

Description

This invention relates to the provision of overlay coatings incorporating thermal barriers on substrates. Such overlay coatings are employed on components which are subjected to high temperature environments, particularly where corrosion and/or erosion is likely to occur; the primary, but not necessarily sole, application of such coatings is to parts of gas turbine engines, particularly gas turbine combustion can ware, stator and rotor blades and guide vanes.

A process of producing an overlay coating comprising a thermal barrier has been described in a paper entitled "Rolls-Royce Experience with Thermal Barrier Coatings Including High Time Service Evaluation" by F. Chris Toriz, Suresh K. Gupta and A. Bennett at pages 81-90 of the proceedings

The 1985 ASM International Conference on Surface Modification and Coatings in Toronto, Canada. In this process the coating is produced by first spray coating on to a suitably prepared substrate surface a protection layer or bond coat of M_1CrAlY (where M is a suitable metal such as nickel or cobalt or nickel and cobalt) using a plasma deposition process, then spray coating another coat of a metal and ceramic by a flame deposition process which produces a deposit whose thermal expansion characteristics are intermediate those of the protection layer and the thermal barrier, and then spray coating a thermal barrier of a refractory material by a plasma deposition process.

While this procedure is, in general, satisfactory there are certain aspects of it which are not ideal. For example, the flame spraying of complex and re-entrant surfaces can be difficult and expensive.

According to the present invention an overlay coating on a substrate is provided by forming a protection layer by composite electrolytic or electroless deposition of a metal matrix M_1 containing particles of $CrAlM_2$ where M_1 is Ni or Co or both and M_2 is one or more of Y, Si, Ti, Hf, Ta or a rare earth element, forming an anchoring coat by composite electrolytic or electroless deposition of a metal matrix containing particles of a larger size than the particles of $CrAlM_2$ of the protection layer, and then spray coating a thermal barrier of a refractory material by a plasma deposition process.

The invention thus differs from that which has previously been proposed in that the protection layer and the anchoring coat are both electrolytically or electrolessly plated rather than being flame sprayed.

The production of an M_1CrAlM_2 layer by plating has already been proposed in GB-A-2167446 where the object is to produce a coating which will, at some stage, be modified by heat treatment and that specification stresses that there should be

close control of the particle size, the broadly preferred size requirement being that at least 99% by weight of the particles in the as-deposited coating are below $25\text{ }\mu\text{m}$ or at least 95% are between 3.0 and $13.6\text{ }\mu\text{m}$. The specification mentions that electrodeposition produces a coating which has a very desirable surface finish.

Electrolytic plating and electroless plating are processes which are well known to produce coatings with smooth, often shiny, surfaces and the incorporation in the deposited matrix of particles of this size still leads to relatively smooth surfaces. A thermal barrier cannot be applied directly to a spray coated M_1CrAlY coating with sufficient adhesion because the sprayed M_1CrAlY coating is insufficiently rough. A spray coated anchoring coat using coarser particles has been necessary in prior art processes as described above. Consequently it would be thought that composite plating would be quite useless in providing a base for a thermal barrier. Most surprisingly, however, it has been found that an electrolytically or electrolessly plated M_1CrAlM_2 coat followed by a plated anchoring coat with larger particles provides a most satisfactory basis on to which a thermal barrier may be applied by spray coating, with completely satisfactory adhesion between the layers. Thus the plated anchoring coat is used to produce a rough keying surface, something which is quite contrary to the normally accepted property of a plated coat which is one of smoothness.

The preferred constituents of the anchoring coat are the same as or similar to those of the protection layer since, in addition to providing an anchorage function, this coat will be subjected to similar operating conditions to those for which the underlying protection layer is provided.

The preferred constituents of and processes for applying the protection layer are those set out in the aforementioned GB-A-2167446 and for further details of apparatus and processes that may be employed reference may be made to US-A-4305792. The same apparatus and processes may be used for applying the anchoring coat.

The invention may be carried into practice in various ways but the provision of one particular overlay on a gas turbine blade will now be described by way of example.

