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(54) **Vanadium alloyed bearing steel**

(57) An improved vanadium alloyed bearing steel
having the following alloying elements, in weight-%:

C	0.60 - 1.10
Si	0 - 2.10
Mn	0 - 2.00
Ni	0 - 2.00
Cr	0 - 2.00
Mo	0 - 0.75
V	0.25 - 1.00
Fe	incl. possible impurities - ad. 100%.

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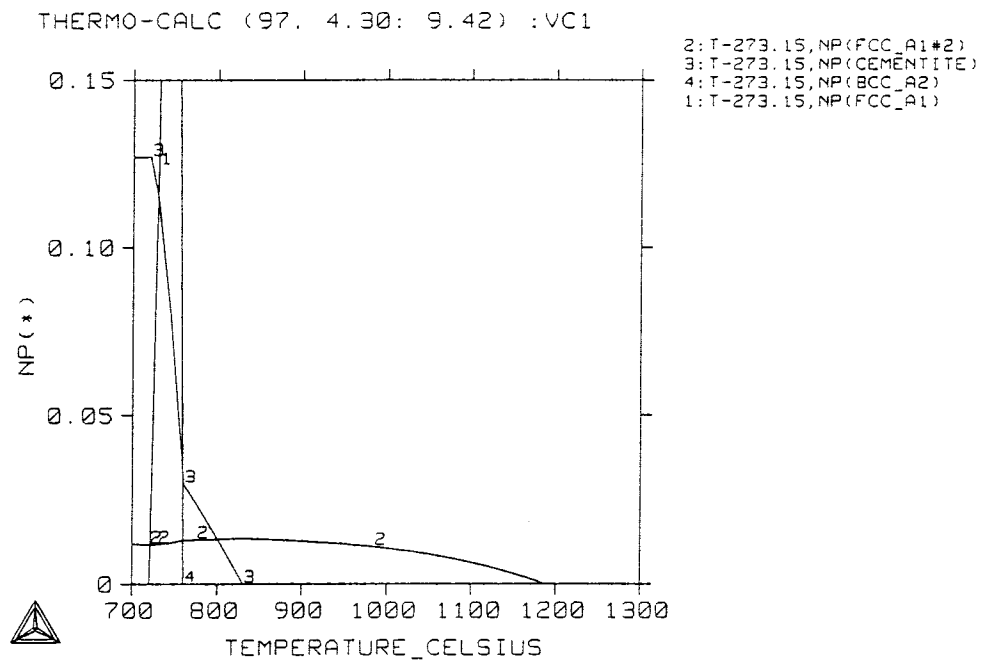


FIGURE 1

DescriptionTechnical field

5 **[0001]** The present invention relates to an improved vanadium alloyed bearing steel.

Background

10 **[0002]** The hardness after martensitic hardening of a soft annealed bearing steel, e.g. AISE 52100 is highly dependent on the carbon content in solid solution and thus the austenitisation conditions for a given quench. A higher austenitisation temperature or longer time leads to more dissolution of carbides. The optimum carbon content in solid solution to give the highest hardness is considered to be somewhere between 0.6 to 0.8 weight% for an oil quenched component. A lower carbon content will give a softer martensite. A higher carbon content will lead to an increased retained austenite content which would decrease the hardness and give a disadvantageous martensite morphology. Furthermore, a too large amount of retained austenite will give poor structural stability.

15 **[0003]** Hardened bearing steels are often subjected to wear. To improve wear properties it is necessary to maximize the hardness. However, this could also be further improved by introducing a fraction of hard carbides such as VC.

20 **[0004]** The toughness of a component made from a bearing steel is relatively low. This could result in catastrophically failure and it would therefore be appreciated to increase the toughness. This could be achieved by alloying with Ni which is an element that improves the toughness.

[0005] Structural stability is important for critical applications and could be improved by Si alloying. Si retards the precipitation of carbide during tempering and thus improves the stability. This could also be beneficial for reducing tempering embrittlement since the precipitation of grain boundary carbides could be reduced.

25 **[0006]** Large components require a high hardenability to enable thorough hardening. The hardenability could be increased with alloying additions.

The Invention

30 **[0007]** The object of the invention is to provide a steel designed to exhibit greater tolerances in austenitising temperature and time to give optimum carbon content.

