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D E C I S I O N
of 25 October 2002

Case Number: T 0692/99 - 3.2.2

Application Number: 96115660.1

Publication Number: 0761836

IPC: C22C 38/44

Language of the proceedings: EN

Title of invention:
Heat resisting steel and turbine rotor

Applicant:
Hitachi, Ltd.

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 54, 56, 76

Keyword:
"Novelty, inventive step (yes, after amendment)"

Decisions cited:
-

Catchword:
-



Case Number: T 0692/99 - 3.2.2

D E C I S I O N
of the Technical Board of Appeal 3.2.2
of 25 October 2002

Appellant: Hitachi, Ltd.
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Representative: Beetz & Partner
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Decision under appeal: Decision of the Examining Division of the
European Patent Office posted 8 February 1999
refusing European patent application
No. 96 115 660.1 pursuant to Article 97(1) EPC.

Composition of the Board:

Chairman: w. D. Weiß
Members: R. Ries
U. J. Tronser

Summary of Facts and Submissions

I. This appeal, which was filed on 7 April 1999, lies against the decision of the Examining Division dated 8 February 1999, refusing patent application No. 96115660.1 filed on 1 February 1990 and published under No. EP 0761 836 A1 as a divisional application of the earlier application 901022007.3 - (EP 0 384 181 A1). The appeal fee was paid on 7 April 1999 and the Statement of Grounds of Appeal was filed on 18 June 1999.

II. The Examining Division found in its decision that the heat resisting steel alloy defined in the application was anticipated by the disclosure of document

D1: JP-A-60 224766.

In the Examining Division's view, the claimed steel Ni-Cr-Mo-V alloy composition was regarded as being a "selection" from the known Ni-Cr-Mo-V-alloy composition disclosed in this document, but the claimed sub-range failed to satisfy the criteria for the novelty of a selection invention.

III. In its Notice of Appeal, the appellant (patent applicant) requested that the decision under appeal be set aside and a patent be granted. On an auxiliary basis, oral proceeding were requested.

Enclosed with its Notice of Appeal, the appellant submitted a translation of document D1 into the English language for a better understanding of its technical teaching (in the following, the translation is called: D1a). In support of novelty and inventive step, the appellant drew attention to the narrowly restricted elemental ranges for the alloy, in particular for

manganese, and to the limiting features relating to the ratios of Mn/Ni, (Mn+Si)/Ni and (V+Mo)/(Ni+Cr) as well as to the bainitic structure of the steel. No indication is found in document D1a that these correlation rules and a manganese content restricted to 0.25 at maximum have such a highly beneficial influence on the high temperature strength, low temperature toughness, creep rupture strength and the high temperature embrittlement expressed by the 50% FATT (fracture appearance transition temperature). The appellant submitted that the claimed combination of technical features leads to a markedly improved and unique balance of the mechanical properties of the claimed steel which make it suitable for manufacturing a turbine rotor shaft comprising high and low pressure portions. In the appellant's view, the claimed Ni-Cr-Mo-V steel composition is novel and involves an inventive step over the teaching given in document D1a.

IV. In response to a communication expressing the Board's provisional position, the appellant filed an amended set of application documents and requested grant of patent thereupon.

V. Oral proceedings were held before the Board on 25 October 2002. The appellant requested that the decision under appeal be set aside and a patent be granted on the basis of the following documents:

claims: 1 to 3

description: pages 1 to 37 and

Figures: 1 to 7

all submitted at the oral proceedings.

Claim 1 reads as follows:

"1. Heat resisting Ni-Cr-Mo-V low alloy steel having a bainitic structure and consisting of, in weight %,

- 0.20 to 0.28% carbon
- ≤ 0.10% silicon
- 0.05 to 0.25% manganese
- 1.6 to 2.0 % nickel
- 1.2 to 2.5 % chromium
- 1.2 to 2.0 % molybdenum
- 0.2 to 0.3 % vanadium
- a ratio $Mn/Ni \leq 0.12$ and/or
- a ratio $(Mn+Si)/Ni \leq 0.18$ and
- a ratio $(V+Mo)/(Ni+Cr) = 0.45$ to 0.7,

optionally:

0.001 to 0.1 % in total of at least one element selected from the group consisting of titanium, boron, aluminium, zirconium, calcium and rare earth elements,

0.005 to 0.15 % of at least one element selected from the group consisting of niobium and tantalum,

0.1 to 1.0 % tungsten,

the balance being iron and incidental impurities."