The blade was first given a preparation treatment suitable for plating and in one example it was immersed in a cyanide cleaner for two minutes followed by a water rinse, etched by immersion for 30 seconds in a ferric chloride etch followed by a water rinse, and given a nickel strike by placing in a nickel bath for 3 minutes at a current density of 3.5 amps per square decimetre. The blade was then secured in the plating barrel described in US-A-4305792 and connected to a cathode contact.

Using the techniques described in the said United States Patent the blade was given a coating to a thickness of between 0.076 and 0.127 mm of CoNiCrAlY, the bath containing a CoNi plating solution and the particles were of CrAlY containing 60 parts by weight of Cr, 40 parts Al and 1.7 parts Y. The particle size distribution was a maximum of 5% by weight below 5 μm , between 10 and 15% by weight below 10 μm and between 35 and 55% by weight below 20 μm . An alternative size distribution would be a maximum of 7.7% by weight below 5 μm , 56% below 10 μm , 94% below 20 μm and 99% below 30 μm .

The blade carrying the protection layer was removed from the apparatus and washed and was then positioned in the apparatus described in GB-A-2182055 containing a similar cobalt plating solution and with the apparatus charged with CrAlY particles having the same composition as those used for the protection layer but with a different size distribution as set out below. Should a delay occur in transferring from the initial M_1CrAlY coat to the second key coat process step, the component surfaces can be reactivated by immersion in the ferric chloride etch and a nickel strike similar to the initial pretreatment. The particle size distribution is such that there is not more than 1% of the powder with a size greater than 150 μm and not more than 15% with a particle size less than 38 μm . Plating proceeded to produce an anchoring coat with a thickness of between 0.025 and 0.15 mm.

The blade was then removed and washed. The coatings were then vacuum heat treated to effect bonding of the superficial powder to the rest of the deposit. For example, the blade could be treated at 1115°C for 2 hours or at a temperature within the range 1050 to 1100°C for 2 hours or within the range 900 to 1200°C for a maximum of 2 hours at 1200°C or a minimum of 1/4 hour at 900°C. The thermal barrier was then sprayed onto the anchoring coat by a plasma flame deposition process. The coat consisted essentially of an 8% yttria stabilized zirconia having a chemical composition by weight of between 7 and 9% Y_2O_3 , maxima of 1.5% SiO_2 , 0.5% CaO , 0.3% MgO , 0.4% Fe_2O_3 , 0.2% Al_2O_3 and 0.2% TiO_2 , and the balance being ZrO_2 . The particle size distribution was such that there was a maximum of 10% with a size greater than 74 μm , between 65 and 100% was above 44 μm and a maximum of 25% was below 44 μm . Instead of the vacuum heat treatment being carried out after the application of the anchoring coat, it could be carried out in the same manner after application of the thermal barrier.

As an alternative to the process described in US-A-4305792, the protective layer may be applied by the same apparatus and processes as are pro-

posed above for applying the anchoring coat and described in the aforesaid GB-A-2182055.

During thermal cycling tests on paddle shaped specimens coated on one side by the process in accordance with the invention and described above and moved in and out of a flame to give a surface temperature rise to 1050°C in 2 minutes, and a fall in 2 minutes, the specimens satisfactorily withstood 1000 thermal cycles where the typical commercial acceptance level is 500 thermal cycles.

