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(54) **Method of applying a coating system**

Verfahren für das Auftragen eines mehrschichtigen Systems

Méthode d'application d'un système de couches

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(73) Proprietor: **Alstom Technology Ltd**
5400 Baden (CH)

(72) Inventors:
- **Khan, Andus Suttar**
  5408 Ennetbaden (CH)
- **Fried, Reinhard**
  5415 Nussbaumen (CH)

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EP-A- 1 253 294 **DE-A- 10 057 187**

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Description

FIELD OF INVENTION

[0001] The invention relates to a process of method of applying a coating system to the surface of an article according to the independent claim.

STATE OF THE ART

[0002] Components designed for use in the area of high temperature environment, e.g. blades or vanes of a gas turbine, are usually coated with environmentally resistant coatings. The coating protects the base material against corrosion and oxidation due to the thermal effect of the hot environment. Most turbine components are coated for protection from oxidation and/or corrosion with, for example, a MCrAlY coating (base coat) and some are also coated with a thermal barrier coating (TBC) for thermal insulation. MCrAlY protective overlay coatings are widely known in the prior art. They are a family of high temperature coatings, wherein M is selected from one or a combination of iron, nickel and cobalt. As an example US-A-3,528,861 or US-A-4,585,481 disclose such kind of oxidation resistant coatings. US-A-4,152,223 as well discloses such method of coating and the coating itself.

[0003] Furthermore, Thermal-Barrier-Coatings (TBC) are known in the state of the art from different patents, i.e US-A-4,055,705, US-A-4,248,940, US-A-4,321,311 or US-A-4,676,994 disclose a TBC-coating for the use in the turbine blades and vanes. The ceramics used are yttria stabilized zirconia and applied by plasma spray, US-A-4,055,705, US-A-4,248,940 or by electron beam process, US-A-4,321,311, US-A-4,676,994 wherein the yttria stabilized zirconia is applied on top of the MCrAlY bond coat.

[0004] The plasma sprayed TBCs generally fail by delamination and a number of factors are thought to contribute to the delamination of the TBC:

a) Unfavorable stress distribution at the TBC-bond coat interface due to thermal expansion mismatch and the difference in physical and mechanical properties between the TBC and bond coat,

b) The growth stress of thermally grown oxide (TGO) due to formation of mixed oxides in preference to pure aluminum oxide,

c) Coating process is not duly optimized which results in a low porosity in the TBC.

[0005] To enhance durability a considerable amount of work has been done in the literature, for example, in the area of stress relief in the TBC system, and also efforts to promote a formation of pure alumina TGO in preference to TGO containing mixed oxides.

[0006] In order to reduce expansion mismatch, US-A-5,863,668 and US-A-6,093,454 are using two layer bond coats, the first layer is MCrAlX and the second layer is MCrAlX mixed with chromia, alumina and other oxides.

[0007] US-A-4,457,948 provided a stress relief in the TBC by a post-coating heat-treatment by a rapid quenching from elevated temperature which resulted in a cracking of the TBC. While US-A-5,073,433, provided a stress relief by a vertical segmentation of a dense TBC. Here a dense TBC is required for the preferred crack morphology. Other examples provided in the literature are of US-B1-6,224,963 where a segmented TBC was produced by a laser drilling in the selected area in the TBC. US-A-5,681,616 produces a segmented TBC by abrading a portion of the TBC with a high pressure liquid jet. Depositing a columnar grained TBC, Gray, et al provided yet another stress relief mechanism described in the US-A-6,180,184, US-A-5,830,586 and US-A-6,306,517. Another example of segmented TBC was in an invention described by Kojima, US patent No.5,840, 434 wherein a segmented TBC was formed by a control of a PVD process parameters. US-A-6,316,078 disclosed a method of forming a macro-segmented TBC by placing a three-dimensional pattern or feature on the surface. The disclosed features could be either raised ribs or grooves on the substrate or on the bond coat.

[0008] In US-A1-2002/0146584 and US-A1-2002/0146541 a surface was formed by cast feature or rivets placed on the surface upon which the TBC was deposited.

[0009] Promoting a pure aluminum oxide TGO on a MCrAlY bond coating have not been very successful. In general the bond coatings deposited by plasma spraying or electron beam process the TGO formed a mixed oxide TGO. A post coating heat-treatment generally do not promote alumina scale at lower temperatures i.e. below 950°C.

