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(54) **NITROGEN ALLOYED STEEL, SPRAY COMPACTED STEELS, METHOD FOR THE PRODUCTION THEREOF AND COMPOSITE MATERIAL PRODUCED FROM SAID STEEL**

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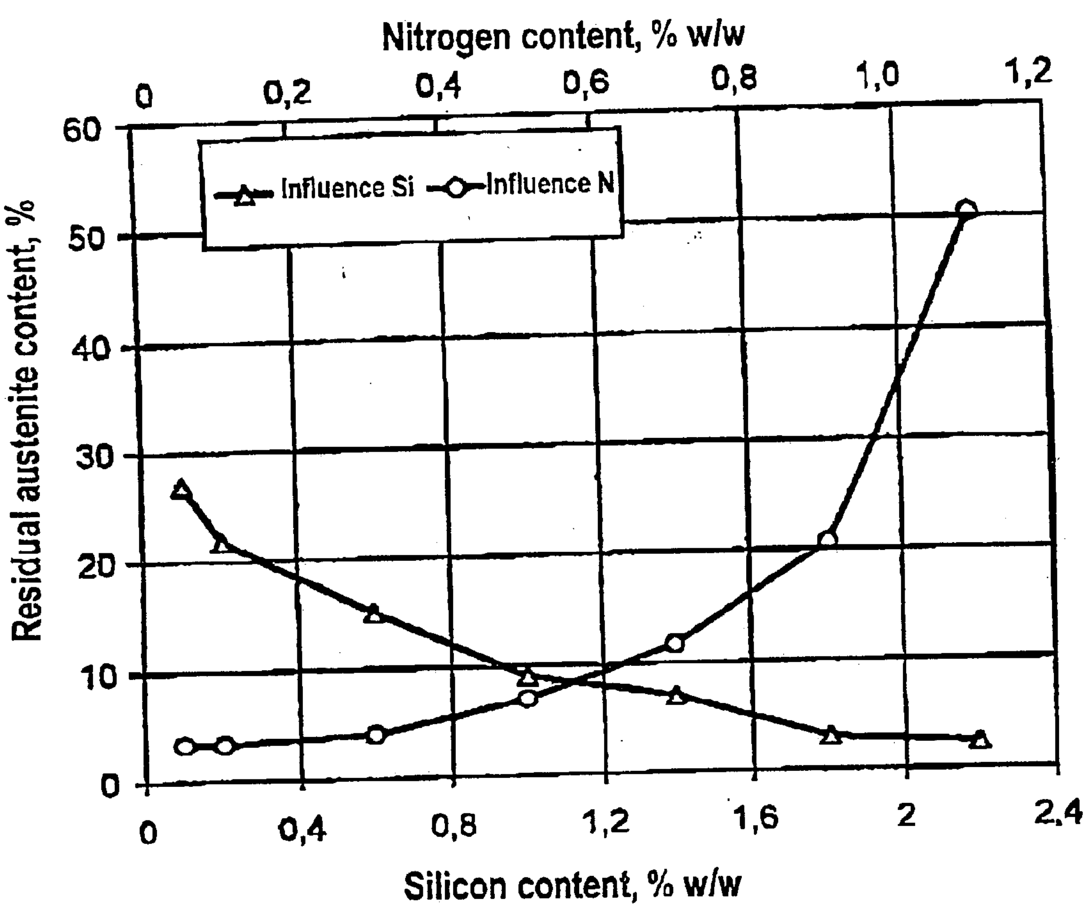
(57) **ABSTRACT**

This invention relates to a nitrogen-alloyed steel with a high wear resistance, which is manufactured via spray compacting and has the following composition (in mass-%): C: 0.8-2.5%, N: 0.03-0.75%, Si: 0.15-1.8%, Mn: ≦1.0%, P: ≦0.03%, S: ≦0.05%, Cr: 4.0-11.5%, Mo: 0.5-6.0%, V: ≦4.0%, Nb: ≦4.0%, W: ≦3.5%, O_2: ≦0.005%, other ally constituents as needed, residual iron and usual contaminants as the residue. The chemical composition has been optimized to have the carbide-carbonitride-forming elements satisfy a wear factor S_v, and to maintain the silicon-nitrogen ratio V_{SiN} in order to minimize the residual austenite contents. In addition, the invention relates to a procedure for manufacturing this type of steel and a composite manufactured using steel according to the invention. The steel material according to the invention has an improved wear resistance and dimensional stability.