[0008] This is achieved with the steel according to the present invention, having the following analysis, in weight-%:

C	0.60 - 1.10
Si	0 - 2.10
Mn	0 - 2.00
Ni	0 - 2.00
Cr	0 - 2.00
Mo	0 - 0.75
V	0.25 - 1.00
Fe	incl. possible impurities - ad. 100%.

45 **[0009]** By alloying with carbide formers, preferably V and also Cr, compared to standard bearing steels, an optimal carbon content is obtained. A higher wear resistance is obtained because of the presence hard VC carbides. Improved toughness can be obtained by Ni addition and a high structural stability can be obtained with Si additions. The required hardenability is balanced by adding Cr, Mo and Mn.

[0010] According to one embodiment of the invention the steel has the following analysis, in weight-%:

C	0.60 - 1.00
Si	0.40 - 2.10
Mn	0.10 - 1.00
Ni	0.50 - 2.00
Cr	0 - 2.00
Mo	0 - 0.50
V	0.25 - 1.00
Fe	incl. possible impurities - ad. 100%.

[0011] According to another embodiment of the invention the steel has the following analysis, in weight-%:

C	0.75 - 0.95
Si	0.80 - 1.80
Mn	0.10 - 1.00
Ni	0.50 - 1.50
Cr	0 - 2.00
Mo	0 - 0.50
V	0.40 - 0.80
Fe	incl. possible impurities - ad. 100%.

Brief description of the Drawings

[0012] The invention will be described more in detail below with reference to the accompanying drawings, in which

Fig. 1 shows mole-% of phases in equilibrium versus temperature for steel A,

Fig. 2 shows a graph corresponding to Fig. 1, for a steel B,

Fig. 3 shows the carbon content in the austenite versus temperature for the steel A, and

Fig. 4 shows a graph corresponding to Fig. 3 for the steel B.

Description of preferred embodiments

[0013] The steel should have sufficient vanadium content to form vanadium carbides which stops excessive carbon from going into solid solution at the austenitisation temperature range. The carbon content and vanadium content should be balanced so that the equilibrium carbon content is optimal at the chosen austenitisation temperature. Such a composition is shown in Table 1.

Table 1

Vanadium alloyed bearing steel according to the invention							
	C	Si	Mn	Cr	Ni	Mo	V
min	0.60	0	0	0	0	0	0.25
max	1.10	2.10	2.00	2.00	2.00	0.75	1.00
Example	0.85	1.30	0.30	1.40	1.00	-	0.60

[0014] A theoretical calculation using the thermodynamic simulation program Thermocalc shows the effect of a vanadium addition. The addition will lead to the formation of a carbide that is stable at higher temperatures. Two steels are compared; steel A with a vanadium addition and steel B without vanadium. The compositions are shown in Table 2.

Table 2

Chemical composition in weight-%.							
Steel	C	Si	Mn	Cr	Ni	Mo	V
A	0,85	1,30	0,30	1,40	1,00	-	0,60
B	0,85	1,30	0,30	1,40	1,00	-	-

[0015] In Fig. 1 a graph illustrating the mole percentage of phases in equilibrium versus temperature is shown for a steel according to Table 2. For this vanadium steel a carbide (VC) is stable up to approximately 1200°C. In Fig. 2, the corresponding graph illustrates that steel B does not have this fraction of carbides.

[0016] The fact that vanadium forms carbides which are stable at a higher temperature results in a wider temperature range for dissolving carbides and thus saturating the austenitic matrix with carbon. This is schematically shown in Figs. 3 and 4, wherein the equilibrium carbon content in austenite (the rest of the carbon is bonded in carbides) is plotted versus temperature. For steel A, Fig. 3, the maximum carbon content (equilibrium) in austenite for a austenitisation temperature of 830-900°C is 0.72 to 0.74 weight-%. For steel B, Fig. 4, the same temperature range gives a carbon content of between 0.75 and 0.85 weight-%. This means that for steel B the time at austenitisation temperature is much

more critical for the carbon content obtained. Furthermore, steel B will not have the fraction of hard vanadium carbides which is beneficial for the wear properties.

5 Claims

1. An improved vanadium alloyed bearing steel having the following analysis, in weight-%:

C	0.60 - 1.10
Si	0 - 2.10
Mn	0 - 2.00
Ni	0 - 2.00
Cr	0 - 2.00
Mo	0 - 0.75
V	0.25 - 1.00
Fe	incl. possible impurities - ad. 100%.

