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**Datasheet for the decision
of 25 August 2011**

Case Number: T 2143/08 - 3.3.05

Application Number: 99967257.9

Publication Number: 1169495

IPC: C25F 5/00

Language of the proceedings: EN

Title of invention:

Electrochemical stripping of turbine blades

Applicant:

CHROMALLOY GAS TURBINE CORPORATION

Headword:

Electrochemical stripping/CHROMALLOY GAS TURBINE CORPORATION

Relevant legal provisions:

EPC Art. 54, 56

Relevant legal provisions (EPC 1973):

-

Keyword:

"Novelty: yes"

"Inventive step: yes"

Decisions cited:

-

Catchword:

-



Case Number: T 2143/08 - 3.3.05

D E C I S I O N
of the Technical Board of Appeal 3.3.05
of 25 August 2011

Appellant: CHROMALLOY GAS TURBINE CORPORATION
4430 Director Drive
San Antonio, TX 78219 (US)

Representative: Müller, Frank Peter
Müller Schupfner & Partner
Patentanwälte
Bavariaring 11
D-80336 München (DE)

Decision under appeal: Decision of the Examining Division of the
European Patent Office posted 16 June 2008
refusing European patent application
No. 99967257.9 pursuant to Article 97(1) EPC.

Composition of the Board:

Chairman: E. Waeckerlin
Members: H. Engl
C. Vallet

Summary of Facts and Submissions

- I. The appeal lies against the decision of the examining division, posted on 16 June 2008, to refuse European patent application EP 99 967 257.9.
- II. The documents cited during the examination procedure were the following:
- D1: US-A-3 779 879
 - D2: US-A-5 985 127 (published on 16 November 1999)
 - D3: US-A-4 128 463
 - D4: US-A-4 142 954
 - D5: US-A-2 840 521.
- III. The examining division considered document D1 to represent the closest prior art. D1 disclosed a method for electrochemical stripping of metallic coatings from a basis metal of the iron group, in particular of aluminide coatings from the surfaces of turbine blades made of Ni based superalloys. More specifically, the parts to be stripped were immersed in a tank containing a solution of an oxidizing acid and anodically connected to a potential of not higher than 2.4 V. The counter-electrode was formed by the inner lead lining of the tank.

The examining division considered in the contested decision that the problem of stripping a coating from the various portions of an article having a complex shape, such as a turbine blade, had already been recognized in D1. In this respect, the examining division referred to the statements contained in D1 according to which it was "*impossible to position [...] a*

blade in the solution in such a manner that all parts of its surface will be at equal distances from the cathode", and that, consequently, it was "inevitable that the closest portions will be stripped first of their coatings".

As a solution to this problem, D1 proposed increasing the critical distance between the workpiece and the cathode to 4 to 6 inches. To prevent the chemical dissolution of already stripped parts, an oxidizing acid was employed and the voltage was limited to 2.4 V.

The examining division took the view that the problem of varying distances had already been recognised in D1, but that an exact shaping of the counter-electrodes was found to be impractical. Insofar, the application under appeal did not overcome a prejudice in the art.

In the examining division's opinion, the skilled electrochemist knew that a homogenous stripping process required a homogenous distribution of the electrical field between the electrodes, which was usually achieved by electrodes having the same distance everywhere. The choice of a grid as a counter-electrode did not require inventive skills either (see decision under appeal, points 8 and 9).

- IV. The notice of appeal was filed by letter dated 7 August 2008. The grounds for appeal were received under cover of a letter dated 16 September 2008, accompanied by two sets of claims constituting the main request and the first auxiliary request.

V. In a communication dated 22 June 2011 the board drew attention to two new documents

D2a: EP-A-0 854 208 (published on 22 July 1998; family document of D2)

and

D6: US-A 3 334 029.

The board observed that the arrangement disclosed in Figure 5 of D2a involved the same idea as the application under appeal, namely to tailor the shape of the cathode so as to correspond to the shape of the portion of the blade to be stripped. Grid-shaped electrodes were known from D6.

VI. By a letter dated 21 July 2011 the appellant replied to the communication issued by the board.

VII. Oral proceedings took place on 25 August 2011. The appellant filed a new main request as the sole pending request and withdrew the auxiliary request.

