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D E C I S I O N
of 23 September 2004

Case Number: T 0618/02 - 3.2.2

Application Number: 97310229.6

Publication Number: 0849370

IPC: C22C 19/05

Language of the proceedings: EN

Title of invention:
High strength nickel base superalloy articles having machined surfaces

Applicant:
UNITED TECHNOLOGIES CORPORATION

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 54, 56

Keyword:
"Novelty (yes)"
"Inventive step (yes)"

Decisions cited:
-

Catchword:
-

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Case Number: T 0618/02 - 3.2.2

D E C I S I O N
of the Technical Board of Appeal 3.2.2
of 23 September 2004

Appellant: UNITED TECHNOLOGIES CORPORATION
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Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 11 December 2001 refusing European application No. 97310229.6 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: T. K. H. Kriner
Members: R. Ries
A. Pignatelli

Summary of Facts and Submissions

I. This appeal is against the decision of the examining division dated 11 December 2001 to refuse European patent application No. 97 310 229.6.

II. The ground of refusal was that the subject matter of claim 1 of the main request and of the auxiliary request did not involve an inventive step having regard to the documents

D1: US-A-5 120 373

D3: E. F. Bradley: "Superalloys, A Technical Guide", page 9, ASM International Ohio, USA, November 1989, page 9, ISBN 0-87170 327

D4: R. T. Holt and W. Wallace: "Impurities and trace elements in Nickel-base superalloys", International Metals Reviews, Review 203, March 1976, pages 1 to 24

The examining division held that - compared with the Mg-free superalloy disclosed in document D1 - the addition of 0.001 to 0.005 wt% Mg to the claimed alloy was obvious to a skilled person to react as a refining aid with sulphur, as evidenced by documents D3 and D4. The division further held that the amounts of the remaining elements of the claimed alloy fell within the definition of the preferred range given in document D1. However, an alloy selected from this range could not be considered as being novel since the skilled person would seriously contemplate working within this preferred range.

III. On 21 February 2002 the appellant (applicant) lodged an appeal against the decision and paid the prescribed fee on the same day.

IV. In an official communication, the Board expressed its provisional position on the case and referred to document

D5: Qi Huang and Jing Xin Ren: "Surface integrity and its effects on the fatigue life of the nickel-based superalloy GH33A", International Journal of Fatigue, 1991, No.4, pages 322 to 326

V. At the end of the oral proceedings which took place on 23 September 2004, the appellant requested that the decision under appeal be set aside and a patent be granted on the basis of the claims 1 and 2, the description pages 2 to 11 filed during the oral proceedings, and the description page 1 and Figure 1 as originally filed.

VI. Independent claims 1 and 2 read as follows:

"1. A hot deformed nickel base superalloy article having a machined surface, said superalloy article comprising a composition, in weight percent, of 2.2Al, 4.6Ti, 15.5Cr, 3.0Mo, 13.5Co, 0.015C, 0.015B, 0.04Zr, 0.001-0.005Mg, balance Ni and unavoidable impurities, said superalloy article being free of carbide stringers and further comprising a plurality of discrete MC carbides, where M is predominantly titanium and C is carbon, which are free from molybdenum for increased fatigue strength."

"2. A method of increasing the fatigue strength of a hot deformed nickel base superalloy article having a machined surface, said method comprising the steps of:

providing a nickel base superalloy composition, said composition comprising, in weight percent, 2.2Al, 4.6Ti, 15.5Cr, 13.5Co, 0.015C, 0.015B, 0.04Zr, 0.001-0.005Mg, balance Ni and unavoidable impurities;

adding, in weight percent, 3.0Mo, thereby forming a final composition;

heat treating the final composition to form an article; and

machining the surface of the article, said article being characterized by being free of carbide stringers and by the presence of a plurality of discrete MC carbides, where M is predominantly titanium and C is carbon, which are free from molybdenum for increased fatigue strength."