Claims

1. A process of producing an overlay coating on a substrate which comprises the steps of:
 - 1) forming on said substrate a protection layer by composite electrolytic or electroless deposition of a metal matrix M_1 containing particles of CrAlM_2 where M_1 is Ni or Co or both and M_2 is one or more of Y, Si, Ti, Hf, Ta or a rare earth element,
 - 2) forming on said protection layer an anchoring coat by composite electrolytic or electroless deposition of a metal matrix containing particles of a larger size than the particles of CrAlM_2 of the protection layer, and then
 - 3) spray coating on said protection layer a thermal barrier of a refractory material by a plasma deposition process.
2. A process according to Claim 1 in which the particles of said anchoring coat are of the same composition as, but of larger particle size than, the particles of said protection layer.
3. A process according to Claim 1 or Claim 2 in which the size distribution of the particles in said protection layer is a maximum of 5% by weight below 5 μm , between 10 and 15% by weight below 10 μm and between 35 and 55% by weight below 20 μm .
4. A process according to Claim 3 in which said protection layer has a thickness of from 0.076 to 0.127 mm.
5. A process according to Claim 1 or Claim 2 in which the size distribution of the particles in said protection layer is a maximum of 7.7% by weight below 5 μm , 56% below 10 μm , 94% below 20 μm and 99% below 30 μm .
6. A process according to any of Claims 1 to 5 in which the size distribution of the particles in said anchoring coat is a maximum of 1% by weight above 150 μm and a maximum of 15% by weight below 38 μm .



Using the techniques described in the said United States Patent the blade was given a coating to a thickness of between 0.076 and 0.127 mm of CoNiCrAlY, the bath containing a CoNi plating solution and the particles were of CrAlY containing 60 parts by weight of Cr, 40 parts Al and 1.7 parts Y. The particle size distribution was a maximum of 5% by weight below 5 μm , between 10 and 15% by weight below 10 μm and between 35 and 55% by weight below 20 μm . An alternative size distribution would be a maximum of 7.7% by weight below 5 μm , 56% below 10 μm , 94% below 20 μm and 99% below 30 μm .

The blade carrying the protection layer was removed from the apparatus and washed and was then positioned in the apparatus described in GB-A-2182055 containing a similar cobalt plating solution and with the apparatus charged with CrAlY particles having the same composition as those used for the protection layer but with a different size distribution as set out below. Should a delay occur in transferring from the initial M_1 CrAlY coat to the second key coat process step, the component surfaces can be reactivated by immersion in the ferric chloride etch and a nickel strike similar to the initial pretreatment. The particle size distribution is such that there is not more than 1% of the powder with a size greater than 150 μm and not more than 15% with a particle size less than 38 μm . Plating proceeded to produce an anchoring coat with a thickness of between 0.025 and 0.15 mm.

The blade was then removed and washed. The coatings were then vacuum heat treated to effect bonding of the superficial powder to the rest of the deposit. For example, the blade could be treated at 1115°C for 2 hours or at a temperature within the range 1050 to 1100°C for 2 hours or within the range 900 to 1200°C for a maximum of 2 hours at 1200°C or a minimum of 1/4 hour at 900°C. The thermal barrier was then sprayed onto the anchoring coat by a plasma flame deposition process. The coat consisted essentially of an 8% yttria stabilized zirconia having a chemical composition by weight of between 7 and 9% Y_2O_3 , maxima of 1.5% SiO_2 , 0.5% CaO , 0.3% MgO , 0.4% Fe_2O_3 , 0.2% Al_2O_3 and 0.2% TiO_2 , and the balance being ZrO_2 . The particle size distribution was such that there was a maximum of 10% with a size greater than 74 μm , between 65 and 100% was above 44 μm and a maximum of 25% was below 44 μm . Instead of the vacuum heat treatment being carried out after the application of the anchoring coat, it could be carried out in the same manner after application of the thermal barrier.

As an alternative to the process described in US-A-4305792, the protective layer may be applied by the same apparatus and processes as are pro-

posed above for applying the anchoring coat and described in the aforesaid GB-A-2182055.

During thermal cycling tests on paddle shaped specimens coated on one side by the process in accordance with the invention and described above and moved in and out of a flame to give a surface temperature rise to 1050°C in 2 minutes, and a fall in 2 minutes, the specimens satisfactorily withstood 1000 thermal cycles where the typical commercial acceptance level is 500 thermal cycles.