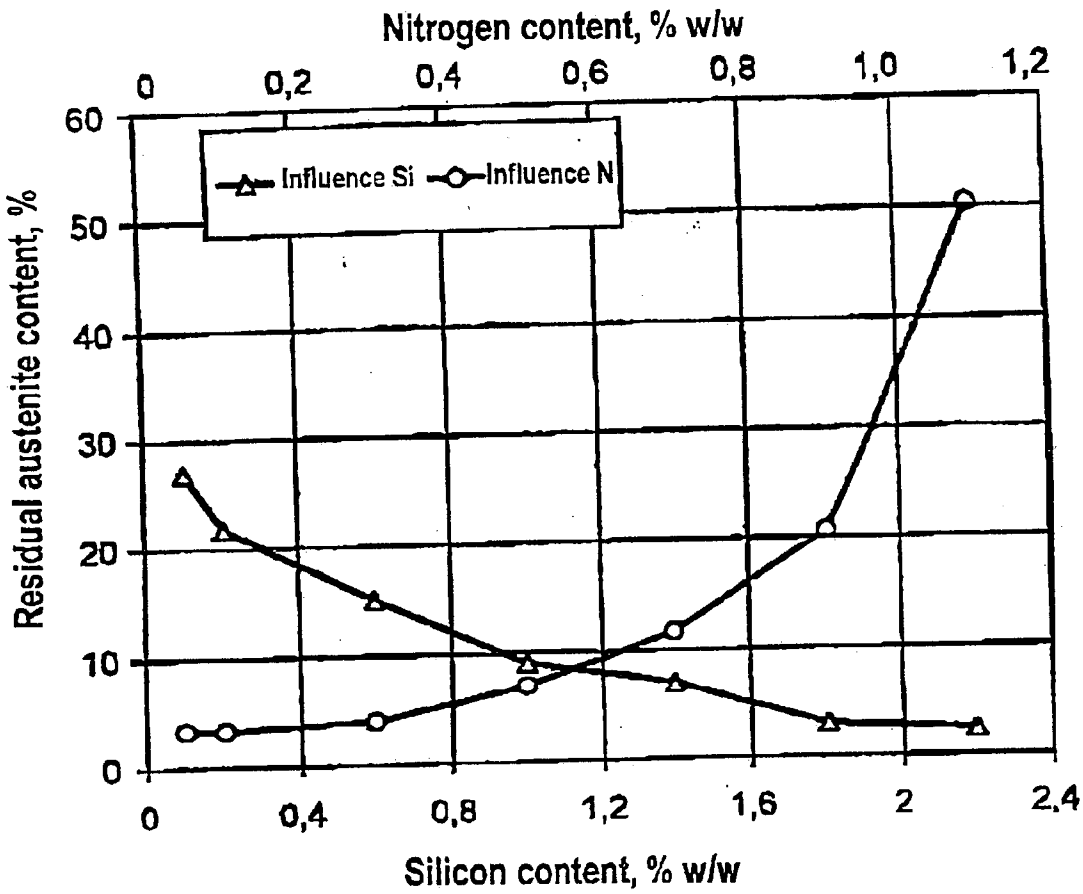

Nitrogen content, % w/w
0
0,2
0,4
0,6
0,8
1,0
1,2
60
50
40
30
20
10
0
Influence Si
Influence N
Residual austenite content, %
0
0,4
0,8
1,2
1,6
2
2,4
Silicon content, % w/w