VIII. Independent claim 1 of said main request reads:

"1. A process for stripping a metallic coating from a turbine blade of a gas turbine engine comprising:

attaching the blade to a positive lead from a power supply;

submerging a portion of the blade with a metallic coating to be stripped into a bath of acidic electro-stripping solution,

wherein said bath contains a negative lead from

the power supply attached to a conductive grid, and wherein the shape of the conductive grid is tailored to the blade shape such that the shape of the grid corresponds to the shape of the portion of the blade to be stripped so as to provide uniform coating removal while avoiding localized wall thickness reduction; and

providing a current to the blade in the bath for a period of time effective to remove the coating from the portion of the blade."

Dependent claims 2 to 8 define preferred embodiments of the process of claim 1.

IX. The appellant essentially argued as follows:

Starting from D1, which represented the closest prior art, the object of the application under appeal was to provide a process for stripping a metallic coating from a turbine blade of a gas turbine engine, which provided a fast and reliable stripping, wherein the coating removal was precisely controlled to avoid affecting the wall thickness of the base material of the blade.

This problem was solved by the process as set out in claim 1, in particular by providing a uniform distance between the electrodes by tailoring the shape of the electrode to the blade shape such that the shape of the electrode corresponded to the shape of the portion of the blade to be stripped. D1 was totally silent about such tailoring of the electrode shape.

Document D2a related to a process of removing a metallic erosion shield (typically of Ti) from a

helicopter rotor blade. Since the erosion shield was attached to the composite blade by a layer of non-metallic adhesive, the electrochemical stripping process stopped naturally as soon as this layer had been reached. Therefore, in D2a there was no risk of damaging the underlying material, in contrast to the present invention, where no such barrier layer existed. The skilled person would not have taken D2a into consideration in order to solve the problem posed. Even if he had done so, he would have applied the process only to articles where the coating was attached to the blade by means of an inert adhesive.

Additionally, in accordance with D2a, the electrode still needed to be moved over the span of the helicopter blade to remove the erosion barrier. Thus, D2a did not disclose tailoring of a conductive grid in the portion of the blade to be stripped. The cathode in the form of a grid provided the advantage of free access of the electrolyte to the portion to be stripped. Due to its inherent flexibility, a cathode grid could also be tailored more easily such that its shape corresponded to the shape of the portion of the blade to be stripped. It should be borne in mind that a gas turbine engine blade exhibited a three-dimensionally curved surface. In contrast, the surface of the helicopter blade shown in D2a was only curved in the blade's cross-section, not flexed along the length of the blade.

D6 related to a process of selective anodic dissolution of a metallic coating wherein copper was being removed from a zirconium article. When the copper was removed, the process automatically stopped, e.g. by forming an

anodic layer. Thus, even though D6 disclosed a cathode provided by a grid, it related to a different problem and would not have been taken into consideration by the skilled person.

X. Requests

The appellant requested that the decision under appeal be set aside and a patent be granted on the basis of claims 1 to 8 of the main request, filed during the oral proceedings.

Reasons for the Decision

1. Amendments (Article 123(2) EPC)

1.1 Claim 1 is based on the original disclosure of claims 1 and 7 and the description, page 2, lines 11 to 13 and 17 to 25, of the application documents as originally filed (and published as WO-A-00 42 242).

1.2 Dependent claims 2 to 8 correspond to claims 3 to 6 and 9 to 11, respectively, as originally filed.

1.3 The requirements of Article 123(2) EPC are thus met.

2. Novelty

2.1 D1 discloses a method for electrochemical stripping of metallic coatings from a basis metal of the iron group, in particular of aluminide coatings from the surfaces of turbine blades made of Ni based superalloys (see column 1, lines 4 to 24). More specifically, the parts

to be stripped are immersed in a tank containing a solution of an oxidizing acid and anodically connected to a potential of not higher than 2.4 V. The counter-electrode is formed by the inner lead lining of the tank (column 2, line 64 to column 3, line 7; example 1; Figure 6).

The problem of the various portions of a complex-shaped article, such as a turbine blade having varying distances to the counter-electrode, is recognized in D1 (column 5, lines 6 to 18). However, D1 considered it *"impossible to position [...] a blade in the solution in such a manner that all parts of its surface will be at equal distances from the cathode"*. It was concluded that it was *"inevitable that the closest portions will be stripped first of their coatings"* (column 5, lines 6 to 11; column 3, lines 44 to 48).

