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Datasheet for the decision of 20 July 2012

Case Number: T 1640/10 - 3.2.07

Application Number: 04256969.9

Publication Number: 1541714

IPC: C23C 30/00

Language of the proceedings: EN

Title of invention:
Method for repairing components using environmental bond coatings and resultant repaired components

Applicant:
GENERAL ELECTRIC COMPANY

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 56

Relevant legal provisions (EPC 1973):
-

Keyword:
"Inventive step (all requests - no)"
"Decision according to the state of the file"

Decisions cited:
-

Catchword:
-

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Case Number: T 1640/10 **-** 3.2.07

D E C I S I O N
of the Technical Board of Appeal 3.2.07
of 20 July 2012

Appellant: (Applicant)
GENERAL ELECTRIC COMPANY
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Representative:
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Decision under appeal:
Decision of the Examining Division of the European Patent Office posted 25 February 2010 refusing European patent application No. 04256969.9 pursuant to Article 97(2) EPC.

Composition of the Board:

Chairman: H. Meinders
Members: H. Hahn
E. Kossonakou

Summary of Facts and Submissions

I. The applicant lodged an appeal against the decision of the Examining Division to refuse the European patent application No. 04 256 969.9.

The Examining Division held that the subject-matter of the independent claims 1 and 7 of the single request dated 17 December 2009 contravened Article 123(2) EPC and that claim 1 additionally did not comply with Article 84 EPC.

II. With its grounds of appeal dated 7 July 2010 the appellant requested to set aside the decision and to grant a patent on the basis of claims 1-10 of the main request, alternatively on the basis of claims 1-10 of the auxiliary request, both as submitted together with the grounds of appeal. In case that the Board should consider a decision other than according to the aforementioned requests, oral proceedings were requested.

III. The independent claims 1 and 7 of the **main request** read as follows (amendments as compared to the independent claims 1 and 7 underlying the impugned decision are in bold with deletions in brackets; emphasis added by the Board):

"1. A method for repairing a coated component, which has been exposed to engine operation to produce a repaired component without a weight penalty, **the method** comprising:
a) providing an engine run component including a base metal substrate of a **[Ni or Co]** superalloy **of** Ni or Co

or combinations **[thereof] of Ni and Co** having thereon a bond coat, wherein the bond coat (20) is selected from the group consisting of

i) a diffusion aluminide coating,

ii) a MCrAlY coating where M is **[nickel]** iron, cobalt, **and/**or **[combinations thereof]** nickel, and

iii) combinations thereof;

b) removing the bond coat (20), wherein a portion of the base metal substrate between 0.0254 - 0.0762 mm (1-3 mils) in thickness is also removed to create a remaining base metal substrate of reduced thickness;

c) applying a lower growth environmental bond coating (21) directly to the remaining base metal substrate comprising an aluminum alloy **[having an aluminum content of 10-20 atomic % and]** selected from the group consisting of

i) a β NiAl alloy consisting essentially of nickel and aluminum and containing zirconium and

ii) a MCrAlY alloy wherein M is nickel, cobalt, iron or combinations thereof and modified to include 10-50 atomic percent aluminum and being less than 0.2032 mm (8 mils) in thickness

creating a diffusion zone between the outer surface of the component and the substrate;

wherein upon subsequent repair of the component, the remaining base metal substrate is removed in an amount less than 0.0762 mm (3 mils) in thickness because of less environmental coating growth into the substrate than the prior bond coat (20), thereby extending component life and increasing repairability of the component and

wherein the lower growth environmental bond coat has a density less than the density of the prior bond

coat (20) and the repaired component does not weigh more than the component prior to repair."

"7. A repaired component comprising:

an engine run component having a base metal substrate of a **superalloy of** Ni **[, Fe]** or Co **[superalloy]** or combinations **[thereof] of Ni and Co**, a portion of the base metal substrate between 0.0254 - 0.0762 mm (1-3 mils) in thickness and an overlying bond coat (20) having been removed to create a remaining base metal substrate of reduced thickness, wherein the overlying bond coat (20) is selected from the group consisting of

i) a diffusion aluminide coating,

ii) a MCrAlY coating where M is iron, cobalt, and/or nickel, and

iii) combinations thereof;

a lower growth environmental bond coating (21) comprising an alloy having an aluminum content of 10-60 atomic percent and selected from the group consisting of

i) a β NiAl alloy consisting essentially of nickel and aluminum and containing zirconium and

ii) a MCrAlY alloy where M is nickel, cobalt, iron or combinations thereof and modified to include 10-50 atomic percent aluminum and being less than 0.2032mm (8 mils) in thickness applied to the remaining base metal substrate

wherein upon subsequent repair of the component, the remaining base metal substrate is removed in an amount less than 0.0762 mm (3 mils) in thickness because of less environmental coating growth into the substrate than the prior bond coat (20), thereby extending component life and increasing repairability

of the component and

wherein the lower growth environmental bond coat has a density less than the density of the prior bond coat (20)and the repaired component does not weigh more than the component prior to repair."

