d'obtention d'une pièce en acier comprenant les étapes consistant à :

- sélectionner un matériau d'acier,
- fabriquer une pièce avec ce matériau d'acier par matriçage ou usinage,
- traiter par cémentation ou carbonitruration au moins une partie de la surface de la pièce,
- effectuer un trempage,
- effectuer une relaxation des contraintes,

caractérisé en ce que
lors de l'étape de sélection on choisit un acier ayant la composition décrite dans l'une quelconque des revendications 1 à 4.

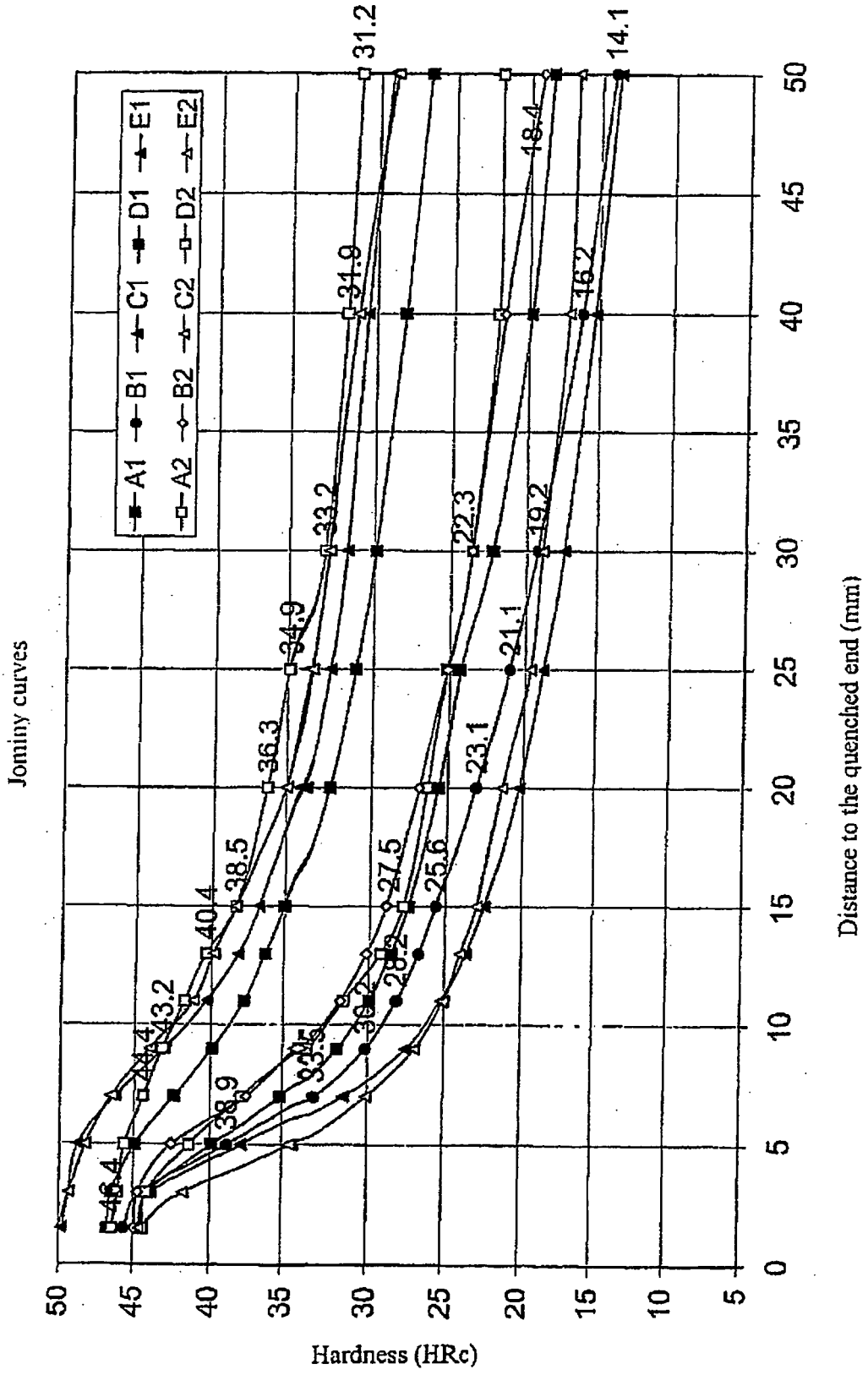
Jominy curves
A1
B1
C1
D1
E1
A2
B2
C2
D2
E2
Hardness (HRc)
Distance to the quenched end (mm)
50
45
40
35
30
25
20
15
10
5
0
31.2
14.1
34.9
18.4
33.2
16.2
34.9
22.3
36.3
19.2
38.5
21.1
40.4
23.1
43.2
27.5
25.6
28.2
30.2
33.5
38.9
46.4

FIG.1

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- EP 0890653 A **[0011]**
- EP 0725156 A **[0012]**
- ES 2013007 A **[0012]**