Claims 2 and 3 relate to the steel alloy comprising not more than 100 ppm oxygen, and to a turbine rotor shaft consisting of the Ni-Cr-Mo-V alloy according to claim 1, respectively.

Reasons for the Decision

1. The appeal complies with the provisions mentioned in Rule 65(1) EPC and is, therefore, admissible.
2. *Amendments; original disclosure; Article 76 EPC*

Whereas the claims of the parent application (which has already been granted: EP 0 384 181; B1 publication) are directed to a steam turbine, a generator system including the steam turbine and a method of producing a rotor shaft for the steam turbine, the independent claims 1 and 3 of the present application relate to a heat resisting bainitic Ni-Cr-Mo-V steel alloy and a rotor shaft for a steam turbine consisting of the claimed steel alloy. Hence, the claims of the parent and divisional application are quite distinct in scope and directed to different inventions.

The restricted elemental ranges of the Ni-Cr-Mo-V alloy and the ratios for Mn/Ni, (Mn+Si)/Ni and (V+Mo)/(Ni+Cr) featuring in claim 1 of the divisional application are directly and unambiguously derivable from the preferred embodiments of the alloy disclosed on pages 12 to 17, 23, 27, 28 of the documents as originally filed. The limitation for the oxygen content to not more than 100 ppm according to claim 2 has its basis on page 26, lines 9 to 11, and the subject matter of claim 3 is disclosed on page 17, lines 19 to 25 of the application as originally filed. These features are also disclosed in the parent application (EP 0 384 181 A2 publication), page, 6, line 13 to page 7, line 45; page 11, lines 47 to 51; claims 12 to 18.

For the sake of clarity, the term "alloy containing..." has been replaced in claim 1 by the wording "alloy consisting of..., optionally ..., the balance being

iron and incidental impurities" thus specifying all compulsory and optional components of the claimed steel alloy.

The description which acknowledges the relevant prior art, in particular that described in document D1, has been suitably adapted to the wording of the revised claims.

The amendments to the claims and to the description, therefore, satisfy the requirements of Articles 76(1), 123(2) and 84 EPC.

3. *The prior art*

Like the present application, document D1a is concerned with a steel alloy for producing a steam turbine rotor shaft having a high tensile strength and toughness at relatively low temperature steam conditions and exhibiting a low temperature embrittlement at high temperature steam conditions (cf. D1a, page 1, (Field of the Invention), page 2 bridging page 3, (Object of the Invention)). To this end, the rotor shaft is formed of a steel composition consisting of 0.10 to 0.35% C, not more than 0.10% Si, not more than 1.0% Mn, 1.5 to 2.5% Ni, 1.5 to 3.0% Cr, 0.3 to 1.5% Mo, 0.05 to 0.25 V, optionally 0.01 to 0.1 Nb, 0.02 to 0.1% N, and the balance being Fe and incidental impurities (cf. D1a, page 3: Summary of the Invention). The remaining documents cited in the Search Report are concerned with different types of steel and are, therefore, more remote. Consequently, document D1a is considered to represent the closest prior art.

4. *Novelty*

The bainitic Ni-Cr-Mo-V low alloy steel claimed in the application differs from the steel given in document D1 by further specifying its metallographic structure about which document D1a remains silent. This metallographic microstructure is the consequence of the narrow restrictions to the manganese content and to the other components which are further confined by the claimed ratios of Mn/Ni, (Mn+Si)/Ni or (V+Mo)/(Ni+Cr) showing how these particular elements are correlated with one another, and the respective heat treatment. None of the examples given in Table 1 of D1a falls within the elemental limitations or meets all the correlation rules defined in claim 1 of the present application.

Consequently, the subject matter of claim 1 is novel with respect to the low alloy steel materials disclosed in document D1a.