Fig. 1

100:1

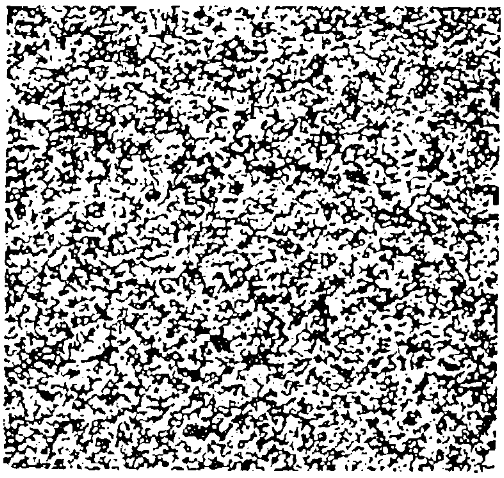


Fig. 2

500:1

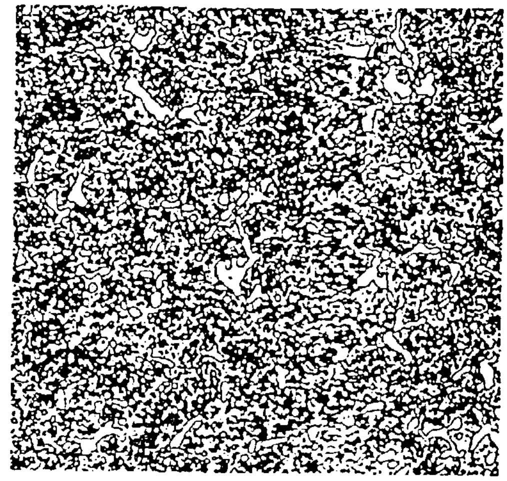


Fig. 3

100:1

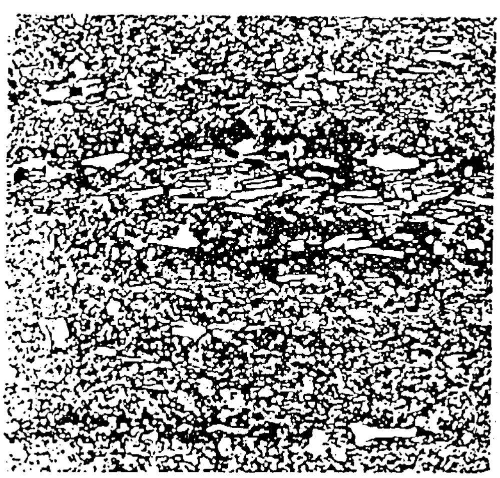


Fig. 4

500:1

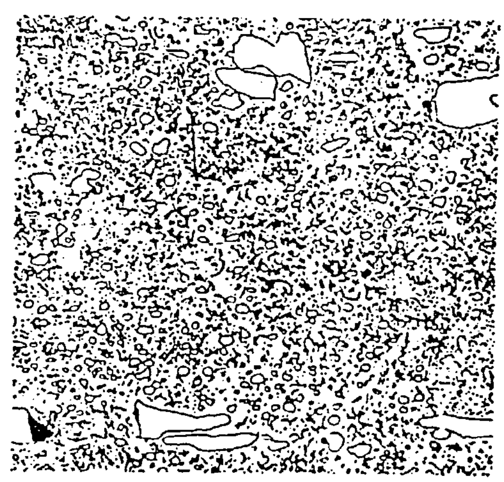


Fig. 5

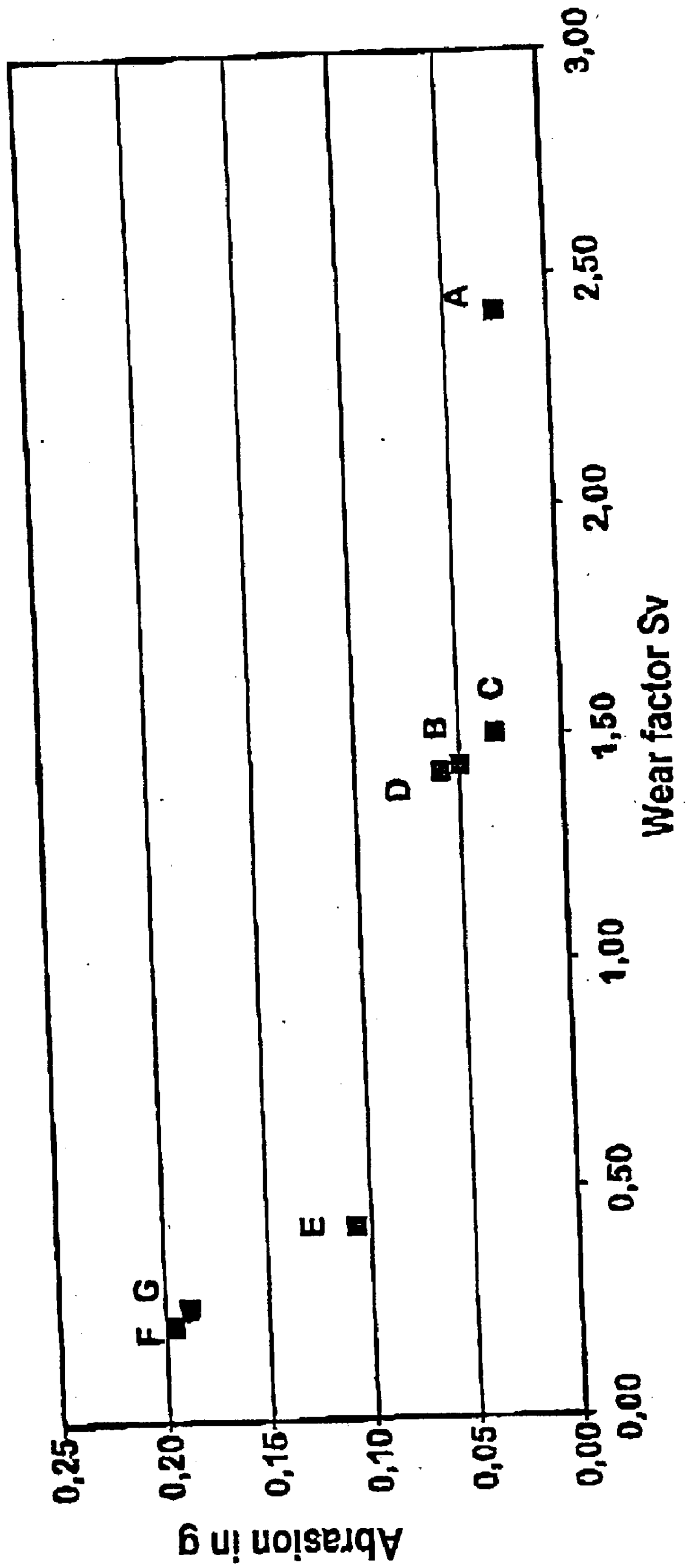

Abrasion in g
0,25
0,20
0,15
0,10
0,05
0,00
0,00
0,50
1,00
1,50
2,00
2,50
3,00
Wear factor Sv
A
B
C
D
E
F
G