[0010] Based on the above literature following comments can be made:

i) While stress relief is provided by Segmented TBC, for examples as disclosed by US-A-5,073,433 but this can be accomplished only in a dense TBC. It is known that a dense TBCs have higher thermal conductivity contrary to the low conductivity ceramic desired for efficient thermal insulation.

ii) Exploitation of the segmentation technologies described in the literature often require special equipment and or complex process parameter control.

iii) Cost-effective manufacturing of TBC on large industrial gas turbine components by the current TBC segmentation technology is difficult.
iv) Additionally, it is not obvious how a durable, porous and thick TBC can be manufactured as disclosed by US-A-5,073,433,
(v) There has been no reliable method of post coating treatment or bond coating processing that allows or promotes formation of a pure alumina only TGO upon the MCrAlY bond coating

SUMMARY OF THE INVENTION

[0011] It is the aim of the present invention to create a coating system with a thin and uniform metallic bond coating that forms purely alumina oxides as thermally grown oxide under a thermal barrier coating.

[0012] According to the present invention a method of applying a coating system to the surface of an article was found, comprising the steps of

- placing a number of rivets on top of said surface of said article distributed so as to induce segmentation of ceramic coating,
- depositing a metallic bond coating to the surface and the rivets a by an electroplating process,
- depositing a ceramic coating on top of said metallic bond coating containing said rivets.

[0013] The advantages of the invention include, inter alia, that the surface of the rivets could be made extremely rough. The rivets can be stamped on or soldered-on the surface or cast features on the surface. It is stated that the MCrAlY bond coating in this invention upon which TBC is built will be deposited by an electroplating process according to unpublished patent application with application no. EP02405881.0 (internal reference number of the applicant B02/046-0). It is noted that the cost of the application of a metallic bond coating 6 by an electroplating process is significantly less than that of conventional plasma spray process. In addition, the electroplating process has a thickness control of ±25 μm or better. This thickness control is desired to reduce the effects of properties of metallic bond coating 6 on the stability of the TBC. Thus, the electroplating process can apply MCrAlY bond coating with a layer thickness in the range of 25 to 400 μm, preferably in the range of 50 to 300 μm. A thin coating increase the TMF life of the coating. Further in contrast to plasma spray process the plating process has no line of sight limitation and can coat complex contour surfaces without any difficulty. In addition the metallic bond coating 6 thus manufactured contains very little oxygen as impurity such as mixed oxides. One example of a MCrAlY coating is Ni-23Co-18Cr-10Al-0.5Y. Generally, the MCrAlY can have a γ/γ'- or γ/β-structure.

[0014] The thick segmented TBC will be deposited using a known state of the art plasma spray process with conventional equipment. The invention disclosed here will not require a dense TBC and will be built up consisting of a high porosity in the range of 10 to 20 %. The present invention is a process for manufacturing of a thick layer of the ceramic coating with an intended thickness of at least between 1 to 10 mm. It is intuitively obvious that the nature of segmentation cracks in the TBC will depend on rivet distribution, rivet size, thickness of the rivets and rivet length.

[0015] This invention is particularly useful when applied to articles such as blades, vanes or any other gas turbine component operating at high temperatures and coated with MCrAlY as bond coating and with TBC as ceramic coating. The inventive coating system including the rivets can be placed locally on the pressure or suction side or on the platform of said turbine blade or vane.

BRIEF DESCRIPTION OF DRAWINGS

[0016] Preferred embodiments of the invention are illustrated in the accompanying drawings, in which

Fig. 1 shows a gas turbine blade as an example and
Fig. 2 shows a coating system according to the present invention.

[0017] The drawing shows only parts important for the invention.