Independent claims 1 and 7 of the **auxiliary request** read as follows (amendments as compared to the main request are in bold with deletions in brackets; emphasis added by the Board):

"1. A method for repairing a coated component, which has been exposed to engine operation to produce a repaired component without a weight penalty, the method comprising:
a) providing an engine run component including a base metal substrate of a superalloy of Ni or Co or combinations of Ni and Co having thereon a bond coat, wherein the bond coat (20) is selected from the group consisting of
i) a diffusion aluminide coating,
ii) a MCrAlY coating where M is iron, cobalt, and/or nickel, and
iii) combinations thereof;
b) removing the bond coat (20), wherein a portion of the base metal substrate between 0.0254 - 0.0762 mm (1-3 mils) in thickness is also removed to create a remaining base metal substrate of reduced thickness;
c) applying a lower growth environmental bond coating (21) directly to the remaining base metal substrate comprising an aluminum alloy **[selected from the group]** consisting of
[i)] a β NiAl alloy consisting essentially of nickel and aluminum and containing zirconium **[and**

ii) a MCrAlY alloy wherein M is nickel, cobalt, iron or combinations thereof and modified to include 10-50 atomic percent aluminum and being less than 0.2032 mm (8 mils) in thickness]

creating a diffusion zone between the outer surface of the component and the substrate;

wherein upon subsequent repair of the component, the remaining base metal substrate is removed in an amount less than 0.0762 mm (3 mils) in thickness because of less environmental coating growth into the substrate than the prior bond coat (20), thereby extending component life and increasing repairability of the component and

wherein the lower growth environmental bond coat has a density less than the density of the prior bond coat (20) and the repaired component does not weigh more than the component prior to repair."

"7. A repaired component comprising:

an engine run component having a base metal substrate of a superalloy of Ni or Co or combinations of Ni and Co, a portion of the base metal substrate between 0.0254 - 0.0762 mm (1-3 mils) in thickness and an overlying bond coat (20) having been removed to create a remaining base metal substrate of reduced thickness, wherein the overlying bond coat (20) is selected from the group consisting of

i) a diffusion aluminide coating,

ii) a MCrAlY coating where M is iron, cobalt, and/or nickel, and

iii) combinations thereof;

a lower growth environmental bond coating (21) comprising **[an alloy having an aluminum content of 10-60 atomic percent and selected from the group**

consisting of
i)] a β NiAl alloy consisting essentially of nickel and aluminum and containing zirconium **[and**
ii) a MCrAlY alloy where M is nickel, cobalt, iron or combinations thereof and modified to include 10-50 atomic percent aluminum and being less than 0.2032mm (8 mils) in thickness applied to the remaining base metal substrate]

wherein upon subsequent repair of the component, the remaining base metal substrate is removed in an amount less than 0.0762 mm (3 mils) in thickness because of less environmental coating growth into the substrate than the prior bond coat (20), thereby extending component life and increasing repairability of the component and

wherein the lower growth environmental bond coat has a density less than the density of the prior bond coat (20)and the repaired component does not weigh more than the component prior to repair."

IV. With a communication dated 11 April 2012 and annexed to summons for oral proceedings set for 21 August 2012 the Board presented its preliminary and non-binding opinion with respect to claims 1-10 of the above two requests.

The Board stated amongst others that the subject-matter of independent claims 1 and 7 of both the main and the auxiliary request lacked inventive step, as follows:

"5.1 *The following documents cited in the search report and in the examination proceedings are considered to be particularly relevant:*

D2 = EP-A-0 985 745

D5 = US-B1-6 255 001
D6 = EP-A-0 992 612
D7 = US-A-2003/082297

5.2 D7 discloses a method for repairing a turbine blade being removed from service and the MCrAlY or other bond coat is stripped from the entire blade. The blade and tip region are inspected and repaired if necessary, after which the MCrAlY bond coat layer is reapplied to the blade followed by suitable heat treatment of the entire blade. A non abradable thermal barrier coating is then applied to the tip region of the blade on top of said MCrAlY bond coat (see claim 1). This method increases the interval between repairs and makes future repairs easier (see page 1, paragraphs [0011] to [0013]; page 2, paragraph [0024]).