Fig. 6

NITROGEN ALLOYED STEEL, SPRAY COMPACTED STEELS, METHOD FOR THE PRODUCTION THEREOF AND COMPOSITE MATERIAL PRODUCED FROM SAID STEEL

[0001] The invention relates to a nitrogen-alloyed, ledeburitic steel with a high wear resistance. In addition, the invention relates to the manufacture of this type of steel and a composite, which is manufactured using steel according to the invention.

[0002] Ledeburitic chromium steels are often used for tools and components requiring a high wear resistance. Such steels are indicated, for example, in the steel iron list under material numbers 1.2080 (X210Cr12), 1.2201 (X165CrV12), 1.2376 (X96CrMoV12), 1.2378 (X220CrVMo12-2), 1.2379 (X155CrVMo12-1), 1.2380 (X220CrVMo13-4), 1.2436 (X210CrW12), 1.2601 (X165CrMoV12), 1.2880 (X165CrCoMo12) and 1.2884 (X210CrCoW12). The respective steels each have carbon contents exceeding 0.9 mass-%, chromium contents exceeding 10 mass-% and various additives of the elements molybdenum, vanadium and tungsten. They are primarily used for manufacturing tools and components employed for separating or cold-forming metals or processing plastics.

[0003] The known steels of the aforementioned kind are melted in an electric arc furnace under an ambient pressure. After the melt has been tapped, it is treated further with pan-metallurgical procedures, e.g., with a pan furnace or a degassing system, to reduce gases dissolved in the steel, e.g., the hydrogen, oxygen and nitrogen shares contained in the respective steel. In particular 0.1 to 0.4 mass-% of the element silicon is used for deoxidation to bind the oxygen dissolved in the liquid melt to oxides. These are then separated out with the refining slag.

[0004] Nitrogen solubility during manufacture in electric slag furnaces under an ambient pressure is by nature very low. For example, H. Berns and J. Lueg in "Nitrogen-Alloyed Tool Steels", Neue Hütte 36 (1991) 1, pp. 13-18 explained that only 0.04% nitrogen dissolves in pure iron smelts at a temperature of 1600° C. Since these contents are further reduced during the mentioned pan-metallurgical treatments, steels manufactured in this way contain only nitrogen contents of between 0.005 and 0.025 mass-%, according to experience.

[0005] If special requirements are placed on their level of purity and segregation, the steels in question are additionally refined in an electric slag or arc-vacuum melting procedure. Once the melt has been cast into ingots or as a billet, or after the additional refining, the ingots or continuously cast bars are varyingly sized for delivery in a thermoforming process, e.g., via forging or rolling.

[0006] Due to their different carbon or carbide contents, the known ledeburitic chromium steels have varying levels of wear resistance in the hardened and tempered state. In this case, the carbides are linearly and irregularly distributed in the material structure due to the inevitable segregations that occur during ingot or continuous casting. This holds true even if the steels were refined after ingot or continuous casting.

[0007] The carbide distribution always leads to problems if the objective is to fabricate a component, e.g., a tool, having good cutting edge stability out of one of the known chromium steels. Problems have also been discovered in practice during the generation of finely contoured tool areas, e.g., threads in thread rolling dies. In these applications, the respectively present structure of the carbides brings with it the danger of cracking and chipping, which as a result significantly reduce the service life of the respective tools.

[0008] The object of the invention is to provide a steel material having a further improved wear resistance and dimensional stability. Also to be indicated are a procedure for manufacturing this kind of steel, and a composite generated with the use of this steel.

[0009] This object is achieved relative to the material by steel manufactured via spray compacting and having the following composition,(in mass-%):

[0010] C: 0.8-2.5%

[0011] N: 0.03-0.75

[0012] Si: 0.15-1.8%

[0013] Mn: $\leqq$1.0%

[0014] P: $\leqq$0.03%

[0015] S: $\leqq$0.05%

[0016] Cr: 5.0-11.5%

[0017] Mo: 0.5-6.0%

[0018] V: $\leqq$4.0%

[0019] Nb: $\leqq$4.0%

[0020] W: $\leqq$3.5%

[0021] O_2: $\leqq$0.005%

[0022] additional alloy constituents as needed, with iron and usual contaminants as the residue,

[0023] wherein a wear factor S_v corresponding to the sum of its weighted contents of Cr, Mo, V, Nb and W satisfies the following condition:

[0024] $0.55<S_v<3.42$

[0025] where: $S_v=(A_{Cr}/9.33)+(A_{Mo}/17.22)+(A_V/3.92)+(A_{Nb}/7.15)+(A_W/14.14)$,

[0026] A_{Cr}: Cr content in mass-%,

[0027] A_{Mo}: Mo content in mass-%,

[0028] A_V: V content in mass-%,

[0029] A_{Nb}: Nb content in mass-%,

[0030] A_W: W content in mass-%,

[0031] and wherein the silicon-nitrogen ratio V_{SiN} satisfies the following condition:

$$0.21\leqq V_{SiN}\leqq 3.31$$

[0032] where:

[0033] $V_{SiN}=A_{Si}+2A_N$,

[0034] A_{Si}: Si content in mass-%,

[0035] A_N: N content in mass-%.