5. *Problem and solution*

Starting from document D1a as the closest prior art, the problem underlying the present application resides in providing a Ni-Cr-Mo-V low alloy steel material which exhibits an improved combination of mechanical properties, including a high temperature tensile strength, a high and low temperature toughness, a specific creep rupture strength, and a low proneness to high temperature embrittlement, which makes the steel alloy applicable for the manufacture of a steam turbine rotor shaft comprising a high and low pressure portion.

This problem is solved by establishing in the steel a bainitic structure, by providing narrow restrictions to the elemental ranges of the compulsory and optional components and by strictly adhering to the correlation rules specified in claim 1.

6. *Inventive step*

Although the problem of providing a good balance of the mechanical properties, (ie a low degree of embrittlement at high temperatures and high tensile strength at relatively low temperatures, a high toughness and creep rupture strength) is also addressed in the prior art D1a, this document neither envisages the claimed solution nor renders the claimed solution obvious, as is shown in the following.

As previously mentioned, document D1a is silent about the microstructure of the steel alloy, whereas the claimed low alloy steel exhibits a fully bainitic structure (cf. page 19, lines 22 to 26 of the application documents as originally filed). The fully bainitic structure, however, contributes markedly to the superior toughness and the superior creep rupture strength of the claimed alloy. It is, therefore, sensible to consider the specific heat treatment both steels are subjected to. Compared with the heat treatment described in the application (heating to 900°-1000°C → cooling 100°C/h → annealing 630°-700°C/40h → furnace cooling; see description pages 19 and 20 as originally filed), it is marked that the steel alloy disclosed in document D1a is heat treated at lower temperatures (heating to 840°C/10h → cooling 100°C/h → annealing at 600°C/20h → air cooling; see D1a, Figure 2). However, as mentioned on page 20, lines 5 to 8, of the present application as filed, the superior toughness is not obtained unless the alloying correlations are met and the annealing temperature is

kept between 630°C and 700°C. Given this situation, it remains unlikely that the steel alloy known from document actually exhibits the completely bainitic structure stipulated in claim 1. Since the Board is not in the position to prove the contrary, any remaining doubt goes to the benefit of the appellant.

In particular, document D1a provides no teaching which points to a particular restriction of the manganese content to 0.05 to 0.25% as claimed. On the contrary, all exemplifying compositions 1 to 4 disclosed in Table 1 of D1a comprise manganese in amounts ranging from 0.31 to 0.36%. However, as can be noted from the graph shown in Figure 6 of the present application, the impact absorption energy increases noticeably provided the manganese content of the alloy is kept below 0.25% and for the same reason, the ratio of Mn/Ni (or Si+Mn)/Ni) is kept at or below 0.12 (cf. Figure 7 of the application).

Moreover and as depicted in Figure 2 of the present application, the claimed steel alloy provides an excellent match in creep rupture strength and the impact absorbing energy, if the ratio $(V+Mo)/(Ni+Cr) = 0.45$ to 0.70 is met. Also in this respect, no indication is given anywhere in document D1a that by strictly adhering to this ratio, the unique balance of the above mentioned mechanical properties could be achieved in the Ni-Cr-Mo-V steel alloy, which makes it suitable for the production of steam turbine rotors integrating high and low pressure portions.

Following the above considerations, a person skilled in the art does not find any indication in document D1a that a pronounced benefit in terms of improvement to the above mentioned mechanical properties can be achieved by the structural and elemental restrictions

to the Ni-Cr-Mo-V steel alloy claimed in the present application. Consequently, the subject matter of claim 1 involves an inventive step vis-à-vis the technical teaching disclosed in document D1a.

6. Dependent claim 2 which relates to a preferred embodiment of the steel alloy according to claim 1 and independent claim 3 which is concerned with a rotor shaft made of the claimed steel alloy for a steam turbine are allowable for the same reasons.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.
2. The case is remitted to the first instance with the order to grant a patent on the basis of

claims: 1 to 3,

description: pages 1 to 37 and

Figures: 1 to 7

all submitted at the oral proceedings.

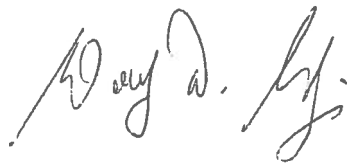
The Registrar:


V. Commare

R.R.

2819.D

The Chairman:



W. D. Weiß