The MCrAlY bond coat is removed from the blade, typically by mechanical or chemical methods such as grinding, etching, use of acid baths, aluminizing methods, or other methods known in the art, chemical methods of removal are preferred (see page 2, paragraph [0025]). The bond coat is preferably a MCrAlY, with M being Fe, Ni, Co, or a mixture of Ni and Co and includes compositions including additional elements or combinations of such elements such as Si, Hf, Ta, Re or noble metals known to those skilled in the art. The MCrAlY may also include a layer of diffusional aluminide, particularly an aluminide that comprises one or more noble metals. Preferably the bond coat will comprise about 34% Ni, 19-23 % Cr, 6-10 % Al, 0.2-0.7% Y, with the balance Co (see page 2, paragraph [0030]). Preferably the bond coat is applied in a thickness between about 50-400 µm. In some situations where there

has been strong oxidation of the blade and the tip has become too thin, a thicker MCrAlY layer may have to be applied, in such a case a thickness of about 200-500 µm should be used (see page 2, paragraph [0029]). According to the example the complete removal of the bond coat is done by chemical stripping and the complete removal is verified by a heat tint (see page 3, [0037] to [0042]).

D7 thus appears to differ from the method and the repaired component claimed in the present application only in the specified thickness ranges (the MCrAlY alloy of D7 overlaps with those of the present application at 10% Al) since chemical stripping of the old bond coat implies the removal of the diffusion layer from the substrate surface which means the removal of some of the base metal substrate. The determination of the optimum thickness for the removal of the old bond coat and for the re-application of the new bond coat appears to be comprised within the ordinary skills of the person skilled in the art. Thus it appears that the person skilled in the art when starting from the teaching of D7 would arrive at the subject-matter of the independent claims 1 and 7 of the main request without inventive skills.

5.3 Similar arguments appear to be valid for the documents D2, D5 and D6 which disclose the advantages that are combined with the application of specific NiAlZr bond coats onto gas turbine components and which produce a minimized diffusion of the bond coat into the substrate to thereby increase the number of refurbishing/repairing treatments.

5.4 For example, D5 discloses a thermal barrier system including a NiAl bond coat containing zirconium which is predominantly in the β-NiAl phase NiAl which preferably contains 0.2-0.5 atomic percent zirconium (see column 3, lines 1 to 11, and lines 24 to 37). This bond coat minimizes diffusion of the bond coat constituents into the surface of the (superalloy) article, preferably a diffusion zone of not more than 5 µm is achieved by the preferred PVD process (see claims 1-14). By limiting diffusion of the bond coat into the substrate, minimal substrate material must be removed during refurbishment of the thermal barrier coating system, when both the bond coat and thermal-insulating ceramic layer must be removed to allow deposition of a new bond coat and ceramic layer on the substrate so that articles such as blades can be refurbished more times than would be possible if a traditional bond coat were used (see column 3, lines 41 to 57; column 5, lines 1 to 20). According top the example the bond coat was applied in a thickness of between about 20 and 50 µm.

Consequently, it appears to be clear to the person skilled in the art that after removal of the old bond coat - i.e. the NiAlZr alloy - the same advantageous NiAlZr alloy should be reapplied. The determination of the optimum thickness for the removal of the old bond coat and for the re-application of the new bond coat is considered to be within the ordinary skills of the person skilled in the art. Thus it appears the person skilled in the art when starting from the teaching of D5 would arrive at the subject-matter of the claims of the main and auxiliary request in an obvious manner.

5.5 D2 discloses a thermal barrier system including a NiAl bond coat containing about 0.2-0.5 atomic percent zirconium which is predominantly in the β-NiAl phase NiAl which preferably contains (see abstract; pages 2-3, paragraphs [0007] and [0008], claims 1-6 and figures 1-2). This bond coat minimizes diffusion of the bond coat constituents into the surface of the (superalloy) article, preferably a diffusion zone of not more than 5 µm is achieved by the preferred PVD process. By limiting diffusion of the bond coat into the substrate, minimal substrate material must be removed during refurbishment of the thermal barrier coating system, when both the bond coat and thermal-insulating ceramic layer must be removed to allow deposition of a new bond coat and ceramic layer on the substrate (see page 3, paragraph [0010]). Optionally, a diffusion barrier layer 32 is applied between the substrate and the bond coat layer (see page 4, paragraph [0016] and claims 7-8).