[0036] As opposed to steels made via smelt metallurgy, an alloyed steel according to the invention fabricated via spray compacting is characterized by a high carbon and elevated nitrogen content given a simultaneously high content of special carbide-forming and nitride-forming elements, which results in a high wear resistance. In this case, the incorporated hard phases, which are present in the form of predominantly type MC (with M=V, Nb, W) and M_7C_3 (with M=Cr, Mo) carbide deposits, and in the form of carbonitride deposits in the form of phases M (C, N) (with M=V, Nb, W) and $M_7(C, N)_3$ (with M=Cr, Mo), are optimized in terms of their size and homogeneously distributed in the microstructure due to the nitrogen additive and employed manufacturing procedure. On the one hand, the work pieces manufactured out of the steel according to the invention have a higher service life even under an abrasive load. On the other hand, the steel according to the invention is readily thermoformable despite the high alloy and hard phase contents due to the homogeneity of its structure. These properties make the steel according to the invention particularly suitable for manufacturing tools or components subjected to high levels of wear, e.g., those generally encountered during materials separation or in the plastics-processing industry owing to the filler content of modern plastics.

[0037] It has been found that in comparison with ledeburitic steels of the kind described at the outset, the spray-compacted, nitrogen-alloyed steels according to the invention have an elevated wear resistance and/or improved tenacity relative to the respective application. As a result, the improved properties of steels according to the invention increase the service life of tools or components made out of these steels. Cutting tools made out of steel according to the invention have an improved edge-holding property and improved cutting edge stability. In addition, components made out of steels according to the invention have an improved resistance to cracking. Steel according to the invention can further be hardened to a hardness of up to 68 HRC with the use of a suitable heat treatment procedure.

[0038] As mentioned, the advantages of steel according to the invention are achieved by combining its alloy constituents with a special manufacturing process, the known spray-compacting method. Spherical drops of a steel melt are atomized in a protective gas stream using a gas atomizer during the spray compacting of steel. The gas quickly cools the metal drops to a temperature lying between the liquidus and solidus, often even under the solidus. The fast-moving drops with a solid or pasty consistency cooled in this way become compacted on a substrate into a dense material composite as a result of their intrinsic kinetic energy. The rapid solidification from the liquid phase here makes it possible to directly influence how the structure of the sprayed ingot is formed. The articles "Near net-shape casting through metal spray deposition—The Osprey process", Otto H. Metelmann et al., Iron and Steel Engineer, November 1988, pp. 25-29 or "The Osprey Process: Principles and Applications", A. G. Leatham et al., The International Journal of Powder Metallurgy, Vol. 29, No. 4, pp. 321-329 describe spray compacting in detail.

[0039] Spray compacting has proven to be an effective process in particular to incorporate the desired nitrogen content into the mentioned ledeburitic steels. As opposed to the cost-intensive procedures normally used to increase the nitrogen content in steels, e.g., pressure electric slag refining process, under partial nitrogen pressures of up to 42 bars, or the powder metallurgical nitrogenization of metal powder with ammonia, spray compacting is characterized both by its effectiveness and economic efficiency. While testing the procedure according to the invention, contents of up to 0.85 mass-% nitrogen could be established in the solidified ingot by spraying with a nitrogen gas. In addition, this procedure makes it possible to preliminarily alloy the melt with a basic quantity of dissolved nitrogen and further nitrogenize the metal drops in the gas stream prior to spraying with charges like chromium nitrogen or nitrated ferrochromium.

[0040] As opposed to casting, spray compacting enables the manufacture of segregation and pore-free products having a homogeneous structure and high density. In this case, product properties similar to those during the powder metallurgical manufacture of such products can be achieved at a higher dimensional flexibility and given fewer procedural steps.

[0041] In addition to the other alloy constituents, steels according to the invention with particularly outstanding properties have a C content of 1.0-1.9 mass-%, an N content of 0.05-0.5 mass-%, an Si content of 0.15-1.5 mass-%, a Cr content of 5.0-10.0 mass-%, an Mo content of 0.5-5.5 mass-%, a V content $\leqq$3.5 mass-%, an Nb content $\leqq$3.5 mass-% and a W content $\leqq$3.0%. Steels of this composition have an especially high wear resistance.