VII. The appellant argued as follows:

The present claims define, in essence, a point composition which falls within the generic disclosure of the compositional ranges of the alloy given in document D1. The disclosure of a generic is, however, not a disclosure of the specific. Apart from the magnesium content not mentioned in document D1, the claimed point-like alloy composition is distinguished from the preferred alloy composition disclosed in document D1 also by its specific amount of Mo. Although the "preferred" ranges specified in Table 1 of document D1 are to include 3 to 5 wt% Mo, this does not mean that the lower limit of 3 wt% Mo could be combined with any composition fitting within the other eight

preferred ranges, the more so since the single example (the most preferred embodiment of D1) teaches towards a selection of the mid-points rather than the end points of the preferred ranges. The only components of the "preferred starting composition" to match with those of the claimed alloy are Al and Ti, whereas the amounts of the remaining elements Mo, C, B, Zr and Mg differ from those of the claimed invention. In the case of Mo (4.1%) a content even above the mid-point (4.0 wt% Mo) has been chosen. Hence, in the absence of any other exemplifying alloy, the nominal composition of the specific example mentioned in the abstract of document D1 emphasizes what is really being disclosed by the list of the preferred ranges.

More importantly, a skilled person would not recognise from document D1 that low cycle fatigue strength would be a problem originating from the Mo-rich MC-carbides which are formed into stringers during the forging operation and damaged during machining. Consequently, this document could not provide any hint to the claimed solution. Putting into practice the teaching of document D1, a person skilled in the art was, therefore, not led to choose the end point of 3 % Mo of the preferred range for Mo while leaving the contents of the remaining components unchanged, i.e. close to the mid-point of the preferred ranges.
Moreover, if the amount of one refractory component (e.g. Mo) is reduced, the decrease in the alloy's mechanical properties associated therewith has to be compensated for by adding other refractory components e.g. tungsten, as can be seen from the various superalloy compositions listed in Table 1 of document

D4. This has not been done with the claimed composition.

Given this situation, the claimed subject is novel and involves an inventive step.

Reasons for the Decision

1. The appeal complies with the provisions of Rule 65(1) EPC and is therefore admissible.

2. *Amendments*

Claim 1 results from a combination of original claim 7 with the technical features given on page 8, lines 15/16 and page 9, lines 1 to 11 of the description as filed. The term "hot deformed" has ample support in the description as filed, e.g. on page 6, line 18 or on page 7, line 16.

Claim 2 is based on the originally filed claims 7 and 8 and the above mentioned parts of the description.

The description has been suitably adapted to the wording of the amended claims.

Hence there are no formal objections to the claims and the description.

3. *The application*

The present invention relates to a hot deformed nickel base superalloy article which consists of a point-like composition and exhibits a machined surface. In these alloys the presence of refractory elements such as Mo and Ti in combination with carbon inevitably leads to the formation of MC carbides which show the tendency to form "carbide stringers" after forging. The description pages 8 and 9 reflect the applicant's finding that the size and morphology of the MC carbides exhibit a profound impact on the fatigue strength and, more specifically, that molybdenum adversely affects the low fatigue cycle (LCF) strength based on its presence in the MC carbides. As further set out on page 2, lines 11 to 19, the micro-structural damage that occurs during the machining process is responsible for initiating LCF failures at relatively low lives. The application, therefore, proposes the limitation of the amount of molybdenum in the superalloy composition to 3.0 wt% and a restriction of the carbon content to 0.015 wt% to promote the formation of discrete Mo-free MC carbides predominantly composed of titanium and carbon which do not form "carbide stringers" during the hot deformation operation.

4. *The closest prior art*

Like the present application, document D1 relates to a wrought high strength nickel base superalloy which is particularly adapted to produce disc pre-forms and shafts for gas turbine engines (cf. D1, column 4, lines 46 to 49; column 7, lines 15 to 20). Table I of document D1 lists a "broad", "intermediate" and

"preferred" composition, each composition having progressively narrower ranges for the various components, and a "preferred starting composition" as the single example is specified in the abstract of document D1. Based on these considerations and given that the known superalloy articles are produced with the same method and are used for the same purpose claimed in the application, document D1 is regarded as representing the closest prior art. This document is already acknowledged as technical background in the description.

The remaining documents are less relevant in that they concern either different types of alloys (D5) or merely represent the technical background knowledge of a person skilled in this field of technology (D3, D4).

5. *Novelty*

Document D1 fails to disclose the presence 0.001 to 0.005 wt% (10 to 50 ppm) magnesium that is required in the claimed alloy as a compulsory component. The subject matter of independent claims 1 and 2 is therefore novel with respect to document D1 already by this technical feature.

Novelty of the claimed article is, however, not established exclusively by the presence of Mg, but also by the fact that the superalloy of the claimed article and method represents a very specific composition which has been designed to exhibit a superior LCF strength. To this end, the alloy set out in claim 1 has been selected from the generic disclosure of alloy compositions confined to the preferred elemental ranges

which are listed in Table 1 of document D1. Although the present claims 1 and 2 refer to a point-like alloy, the values of the different elements may be regarded as sub-ranges, since in practice it is impossible to produce a point-like alloy.