The solution disclosed in D1 consists in increasing the critical distance between the work piece and the cathode to 4 to 6 inches as a convenient distance (see D1, column 5, lines 56 to 59). To prevent chemical dissolution of already stripped parts, an oxidizing acid is employed and the voltage is limited to 2.4 V (D1, claim 1; column 5, lines 19 to 22).

D1 does not suggest, however, the tailoring of the electrode shape to conform to the portion of the blade to be stripped, as required by claim 1 of the main request. In addition, D1 does not disclose that the negative lead is attached to a conductive grid.

Therefore, the claimed subject-matter is novel having regard to the disclosure of D1.

2.2 Document D2, published on 16 November 1999, does not belong to the state of the art relevant to the instant application because the priority date of 14 January 1999 of the latter is validly claimed. However, document D2a, published on 22 July 1998, and claiming the same priority as D2, belongs to the state of the art under the provisions of Article 54(2) EPC.

D2a discloses a process and an apparatus for the electrochemical stripping of erosion-protective metallic coatings from a part (namely the leading edge) of a helicopter rotor blade. The apparatus involves a moveable counter-electrode (cathode) which may be shaped to conform generally to the leading edge of the workpiece (see D1, claims 1 and 12; column 4, lines 20 to 26; column 5, lines 2 to 8; Figure 5, reference signs 11', 18' and 34').

However, D2a does not reveal a process of stripping a metallic coating from blades of a gas turbine engine. Nor does it disclose a negative lead attached to a conductive grid.

Therefore, the claimed subject-matter is novel having regard to D2a.

2.3 D3 discloses a process for the electrochemical stripping of tungsten carbide coatings from a titanium or titanium alloy substrate, such as aircraft components and jet engine blade parts (see claim 11; column 2, lines 3 to 8; column 2, lines 49 to 52). The workpiece is immersed in an aqueous electrolytic bath containing CrO₃ and optionally sulfuric acid (column 3,

lines 22 to 24). The cathodes consist of Pb (column 2, line 67 to column 3, line 2).

As D3 discloses neither an electrode in the form of a grid nor the shaping of the cathode to conform to the surface of the workpiece part to be stripped, the claimed subject-matter is novel having regard to D3.

2.4 D4 is concerned with the electrochemical removal of unwanted braze build-up (30) from certain parts of a stator vane assembly (26, 28) (see claim 1; column 1, lines 6 to 14; column 2, lines 11 to 18; Figures 1 and 2). To this end, the invention proposes a counter-electrode (cathode) in the shape of a disc (34) having a number of threaded extensions (36) and heads (38) fitting within the gaps of the vanes (28) (see column 2, lines 11 to 26; Figure 2). The gap between the cathode (screw) and the anode (excess braze on the vanes) automatically controls the cell resistance and the current flow and thus the extent of the metal removed (see column 3, lines 4 to 17).

D4 thus may be seen as disclosing adapting the shapes of cathode and work piece in order to control metal removal. However, D4 does not disclose a cathode in the shape of a grid. Therefore, at least for this reason, the claimed subject-matter is novel having regard to D4.

2.5 D5 relates to an electrolytic process for removing metal coatings, such as deposits of Cr, Ni, Zn or Cu, from aluminium substrates without removal or loss of Al (see column 1, lines 15, 16, 43 to 47; column 2, lines 3 to 6). The stripping bath consists of dilute aqueous

sulphuric acid, the temperature is 65 to 100°F and the current density 4 to 130 A/in² (column 1, lines 64 to 68; column 2, lines 17 to 25). Under the said conditions, it was found that as soon as the metal overlying the Al substrate is removed, the current drops to zero and the removal action selectively ceases without attack of the base Al (column 2, lines 34 to 48).

D5 discloses neither a cathode in the form of a grid, nor the shaping of the cathode to conform to the surface of the workpiece part to be stripped. The claimed subject-matter is thus novel having regard to the disclosure of D5.