[0042] A carbon share exceeding 1 mass-% and nitrogen content exceeding 0.05 mass-% is advantageous to achieve a hardness exceeding 60 HRC. At the same time, the presence of the carbon and nitrogen also has a favorable influence on the quantity of included hard phases, and hence the wear behavior.

[0043] In particular alloying with nitrogen has a homogenizing effect on the microstructure and limits the hard phase size during spray compacting. This has positive effects on the tenacity properties of steels according to the invention. By contrast, contents of the element nitrogen that exceed the value of 0.75 mass-% lead to a deterioration in the wear behavior due to higher residual austenite contents and greatly diminished hard phase sizes.

[0044] The silicon usually contained in steels in small quantities for reasons of deoxidation is provided with a content by weight of 0.1 to preferably 1.5 mass-% in steel according to the invention, since it remains dissolved in the basic matrix and increases secondary hardness. It was also found that increasing silicon content yields a reduction in the residual austenite content caused by increasing nitrogen contents. The residual austenite content reduces wear resistance as a "soft" structural component. In this way, the nitrogen and silicon contained in the steel according to the invention in the specified limits optimally enhance and influence each other in their effect on hardness and wear resistance. The joint effect of the nitrogen and silicon contents on the residual austenite content is shown on **FIG. 1**, which shows the radioscopically measured residual austenite contents in ledeburitic chromium steels according to the invention as a function of silicon and nitrogen content (heat treatment: 1075° C./15 min in a warm bath and 560° C./1 h in air).

[0045] It has been found that the presence of tungsten is not absolutely required to achieve a hardness in steel generated according to the invention, since the minimum of special carbide formers contained therein is sufficient to form the required hard phases. Therefore, elevated manufacturing costs can be avoided by not adding tungsten to the steel used according to the invention.

[0046] Cobalt is not contained in steel with a composition according to the invention, since this element can have negative effects on the tenacity, and would help drive up material costs.

[0047] The chromium content is limited to values ≦11.5 mass-%, and preferably lies in the specified, lower content range, so as to also positively influence the tenacity of the steel generated according to the invention.

[0048] Depending on the application, it may also be beneficial for steel according to the invention to have additional precipitation-hardening elements, such as up to 0.75 mass-% nitrogen, up to 0.05 mass-% boron, up to 0.5 mass-% titanium, up to 0.5 mass-% zirconium and/or up to 0.25 mass-% aluminum. These additional alloy constituents make it possible to further increase the hardness, and hence the wear resistance of steel according to the invention.

[0049] It has been found that steel according to the invention has an optimized wear resistance if the wear factor S_v corresponding to the sum of its weighted contents of carbide-forming elements Cr, Mo, V, Nb and W measures between 0.55 and 3.42.

[0050] At the same time, an optimized silicon-nitrogen ratio V_{SiN} is to be set in order to influence the effect of the austenite stabilizing element nitrogen by the ferrite stabilizing effect of the element silicon, and further optimize the wear resistance in steels according to the invention. It has been shown that, when observing the range of 0.21 to 3.31 provided according to the invention for the nitrogen-silicon ratio, the residual austenite constituents harmful to wear resistance can be diminished to values ≦25% already after a single tempering.

[0051] In another advantageous configuration of the invention, nitrogen-alloyed steel according to the invention contains additional hard materials, such as titanium carbide (TiC), silicon carbide (SiC), niobium carbide (NbC), chromium carbide (CrC), titanium nitride (TiN), tungsten carbide (WC), in its matrix, which had been injected as solid particles in the spray jet during spray compacting. This measure further increases wear resistance, wherein the good tenacity properties of the nitrogen-alloyed matrix are retained.

[0052] With respect to the procedure for manufacturing steel according to the invention, the aforementioned object is achieved by spray compacting the steel using nitrogen as the spray gas, thermoforming the steel after spray compacting at initial temperatures of up to 1150° C., cooling the thermoformed steel, reheating the cooled steel to an austenizing temperature of 1075° C. to 1225° C., quenching the reheated steel and tempering the quenched steel at temperatures of 150° C.-625° C. Tempering preferably takes place at temperatures of between 150° C. and 300° C. or between 500° C. and 625° C. As opposed to the pressure-nitrogenized steels, the optimal setting of the silicon-nitrogen ratio eliminates the need for deep-freezing for residual austenite conversion. Observing the procedural parameters according to the invention makes it possible to achieve a hardness of up to 68 HRC, even if supplementary forming steps are required during further processing. Thermoforming can here take place via forging or rolling.

[0053] Finally, steel according to the invention can be used especially well to generate a composite material having at least one first layer produced by a first steel and at least a second layer formed by a spray compacted steel according to the invention, wherein the steel of the first layer has a different composition than the spray-compacted steel. In such a composite material, the varying properties of the individual layers can be optimally combined. For example, the steel according to the invention can form a wear resistant cover layer on a tenacious first layer.

[0054] The invention will be explained in greater detail below based on embodiments.