2. A steel according to claim 1 having the following analysis, in weight-%:

C	0.60 - 1.00
Si	0.40 - 2.10
Mn	0.10 - 1.00
Ni	0.50 - 2.00
Cr	0 - 2.00
Mo	0 - 0.50
V	0.25 - 1.00
Fe	incl. possible impurities - ad. 100%.

3. A steel according to claim 1 having the following alloying elements, in weight-%:

C	0.75 - 0.95
Si	0.80 - 1.80
Mn	0.10 - 1.00
Ni	0.50 - 1.50
Cr	0 - 2.00
Mo	0 - 0.50
V	0.40 - 0.80
Fe	incl. possible impurities - ad. 100%.

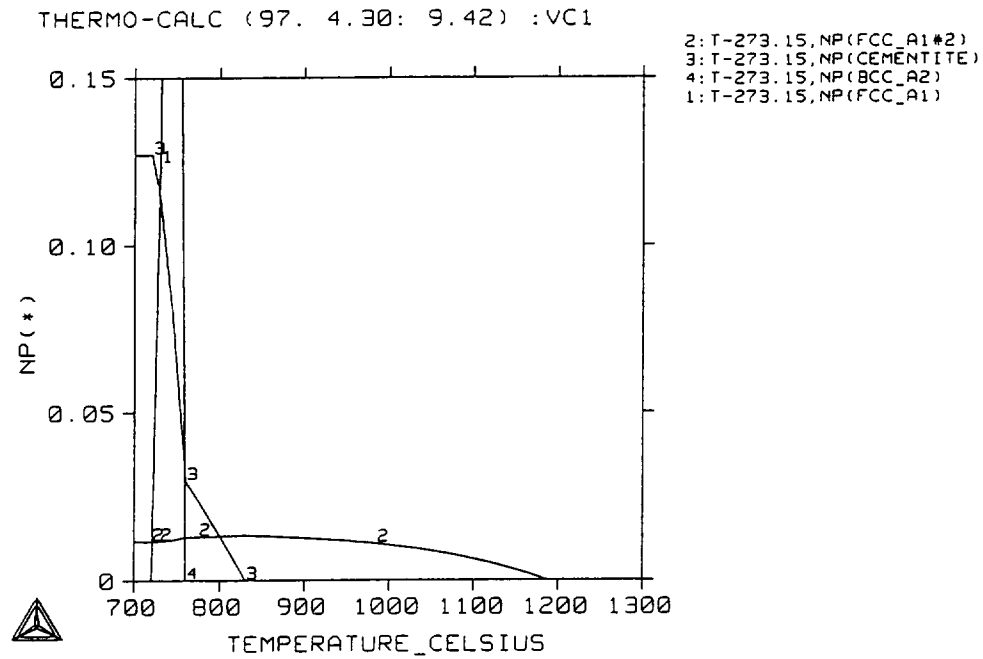


FIGURE 1

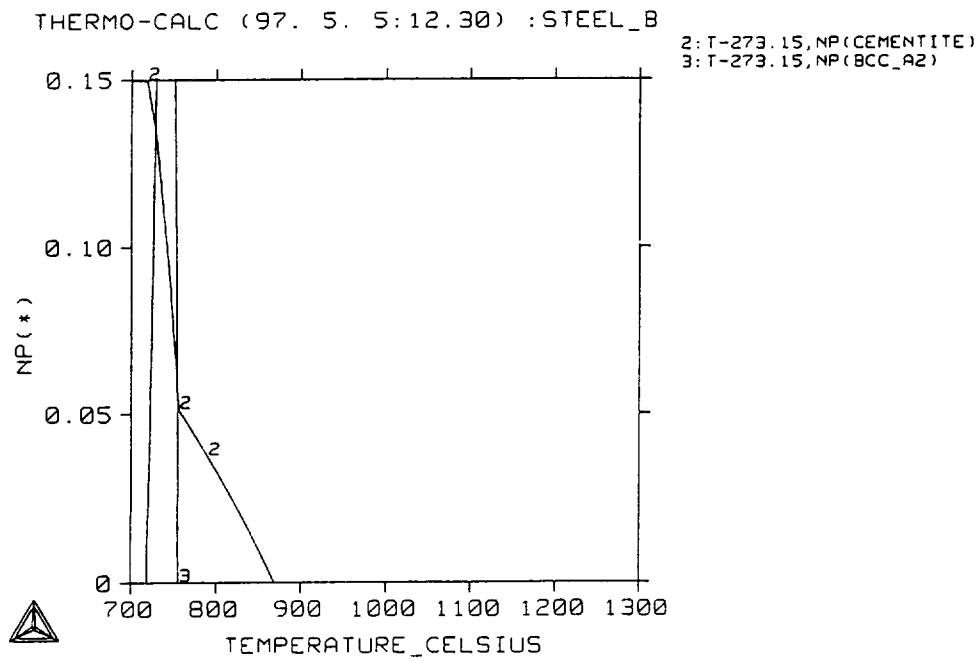


FIGURE 2

THERMO-CALC (97. 4.30: 9.42) :VC1

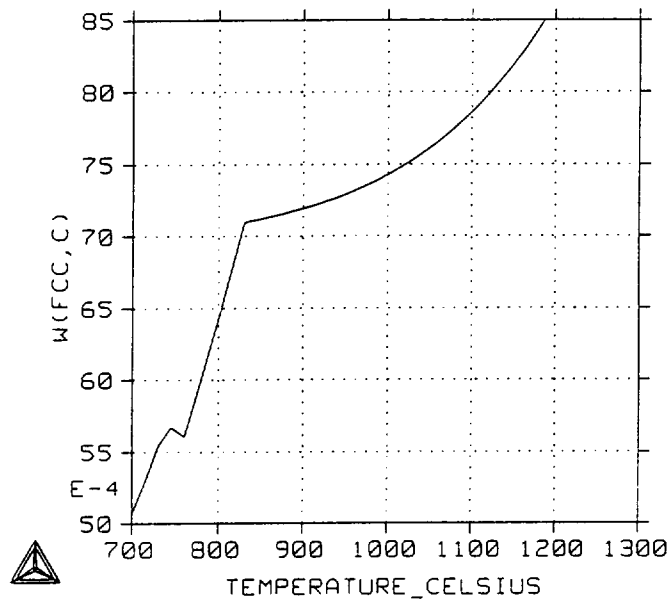


FIGURE 3

THERMO-CALC (97. 5. 5:12.30) :STEEL_8

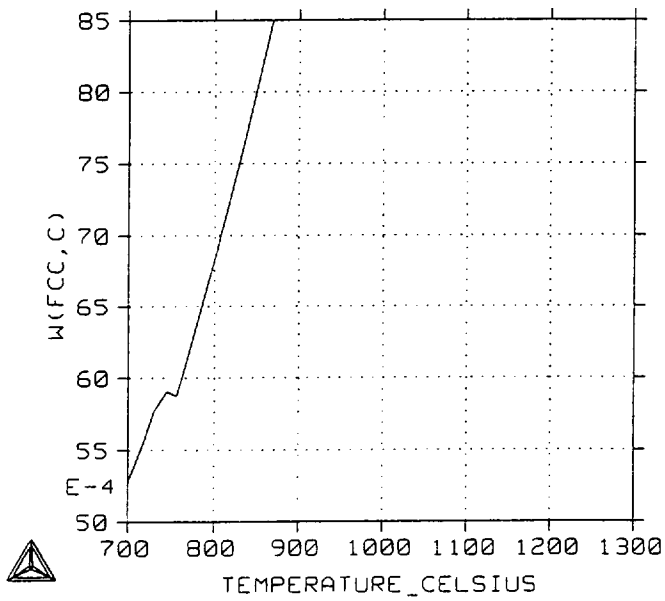


FIGURE 4



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EUROPEAN SEARCH REPORT

Application Number
EP 98 85 0125

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X	PATENT ABSTRACTS OF JAPAN vol. 095, no. 011, 26 December 1995 & JP 07 216508 A (DAIDO STEEL CO LTD), 15 August 1995 * table 1, example 2 * * abstract *	1-3	
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The present search report has been drawn up for all claims			
Place of search MUNICH		Date of completion of the search 6 November 1998	Examiner Bjoerk, P
CATEGORY OF CITED DOCUMENTS X: particularly relevant if taken alone Y: particularly relevant if combined with another document of the same category A: technological background O: non-written disclosure P: intermediate document T: theory or principle underlying the invention E: earlier patent document, but published on, or after the filing date D: document cited in the application L: document cited for other reasons &: member of the same patent family, corresponding document			

EPO FORM 1503 03/92 (P04/C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 98 85 0125

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06-11-1998

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