According to the case law of the Boards of Appeal of the EPO, a selection of a sub-range of numerical values from a broader range is possible when each of the following criteria is satisfied:

(i) the selected sub-range should be narrow;

(ii) the selected sub-range should be sufficiently removed from the preferred part of the known range (as illustrated for instance in the examples given in the prior art);

(iii) the selected sub-range should not be an arbitrarily chosen specimen from the prior art, i.e. not merely one way of carrying out the prior teaching, but must provide a new invention (purposive selection).

In the present case, the selected "sub-range" stipulated in claims 1 and 2 has been limited to a nominal point-like superalloy composition and is, therefore, extremely narrow as compared with the preferred ranges listed in D1, Table 1. Moreover, the claimed alloy is, in particular by having its Mo-content reduced to 3.0 wt%, sufficiently far removed from the single example given in document D1 which comprises 4.1 wt% Mo and is situated at about the mid-point of the preferred range for Mo. Moreover, it

cannot be contested that, by its low Mo-content, the claimed superalloy composition offers something different from the properties of the preferred area of alloys disclosed in document D1, namely a significantly improved LCF strength which is not achieved with an alloy comprising 4.1 wt Mo. This finding has been convincingly demonstrated in the application by comparing the performance of the claimed superalloy with that of the conventionally used alloy PWA1113 which has a chemistry very close to that of the "preferred starting composition" referred to in document D1. The claimed composition, therefore, represents also a purposive selection and not a mere embodiment of the prior art.

The subject matter of claim 1, and likewise of independent claim 2, is therefore novel with respect to the technical teaching given in document D1.

6. *Inventive step*

6.1 Starting from this prior art, the problem underlying the present application, therefore, resides in providing Ni-base superalloy articles which display improved LCF properties after machining, in particular when using WC tool inserts.

The solution to this problem resides in the control of the carbon content and, more importantly, of the amount of molybdenum in the MC carbides such that the MC carbides are free from molybdenum. Such Mo-free carbides are achieved by restricting in the alloy the Mo-content to 3.0 wt% and the carbon content to 0.015 wt%. This type of carbide is not excessively damaged

during conventional WC-lathe turning and, therefore, does not cause premature failure of the article.

6.2 The reliability problem of LCF strength not being addressed anywhere in document D1, and neither in any of documents D3 and D4, the teaching of these documents could not afford a skilled person a perspective or indication as to the solution of the identified technical problem. It is only document D5 which deals with the effects of the surface integrity created by machining on the low cycle fatigue life of Ni-based superalloy GH33A (cf. D5, page 325). However, as can be learned from Table 1 of document D5, superalloy GH33A does not comprise Mo and Co as alloying elements and is, therefore, a totally different type of alloy. Thus, even by combining the technical teaching given in documents D1 and D5, the subject matter of claim 1 would not be arrived at.

6.3 It may be argued that a skilled person putting into practice the known superalloy according to D1 would have worked in the "preferred range" and hence would have selected e.g. an alloy comprising 3.0 wt% Mo.

It is beyond doubt that the preferred range actually includes the possibility to select a superalloy having a Mo-content of 3 wt% and that the claimed composition could have selected from the preferred range. However, given that the identified technical problem was neither mentioned nor even suggested in document D1, there was no recognisable pointer in the state of the art for a skilled person to design the superalloy composition stipulated in the independent claims 1 and 2 of the present invention.

6.4 In this respect, the Board concurs with appellant's argument that by making only slight changes in the amount of one or more constituents, the superalloy's well balanced match in its mechanical properties, forgability and corrosion behaviour can be significantly altered. Consequently, a skilled person would, in the absence of any other technical information, adhere to the proven "preferred starting composition" disclosed as the single example in document D1 rather than make any costly changes to this balanced composition.

7. Consequently, the subject matter of claim 1 is novel and involves an inventive step.

7.1 The article according to claim 1 being novel and inventive, the same statement is true for the method of producing this article set out in claim 2.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The case is remitted to first instance with the order to grant a patent on the basis of the following documents:

Claims: 1 and 2 as filed during the oral proceedings of 23 September 2004

Description: page 1 as originally filed,
pages 2 to 11 as filed during the oral proceedings of 23 September 2004,

Drawings: Figure 1 as originally filed.

The Registrar: The Chairman:

V. Commare T. Kriner