[0055] Table 1 shows the chemical compositions of seven steels A-G in mass-%. In addition, the wear factor S_v, the silicon-nitrogen ratio V_{SiN} and the abrasion in grams determined in a wear test are recorded for each of the steels.

[0056] Steels A-D are steels according to the invention, while steels E-G are cited for comparison.

[0057] In order to manufacture spray-compacted, nitrogen-alloyed steels, a melt was generated out of scrap and/or pure metals with the addition of the required alloy constituents respectively. The melt was subsequently atomized in spherical drops in a nitrogen-containing protective gas stream.

[0058] During atomization in the nitrogen-containing as stream, a nitrogenization and rapid cooling of the metal drops to a temperature between the liquidus and solidus occurs, so that the drops have a solid to pasty consistency after cooling in the gas stream. The drops generated in this way and moving at a high speed of 40 to 80 m/s were aimed at a base plate, on which the drops compacted into a dense material composite due to their intrinsic high kinetic energy. Due to the rapid solidification of the metal drops from the liquid phase taking place in the gas stream and the incorporated nitrogen content, the ingot generated in this way via spray compacting has a uniform distribution of the hard phases and carbide or carbonitride variables that are clearly diminished in comparison to steels produced via smelt metallurgy.

[0059] **FIGS. 2 and 3** each show the micrograph of nitrogen-alloyed steel manufactured via spray compacting according to the invention in an annealed state, **FIG. 2** showing the respective microstructure at a magnification of 100:1, and **FIG. 3** at a magnification of 500:1.

[0060] By way of comparison, **FIGS. 4 and 5** show a corresponding depiction of the microstructure of the same steel without added nitrogen when the steel is manufactured in a conventional manner via smelt metallurgy.

[0061] The high structural homogeneity readily visible from **FIGS. 2 and 3** enables the problem-free forming of the spray-compacted ingot via forging or rolling. Ingot or diffusion annealing can precede forming.

[0062] The improved formability of steels generated according to the invention makes it possible to execute thermoforming at lower temperatures relative to the conventional procedure. The respectively required hardness of the components or tools made out of the steels according to the invention can be set after shaping by hardening at an austenizing temperature of between 1075° C. and 1225° C.

with subsequent tempering between 150° C. and 625° C., wherein hardnesses of up to 68 HRC can be reached.

[**0063**] Steels according to the invention have a balanced ratio between the carbide or carbonitride-forming elements, which is characterized by a wear factor S_v determined in the manner described above and lying between 0.55 and 3.42. This balanced ratio between the carbide/carbonitride formers results in a superior wear resistance of steels according to the invention, which was corroborated in wear tests (**FIG. 6**).

[**0064**] In these tests, the wear behavior of steels A-G was checked during exposure to rolling friction under a load of 8.0 Nm×10^{-6}, wherein the counter-roller was made out of the rapid machining steel with material number 1.3207 according to the steel-iron list, and had a hardness of 67 HRC.

[**0065**] In order to check the wear and dimensional stability of steel according to the invention in practice, a raw ingot having a diameter of 400 mm was fabricated out of the nitrogen-alloyed steel C, whose composition is shown on Table 1, in a first examination via spray compacting. A with-the-grain forging machine was used to deform this ingot to a diameter of 115 mm in a dual heating forging process, wherein the initial forging temperature lay at 980° C., and the final forging temperature at 969° C.

[**0066**] The forged ingot was then soft annealed. Thread rolling dies with dimensions of 85 mm×50 mm×24 mm and 95 mm×50 mm×24 mm were then manufactured out of the soft annealed material. These tools were subsequently brought to a hardness of 62 HRC via heat treatment.

[**0067**] The thread rolling dies were used to manufacture screws out of a stainless steel with material number 1.4401 according to the steel-iron list. The work results and wear condition of the tools manufactured out of the steel according to the invention were compared with the work results and wear condition of thread rolling dies manufactured out of a steel made via smelt metallurgy having an identical chemical composition, but no added nitrogen. It was shown that thread rolling dies manufactured out of the steel according to the invention had twice the service life as the thread rolling dies made out of conventional steel of identical composition. The tools fabricated out of the steel according to the invention could be used to make 140,000 screws, while the tools manufactured out of the conventionally produced steel were worn after making 70,000 screws. Special emphasis in this regard must be placed on the excellent dimensional stability of the tools made out of the steel according to the invention at the thread crests.

[**0068**] In a second inspection, the nitrogen-alloyed steel C on Table 1 manufactured via spray compacting was drawn out to dimensions of 160 mm×160 mm and soft annealed. The forged steel was used to make blanking dies for chain links comprised of a micro-alloyed steel, which were punched out of 4 mm thick sheets.

