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(54) Method of applying a coating system

(57) It is disclosed a method of applying a coating system to the surface (8) of an article (1). In a first step a metallic bond coating (6) to the surface (8) of the article (1) is deposited, then a number of rivet (9) on top of the metallic bond coating (6) is applied. In a second step a thick, segmented ceramic coating (7) on top of the metallic bond coating (6) and the rivets (6) is deposited. The present invention is a process for manufacturing of a thick layer of the ceramic coating 7 with an intended thickness of at least between 1 to 10 mm.

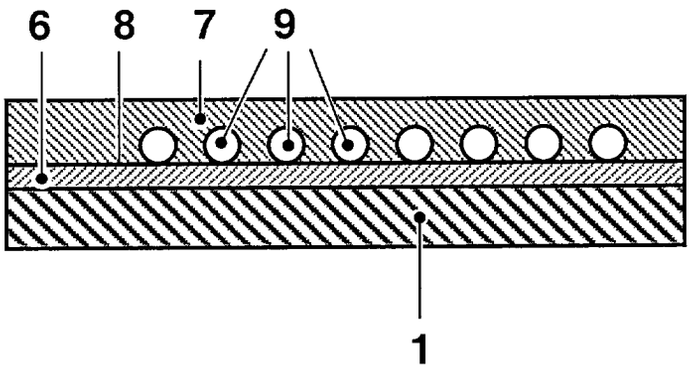


Fig. 2

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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 durable, thick and porous thermal barrier coating, which is at the same time segmented.

[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

- depositing a metallic bond coating to the surface by an electroplating process,
- placing a number of rivets on top of the metallic bond coating,
- depositing a ceramic coating on top of said metallic bond coating and 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. For example, if soldered, sintered-on rivets represent very stable and positively locking anchor points for the TBC layer which is to be sprayed on, so that comparatively thick, stably adhering ceramic thermal barrier coatings can be produced. The 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.

[0014] 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-structu re.

[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 a metallic bond coating 6 is deposited to the surface 8 of the article 1 by an electroplating process. Before the metallic bond coat 6 is applied, the surface 8 is prepared by cleaning, grit blasting and other preparation methods including chemical etching. Then a number of rivets 9 are deposited on top of the bond coating 6. A Thermal Barrier Coating (TBC) as ceramic coating 7 such as Y stabilized zirconia is deposited on top of the metallic bond coating 6 and 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 ±25 μm or better, whereas a conventional plasma spray coating process have thickness scatter of ±75 μm or more. A thickness control ±25 μm 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 the metallic bond coating 6. 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. For example, if soldered, sintered-on rivets 8 represent very stable and positively locking anchor points for the TBC layer which is to be sprayed on, so that comparatively thick, stably adhering ceramic thermal barrier coatings can be produced. The 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.

[0023] 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

[0024]

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

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

2. The method in claim 1, wherein as metallic bond coating (6) is MCrAlY is applied.

3. The method in claim 2, wherein a MCrAlY with a γ/γ'- or γ/β-structure is applied by the electroplating process.

4. The method in any of the claims 1 to 3, wherein a layer thickness of the metallic bond coat (6) is applied in the range of 25 to 400 μm.

5. The method in claim 4, wherein a layer thickness of the metallic bond coat (6) is applied in the range of 50 to 300 μm.

6. The method in any of the claims 1 to 5, wherein with a plasma spray process a ceramic coating (7) with a thickness in a range of 1 mm to 10 mm is applied.

7. The method in claim 6, wherein a ceramic coating (7) with a porosity of 10 to 20 % is applied.

8. The method in any of the claims 1 to 7, wherein rivets (9) are stamped on or soldered to the metallic bond coating (6).

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

10. The method in claim 9, comprising the step of using

rivets (9) made from stainless steel, nickel base, cobalt bade or iron base alloys.

11. The method in any of the claims 1 to 10, 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).

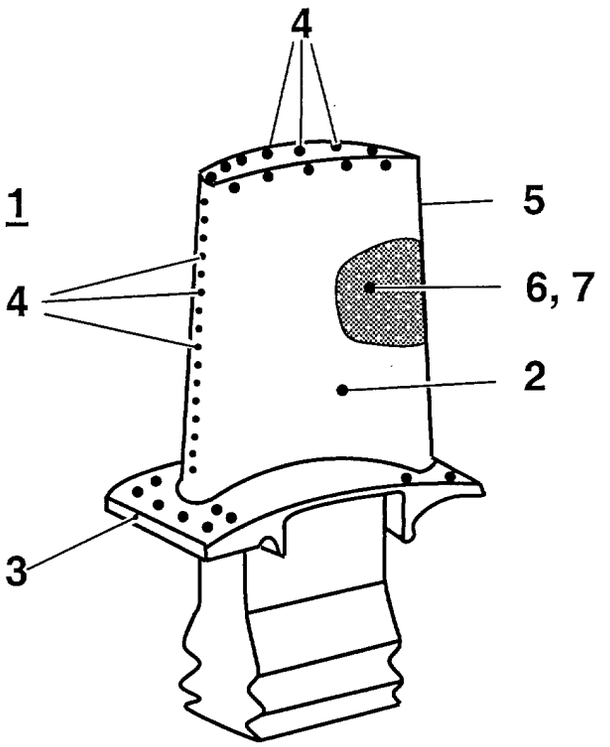


Fig. 1

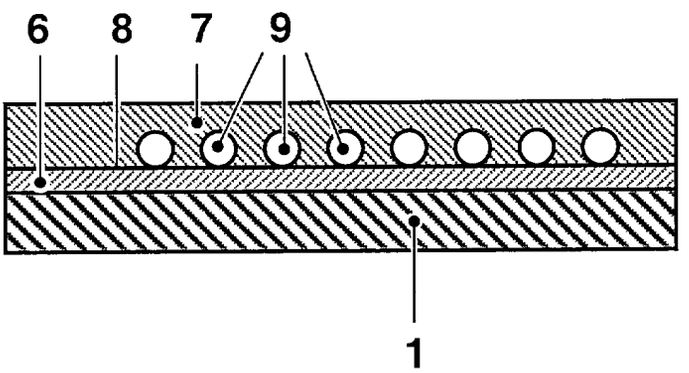


Fig. 2

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 03 40 5463

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X	EP 0 288 156 A (BAJ LTD) 26 October 1988 (1988-10-26) * column 1, line 26-41 * * claims 1,4 * ---	1,2,4,5, 11	
A	EP 0 776 985 A (ABB RESEARCH LTD) 4 June 1997 (1997-06-04) * figure 4 * * column 5, line 46 - column 6, line 20 * * column 9, line 7-29 * -----	1-11	TECHNICAL FIELDS SEARCHED (Int.Cl.7) C23C F01D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	10 October 2003	Haering, C

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 03 40 5463

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