DETAILED DESCRIPTION OF INVENTION

[0018] The present invention is generally applicable to components that operate within environments characterised by relatively high temperature, and are therefore subjected to severe thermal stresses and thermal cycling. Notable examples of such components include the high and low-pressure nozzles and blades, shrouds, combustor liners and augmentor hardware of gas turbine engines. Fig. 1 shows as an example such an article 1 as blades or vanes comprising a blade 2 against which hot combustion gases are directed during operation of the gas turbine engine, a cavity, not visible in Figure 1, and cooling holes 4, which are on the external surface 5 of the component 1 as well as on the platform 3 of the component. Through the cooling holes 4 cooling air is ducted during operation of the engine to cool the external surface 5. The external surface 5 is subjected to severe attack by oxidation, corrosion and erosion due to the hot combustion gases. In many cases the article 1 consists of a nickel or cobalt base super alloy such as disclosed in the state of the art, e.g. from the document US 5,888,451, US 5,759,301 or from US 4,643,782, which is known as "CMSX-4". In principle, the article 1 can be single crystal (SX) or directionally solidified (DS).

[0019] As seen in Fig. 2, the invention is related to a process of applying a coating system to the surface 8 of the article 1. In a first step, the surface 8 is prepared by cleaning, grit blasting and other preparation methods including chemical etching. Then a number of rivets 9 are placed on top of the surface 8 of said article 1 and a metallic bond coating 6 is deposited on the surface 8 of the article 1 and the rivets 9 by an electroplating process. Then a Thermal Barrier Coating (TBC) as ceramic coating 7 such as Y stabilized zirconia is deposited on top of the metallic bond coating 6 containing the rivets 9.

[0020] It is noted that the cost of the application of a metallic bond coating 6 by an electroplating process is significantly less than that of conventional plasma spray process. In addition, the electroplating process has a thickness control of $\pm 25\ \mu m$ or better, whereas a conventional plasma spray coating process have thickness scatter of $\pm 75\ \mu m$ or more. A thickness control $\pm 25\ \mu m$ or better of the metallic bond coating 6 is desired to reduce the effects of properties of metallic bond coating 6 on the stability of the TBC. Thus, the electroplating process can apply MCrAlY bond coating with a layer thickness of 25 to 400 μm, preferably in the in the range of 50 to 300 μm. A thin coating increase the TMF life of the coating. Further in contrast to plasma spray process the plating process has no line of sight limitation and can coat complex contour surfaces without any difficulty. In addition the metallic bond coating 6 thus manufactured contains very little oxygen as impurity such as mixed oxides. One example of a MCrAlY coating is Ni-23Co-18Cr-10Al-0.5Y. Generally, the MCrAlY can have a γ/γ'- or γ/β-structure.

[0021] It is reasonable to assume that persons skilled in the art will acknowledge that a multitude of surface structure or features can be envisioned with the placement or distribution of rivets 9, rivet height. Especially rivets 9 in form of a wire or a pin or a wire mesh can be placed on top of said surface 8 of the article 1. Such rivets 9 can be made from stainless steel, nickel base, cobalt or iron alloys.

[0022] The advantages of the invention include, inter alia, that the surface of the rivets 6 could be made extremely rough. The rivets 6 can be stamped on or soldered on the surface 8 or cast features on the surface 8. The rivets 6 are distributed in a way as to induce segmentation of the ceramic coating 7 applied afterwards on top of the bond coating 6.

[0023] The thick segmented TBC will be deposited using a known state of the art plasma spray process with conventional equipment. The invention disclosed here will not require a dense TBC and will be built up consisting of a high porosity in the range of 10 to 20 %. The present invention is a process for manufacturing of a thick layer of the ceramic coating with an intended thickness of at least between 1 to 10 mm. It is intuitively obvious that the nature of segmentation cracks in the TBC will depend on rivet distribution, rivet size, thickness of the rivets and rivet length.

[0024] The invention is particularly advantageous when applied to a blade or a vane or any other gas turbine component consisting of a nickel or cobalt base alloy exposed to a high temperature environment and coated with MCrAlY as bond coating and with TBC as ceramic coating. The inventive coating system including the rivets 9 can be placed locally on the pressure or suction side or on the platform 3 of said turbine blade or vane.

REFERENCE NUMBERS

[0025]

1 Article
2 Blade
3 Platform
4 Cooling holes
5 External surface of article 1
6 Metallic bond coating
7 Ceramic coating
8 Surface of article 1
9 Rivets

Claims

1. A method of applying a coating system to the surface (8) of an article (1) comprising the steps of

   - placing a number of rivets (9) on top of said surface (8) of said article (1)
   - depositing a metallic bond coating (6) to the surface (8) and the rivets (9) by an electroplating process,
   - depositing a ceramic coating (7) on top of said metallic bond coating (6) containing said rivets (9),

   wherein as metallic bond coating (6) a MCrAlY with a γ/γ'- or γ/β-structure is applied.