[**0069**] The work results and wear behavior of the blanking dies made out of the steel according to the invention were again compared with a blanking die fabricated out of a steel manufactured via smelt metallurgy having the same composition, but without nitrogen. It was also shown in this case that the tool made out of the steel according to the invention had a clearly improved service life relative to the comparison tool. The blanking die made out of the steel according to the invention was still operational after the fabrication of 290,000 chain links, while the comparison tool was already worn after stamping 200,000 chain links. In this conjunction, it must be emphasized that the punching die made out of the steel according to the invention still had very good cutting edge stability even after the fabrication of the 290,000 chain links.

TABLE 1

Steel	C	Si	Mn	P	S	Cr	Mo	V	Nb	W	N	S_V	V_{SiN}	Abrasion
A	2.11	0.79	0.56	0.012	0.028	9.87	2.69	3.15	2.674	0.42	0.485	2.42	1.76	0.025
B	1.62	0.61	0.32	0.025	0.003	10.80	0.78	0.89	0.007	0.01	0.101	1.43	0.81	0.049
C	1.52	0.54	0.29	0.015	0.012	11.32	0.78	0.95	0.003	0.01	0.077	1.50	0.69	0.031
D	1.12	1.46	0.88	0.018	0.023	5.11	1.51	3.05	0.013	0.02	0.166	1.42	1.79	0.058
E	1.13	0.25	0.31	0.018	0.005	3.26	0.54	0.09	0.101	0.01	0.007	0.42	0.26	0.106
F	0.79	0.41	0.32	0.021	0.003	1.77	0.24	0.01	0.001	0.01	0.007	0.21	0.42	0.196
G	0.82	0.11	0.22	0.034	0.018	2.11	0.24	0.01	0.001	0.02	0.009	0.24	0.13	0.188

1. A nitrogen-alloyed steel with a high wear resistance fabricated via spray compacting and having the following composition (in mass-%):

C: 0.8-2.5%

N: 0.03-0.75%

Si: 0.15-1.8%

Mn: ≦1.0%

P: ≦0.03%

S: ≦0.05%

Cr: 5.0-11.5%

Mo: 0.5-6.0%

V: ≦4.0%

Nb: ≦4.0%

W: ≦3.5%

O_2: ≦0.005%

additional alloy constituents as needed, with iron and usual contaminants as the residue,

wherein a wear factor S_v corresponding to the sum of its weighted contents of Cr, Mo, V, Nb and W satisfies the following condition:

$0.55 < S_v < 3.42$

where: $S_v=(A_{Cr}/9.33)+(A_{Mo}/17.22)+(A_V/3.92)+(A_{Nb}/7.15)+(A_W/14.14)$,

A_{Cr}: Cr content in mass-%,

A_{Mo}: Mo content in mass-%,

A_V: V content in mass-%,

A_{Nb}: Nb content in mass-%,

A_W: W content in mass-%,

and wherein the silicon-nitrogen ratio V_{SiN} satisfies the following condition:

$0.21 \leqq V_{SiN} \leqq 3.31$

where:

$V_{SiN}=A_{Si}+2\ A_N$,

A_{Si}: Si content in mass-%,

A_N: N content in mass-%.

2. The steel according to claim 1, characterized in that it has a C content of 1.0-1.9 mass-%, an N content of 0.05-0.5 mass-%, an Si content of 0.15—1.5 mass-%, a Cr content of 5.0-10.0 mass-%, an Mo content of 0.5-5.5 mass-%, a V content ≦3.5 mass-%, an Nb content ≦3.5 mass-% and a W content ≦3.0%.

3. The steel according to one of the preceding claims, characterized in that it contains up to 0.05 mass-% boron.

4. The steel according to one of the preceding claims, characterized in that it contains up to 0.5 mass-% titanium.

5. The steel according to one of the preceding claims, characterized in that it contains up to 0.5% zirconium.

6. The steel according to one of the preceding claims, characterized in that it contains up to 0.25 mass-% aluminum.

7. The steel according to one of the preceding claims, characterized in that it contains additional hard materials, such as titanium carbide, silicon carbide, niobium carbide, chromium carbide, titanium nitride, tungsten carbide, in its matrix, which were injected into the spray jet during spray compacting as solid particles.

8. A procedure for manufacturing a steel according to one of the preceding claims, characterized in that

the steel is spray compacted using nitrogen as the spray gas,

the steel is thermoformed after spray compacting at initial temperatures of up to 1150° C.,

the thermoformed steel is cooled,

the cooled steel is reheated to an austenizing temperature of 1075° C. to 1225° C.,

the reheated steel is quenched, and

the quenched steel is tempered at temperatures of 150° C.-625° C.

9. The procedure according to claim 8, characterized in that tempering takes place at temperatures of between 150° C. and 300° C.

10. The procedure according to claim 8, characterized in that tempering takes place at temperatures of between 500° C. and 625° C.

11. A composite material with at least one first layer generated by a first steel and at least a second layer formed by nitrogen-alloyed, spray-compacted steel according to one of claims 1 to 7, wherein the steel in the first layer has a different composition than the spray-compacted steel.

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