- 2.6 D6 relates to a process for the selective anodic dissolution of a metal coating of Cu or Cu alloy from a Zr or Zr-base alloy article. The electrolyte preferably contains 25 to 100 g/l of sulphuric acid and 50 to 100 g/l of CuSO₄ (see column 1, lines 63 to 69). The cathode is constituted by grids of wire or expanded metal located above and below the anode at a minimum distance of 5 mm (see column 2, lines 39 to 43). The process may be applied to metallic parts of various different shapes, for instance to tubular or hollow parts using an auxiliary cathode entering in the re-entrant part (see column 3, lines 19 to 27).

D6 does not disclose a process for stripping a coating from gas turbine blades. Shaping of the electrode to conform to the surface of the part of the workpiece to be stripped is not disclosed, either. Therefore, the claimed subject-matter is novel having regard to the disclosure of D6.

2.7 In summary, the subject-matter of claim 1 of the main request is novel in view of the cited prior art. The requirements of Article 54 EPC are met.

3. Inventive step

3.1 The invention is concerned with a process for the electrochemical stripping of metallic coatings from gas turbine engine blades.

3.2 *Closest prior art*

The board can accept that D1 is to be considered as the closest prior art document. As mentioned above, D1 is concerned with a method for electrochemically stripping of metallic coatings from a basis metal of the iron group, in particular of aluminide coatings from the surfaces of gas turbine engine blades made of Ni based superalloys (see column 1, lines 4 to 24).

3.3 *Technical problem*

Starting from D1, the technical problem can be defined as providing a method for electrochemically stripping of metallic coatings from the blades of a gas turbine engine, which method is fast and does not reduce the wall thickness of the substrate (see in this respect page 3, lines 19 to 26 of the present application).

3.4 *Solution*

As a solution to this technical problem, the application proposes an electrochemical stripping method according to claim 1, characterized in that the

negative electrode is formed by a conductive grid, and in that the shape of the conductive grid is tailored to the blade shape such that the shape of the grid corresponds to the shape of the portion of the blade to be stripped.

3.5 *Success of the solution*

Shaping of the conductive grid, tailored to the blade shape such that the shape of the grid corresponds to the shape of the portion of the blade to be stripped, reduces or even eliminates variation in the distance between work piece and electrode and hence makes it possible to apply a uniform stripping current density, thereby reducing the danger of electrolytic attack on the substrate. Likewise, there is no need to increase the distance between the workpiece and electrode or to limit the voltage, as suggested in D1, in order to obtain an even stripping of the parts. Because of the reduced distance, it is plausible that the stripping process proceeds fast (typically from 30 s to 10 min; see description, page 3, first paragraph).

In comparison, D1 requires an increased distance of 4 to 6 inches (10.2 to 15.2 cm) between the work piece and the cathode and a voltage limited to 2.4 V to prevent the chemical dissolution of already stripped parts. Under these conditions, the stripping process is slow and typically takes several hours (see D1, column 3, lines 34 to 40; examples I and II).

As regards the selection of a conductive grid attached to the negative lead from the power supply, the board accepts the argument submitted by the appellant that

grids may be adapted to conform to complex surfaces more easily than other types of electrodes, such as the lead lining used in the process of D1 (see column 6, lines 3 to 4; Figure 5) or the shaped block electrode used in the method of D2a (see column 3, lines 16 to 19; Figures 2, 4, reference sign 34; Figure 5, reference sign 34'). In view of the fact that the turbine blades of gas turbine engines are known to have a very complex geometry (see D1, column 5, lines 6 to 9), the easy adaptability of grids to complex surfaces offers an important technical advantage.

The board is therefore satisfied that the underlying problem is successfully solved.

3.6 *Obviousness*

It remains to be decided whether the claimed solution was obvious having regard to the prior art. In particular, the question to be decided is whether it was obvious to provide the claimed tailoring of an electrode in the form of a conductive grid to the turbine blade's shape such that the shape of the electrode corresponds to the shape of the portion of the blade to be stripped, in view of the problem posed.

- 3.6.1 The board accepts the examining division's argument that it is common technical knowledge that in order to obtain a uniform stripping, it is desirable to have a homogenous distribution of the electrical field between the electrodes. Such a homogenous distribution is usually obtained by arranging the work piece and the counter-electrode at a constant distance.