2. The method in claim 1, wherein a layer thickness of the metallic bond coat (6) is applied in the range of 25 to 400 μm.

3. The method in claim 2, wherein a layer thickness of the metallic bond coat (6) is applied in the range of 50 to 300 μm.

4. The method in any of the claims 1 to 3, wherein with a plasma spray process a ceramic coating (7) with a thickness in a range of 1 mm to 10 mm is applied.

5. The method in claim 4, wherein a ceramic coating (7) with a porosity of 10 to 20 % is applied.

6. The method in any of the claims 1 to 5, wherein rivets (9) are stamped on, soldered on or cast features on top of said surface (8) of said article (1).

7. The method in any of the claims 1 to 6, wherein rivets (9) in form of a wire or a pin or a wire mesh are placed on top of said surface (8) of said article (1).

8. The method in claim 7, comprising the step of using rivets (9) made from stainless steel, nickel base, cobalt bade or iron base alloys.

9. The method in any of the claims 1 to 8, wherein said coating system is placed locally on the pressure or suction side or on the platform (3) of a turbine blade or vane as the article (1).

Patentansprüche

1. Verfahren für die Anwendung eines Beschichtungssystems auf die Oberfläche (8) eines Gegenstandes (1), welches folgende Schritte aufweist:

   - Anbringen einer Anzahl von Nieten (9) auf der Oberfläche (8) des Gegenstandes (1),
   - Aufbringen einer metallischen Haftbeschichtung (6) auf die Oberfläche (8) und die Nieten (9) durch einen Galvanisierungsprozess,
   - Aufbringen einer keramischen Beschichtung (7) auf die metallische Haftbeschichtung (6), die die Nieten (9) enthält,

   wobei als metallische Haftbeschichtung (6) MCrAlY mit einer γ/γ'- oder γ/β-Struktur angewandt wird.

2. Verfahren nach Anspruch 1, wobei eine Schichtdicke der metallischen Haftbeschichtung (6) in einem Bereich von 25 bis 400 μm angewandt wird.

3. Verfahren nach Anspruch 2, wobei eine Schichtdicke der metallischen Haftbeschichtung (6) in einem Bereich von 50 bis 300 μm angewandt wird.

4. Verfahren nach einem der Ansprüche 1 bis 3, wobei mittels eines Plasmasprühprozesses eine keramische Beschichtung (7) mit einer Dicke in einem Bereich von 1 mm bis 10 mm angewandt wird.

5. Verfahren nach Anspruch 4, wobei eine keramische Beschichtung (7) mit einer Porosität von 10 bis 20 % angewandt wird.

6. Verfahren nach einem der Ansprüche 1 bis 5, wobei die Nieten (9) auf der Oberfläche (8) des Gegenstandes (1)

eingeschlagene, aufgeschweißte oder angegossene Strukturen sind.

7. Verfahren nach einem der Ansprüche 1 bis 6, wobei Nieten in der Form eines Drahtes, eines Stifts oder eines Drahtgitters auf der Oberfläche (8) des Gegenstandes (1) angebracht werden.

8. Verfahren nach Anspruch 7, welches den Schritt des Verwendens von Nieten (9) aufweist, die aus Edelstahl, Nickelbasis-, Kobaltbasis- oder Eisenbasislegierungen hergestellt sind.

9. Verfahren nach einem der Ansprüche 1 bis 8, wobei das Beschichtungssystem lokal auf die Druck- oder Saugseite oder auf die Plattform (3) eines Turbinenblatts oder einer Turbinenschaufel als dem Gegenstand (1) angebracht wird.

Revendications

1. Méthode d'application d'un système de couches à la surface (8) d'un article (1), comprenant les étapes consistant à :

- placer un certain nombre de rivets (9) sur ladite surface (8) dudit article (1),
- déposer une couche de liaison métallique (6) sur la surface (8) et les rivets (9) par un procédé de placage par électrodéposition,
- déposer une couche céramique (7) par-dessus ladite couche de liaison métallique (6) contenant lesdits rivets (9),

une couche de MCrAlY ayant une structure γ/γ' ou γ/β étant appliquée en tant que couche de liaison métallique (6).