Consequently, it appears to be clear to the person skilled in the art that after removal of the old bond coat the same advantageous NiAlZr alloy should be reapplied. The determination of the optimum thickness for the removal of the old bond coat and for the re-application of the new bond coat appears to reside within the ordinary skills of the person skilled in the art. Thus it appears the person skilled in the art when starting from the teaching of D2 would arrive at the subject-matter of the claims of the main and auxiliary request in an obvious manner.

5.6 D6 discloses NiAl coating systems for articles such as turbine, combustor and augmentor components of a gas

turbine engine which comprises a β-phase NiAl intermetallic layer containing 30 to 60 atomic percent aluminium and at least one element chosen from the group consisting of 0.5 to 25 atomic percent chromium, 0.1 to 5 atomic percent titanium, 0.1 to 5 atomic percent tantalum, 0.1 to 5 atomic percent silicon, 0.01 to 2.0 atomic percent hafnium, and 0.02 to 0.2 atomic percent gallium (see abstract; Table I and claim 1). Bond coats made from these modified NiAl alloys exhibited considerably more resistance to spallation than stoichiometric NiAl and all alloyed NiAl specimens performed better than the baseline PtAl bond coat specimens (see page 7, lines 53 to 58 and Table IV). Another benefit attributable to the addition of chromium to NiAl bond coats is evidenced in figure 4, which shows bond coat growth and substrate consumption as being significantly reduced for NiAlCrZr bond coats as compared to NiAlZr bond coats and even more significantly reduced when compared to NiAl bond coats containing no additions. These results indicate that NiAlCrZr bond coats are better able to retain the critical airfoil wall thickness during engine operation, and promote the repairability of airfoils as a result of less wall consumption. These bond coats can be used as environmental coatings or in combination with a thermal barrier coating system (see page 8, lines 3 to 14 and lines 17 to 19). D6 thus teaches the skilled person that the modified NiAl bond coats show less interdiffusion than an ordinary, unalloyed NiAl bond coat so that the repairability is promoted due to the fact that less material of the substrate is consumed by this interdiffusion during the use of the turbine component. Therefore, when the turbine component has to be repaired, less material originating from the

substrate has to be stripped and the component can be repaired more often. Consequently, the same conclusion as with respect to D2 and D5 appears to be valid and it appears that the teaching of D6 allows the person skilled in the art to arrive at the subject-matter of the claims of the main and auxiliary request."

The appellant was given the opportunity to file observations to the communication provided they were filed at least one month before the date of the oral proceedings.

V. With letter of 3 May 2012 the appellant stated that "the Applicant hereby withdraws their previous request for Oral Proceedings" and requested "that a written decision be issued in accordance with the current state of the file".

This letter did **not** contain any further arguments concerning the objections raised in the Board's communication annexed to the summons to oral proceedings.

Reasons for the Decision

1. The appellant's withdrawal of the auxiliary request for oral proceedings and its request to decide on the current state of the file in its letter dated 3 May 2012 (see point V above) means to the Board, as is consistent Case Law (see Case Law of the Boards of Appeal, 6th edition 2010, VI.C.2.2), that the appellant relies on its written submissions filed until then and will not file further submissions.

2. In the communication accompanying the summons for oral proceedings the Board, taking account of these submissions, amongst others raised objections under Article 56 EPC, explaining why in the Board's opinion the subject-matter of claims 1 and 7 of the main request and of claims 1 and 7 of the auxiliary request lacked inventive step over the disclosures of either D7, D2, D5 or D6 and the common general knowledge of the person skilled in the art (see point IV above).

3. The appellant did not reply in substance to these objections (see point V above). Since there has been no attempt by the appellant to refute or overcome the objections raised in the above communication, the Board has no reason to depart from its preliminary opinion expressed therein.

4. With regard to the above, the Board concludes - for the reasons already set out in the communication (see point IV above) - that the subject-matter of the independent claims 1 and 7 of the main request and of the independent claims 1 and 7 of the auxiliary request lacks inventive step over either D2, D5, D6 or D7 and the common general knowledge of the person skilled in the art (Article 56 EPC).

5. Consequently, neither request is allowable.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

D. Hampe H. Meinders