D1 indeed states that such an equal distance would be desirable for uniform stripping, but at the same time asserts that it was not feasible because of the very complex geometry of the turbine blades (see column 5, lines 6 to 11). Therefore, in the board's opinion, document D1 cannot be regarded as teaching that the tailoring of the electrode to the turbine blade was known in the art. What D1 factually discloses is that such tailoring was not considered to be feasible.

Therefore, D1 cannot render the claimed subject-matter obvious.

3.6.2 In the process of D2a for the electrochemical stripping of erosion-protective metallic coatings from a part (namely the leading edge) of a helicopter rotor blade, the counter-electrode (cathode) may be shaped to conform generally to the leading edge of the workpiece (see column 4, lines 20 to 26; column 5, lines 2 to 8). As shown in Figure 5 of D2a, the electrode 34' is in the form of an unstructured, solid block. Therefore, the process of D2a involves the feature of tailoring the shape of the cathode so as to correspond to the shape of the portion of the blade to be stripped.

3.6.3 The appellant argued that document D2a related to a process of removing a metallic erosion shield from a helicopter rotor blade. Since the erosion shield concerned was attached to the composite blade by a layer of non-metallic adhesive, the electrochemical stripping process stopped naturally as soon as this layer was reached. Therefore, in the process of D2a there was no risk of damaging the underlying material, in contrast to the present process where no such

barrier existed. In the appellant's view, the skilled person would thus not have taken D2a into consideration.

3.6.4 The board does not ignore the differences in shape, size and construction between a helicopter rotor blade and a gas turbine blade. However, the board considers that the skilled person would definitely take the disclosure of D2 into account since D2a relates to the same technical area as the present application and addresses similar technical problems.

3.6.5 D2a is not limited to a method for removing a metallic coating from a non-metallic substrate, but mentions that the invention can be used to remove a metallic erosion shield from a metallic blade, or a metallic/composite blade, if desired, although careful control of the electrochemical machining technique is required in this case to ensure avoidance of damage to the underlying structure of the blade (see column 4, lines 42 to 49). The board notes, however, that even in such a case the layer of inert adhesive below the metallic erosion shield still protects the underlying metallic structure from being attacked (see column 4, lines 50 to 52). Therefore, the board accepts that the process of D2a requires less process control than the process of the present application, where such an inert and protective adhesive layer is missing.

3.6.6 Still more importantly, D2a does not disclose or suggest an electrode in the form of a conductive grid.

Although the use of grid-type electrodes in a process for electrochemical stripping is known (see D6, column 2, lines 39 to 43), neither D6 nor D2a suggests

the use of a conductive grid in the electrochemical stripping of gas turbine engine blades. In the claimed invention, the electrode in the form of a conductive grid not only provides the technical advantage of better access for the electrolyte to the portion of the blades to be stripped, but, due to its flexibility, also allows the grid to be tailored more easily, such that its shape corresponds precisely to the shape of the portion of the blade to be stripped. As already mentioned, a gas turbine engine blade exhibits a complex three-dimensionally curved surface (see for instance D3, Figure 1), which does not easily lend itself to being reproduced by a counter-electrode shaped from solid material as in D2a. The board therefore accepts that providing the electrode in the form of a conductive grid contributes in an important manner to the solution of the technical problem, insofar as it renders the adaptation of the shape of the electrode to the shape of the portion to be stripped feasible.

3.6.7 The remaining prior art documents do not provide a hint in this direction, either. In particular, D3 discloses a conventional process of stripping gas turbine engine blades, and neither suggests an electrode in the form of a grid, nor the shaping of the cathode to conform to the surface of the work piece part to be stripped. D4 and D5 relate to technical fields which are quite remote from the filed of the present application. Therefore, these documents would not have been considered by the skilled person in view of the problem posed.

3.7 The subject-matter in accordance with claim 1 therefore involves an inventive step.

3.8 The dependent claims 2 to 8 define preferred embodiments of the inventive process and derive their patentability from claim 1.

The requirements of Article 56 EPC are thus met.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.
2. The case is remitted to the department of first instance with the order to grant a patent on the basis of claims 1 to 8 filed during the oral proceedings, and a description to be adapted.

The Registrar

The Chairman

C. Vodz

E. Waeckerlin