2. Méthode selon la revendication 1, dans laquelle une épaisseur de couche de la couche de liaison métallique (6) est appliquée dans la plage de 25 à 400 μm.

3. Méthode selon la revendication 2, dans laquelle une épaisseur de couche de la couche de liaison métallique (6) est appliquée dans la plage de 50 à 300 μm.

4. Méthode selon l'une quelconque des revendications 1 à 3, dans laquelle, avec un procédé de pulvérisation au plasma, on applique une couche céramique (7) ayant une épaisseur dans la plage de 1 mm à 10 mm.

5. Méthode selon la revendication 4, dans laquelle on applique une couche céramique (7) ayant une porosité de 10 à 20%.

6. Méthode selon l'une quelconque des revendications 1 à 5, dans laquelle des rivets (9) sont matricés sur, brasés sur, ou impriment des caractéristiques sur le dessus de ladite surface (8) dudit article (1).

7. Méthode selon l'une quelconque des revendications 1 à 6, dans laquelle des rivets (9) en forme de fil métallique ou de goupille ou de maillage métallique sont placés par-dessus ladite surface (8) dudit article (1).

8. Méthode selon la revendication 7, comprenant l'étape consistant à utiliser des rivets (9) fabriqués en acier inoxydable, en alliages à base de nickel, de cobalt ou de fer.

9. Méthode selon l'une quelconque des revendications 1 à 8, dans laquelle ledit système de couches est placé localement sur le côté pression ou aspiration ou sur la plate-forme (3) d'une aube ou d'une pale de turbine en tant qu'article (1).

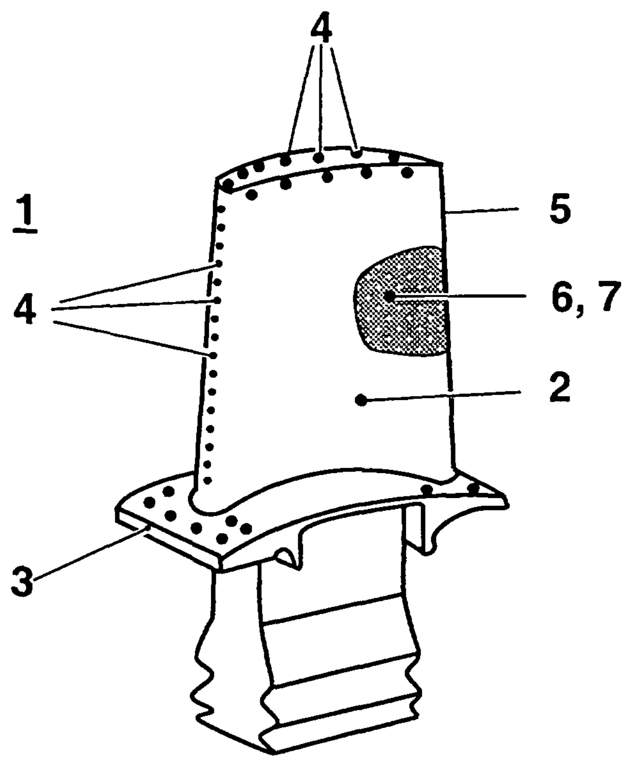

Fig. 1

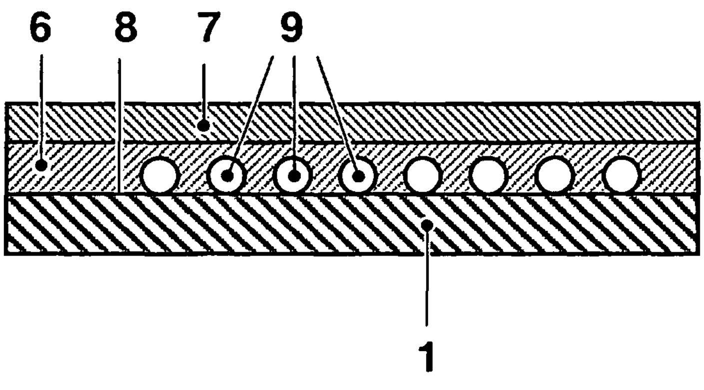

Fig. 2