Claims

1. A process of producing an overlay coating on a substrate which comprises the steps of:
 - 1) forming on said substrate a protection layer by composite electrolytic or electroless deposition of a metal matrix M_1 containing particles of CrAlM_2 where M_1 is Ni or Co or both and M_2 is one or more of Y, Si, Ti, Hf, Ta or a rare earth element,
 - 2) forming on said protection layer an anchoring coat by composite electrolytic or electroless deposition of a metal matrix containing particles of a larger size than the particles of CrAlM_2 of the protection layer, and then
 - 3) spray coating on said protection layer a thermal barrier of a refractory material by a plasma deposition process.
2. A process according to Claim 1 in which the particles of said anchoring coat are of the same composition as, but of larger particle size than, the particles of said protection layer.
3. A process according to Claim 1 or Claim 2 in which the size distribution of the particles in said protection layer is a maximum of 5% by weight below 5 μm , between 10 and 15% by weight below 10 μm and between 35 and 55% by weight below 20 μm .
4. A process according to Claim 3 in which said protection layer has a thickness of from 0.076 to 0.127 mm.
5. A process according to Claim 1 or Claim 2 in which the size distribution of the particles in said protection layer is a maximum of 7.7% by weight below 5 μm , 56% below 10 μm , 94% below 20 μm and 99% below 30 μm .
6. A process according to any of Claims 1 to 5 in which the size distribution of the particles in said anchoring coat is a maximum of 1% by weight above 150 μm and a maximum of 15% by weight below 38 μm .



7. A process according to Claim 6 in which the said anchoring coat has a thickness of from 0.025 to 0.15 mm.

8. A process according to any of Claims 1 to 7 wherein said thermal barrier consists essentially of yttria stabilized zirconia.

9. A process according to Claim 8 wherein the particle size distribution in the thermal barrier is a maximum of 10% by weight greater than 74 μm , between 65% and 100% above 44 μm , and not more than 25% below 44 μm .

10. A process according to Claim 1 for producing an overlay coating on a gas turbine engine component which comprises the steps of:

1) preparing the surface of said component for electroplating,

2) electroplating on said surface to a depth of from 0.076 to 0.127 mm a protection layer of CoNi containing particles of CrAlY containing 60 parts by weight of Cr, 40 parts Al and 1.7 parts Y,

3) electroplating on said protection layer to a depth of from 0.025 to 0.15 mm an anchoring coat of a cobalt-containing metal matrix containing CrAlY particles having a greater particle size than those of the protection layer,

4) spray coating on said protection layer a thermal barrier of a refractory material by a plasma deposition process, and

5) after step 3 or after step 4, heat treating said component.

dépôt sous plasma.

2. Procédé suivant la revendication 1, dans lequel les particules de la couche d'ancrage ont la même composition, mais d'une granulométrie plus élevée que les particules de la couche de protection.

3. Procédé suivant la revendication 1 ou 2, dans lequel le spectre granulométrique des particules dans la couche de protection comprend 5% en poids au maximum au-dessous de 5 μm , entre 10 et 15% en poids au-dessous de 10 μm et entre 35 et 55% en poids au-dessous de 20 μm .

4. Procédé suivant la revendication 3, dans lequel la couche de protection a une épaisseur de 0,076 à 0,127 mm.

5. Procédé suivant la revendication 1 ou 2, dans lequel le spectre granulométrique des particules dans la couche de protection comprend 7,7% en poids au maximum au-dessous de 5 μm , 56% au-dessous de 10 μm , 94% au-dessous de 20 μm et 99% au-dessous de 30 μm .

6. Procédé suivant l'une quelconque des revendications 1 à 5, dans lequel le spectre granulométrique des particules dans la couche d'ancrage comprend 1% en poids au maximum au-dessus de 150 μm et 15% en poids au maximum au-dessous de 38 μm .

7. Procédé suivant la revendication 6, dans lequel la couche d'ancrage a une épaisseur de 0,025 à 0,15 mm.

8. Procédé suivant l'une quelconque des revendications 1 à 7, dans lequel la barrière thermique consiste essentiellement en zircone stabilisée par de l'oxyde d'yttrium.

9. Procédé suivant la revendication 8, dans lequel le spectre granulométrique de la barrière thermique comprend 10% en poids au maximum au-dessus de 74 μm , entre 65 et 100% au-dessus de 44 μm et pas plus de 25% au-dessous de 44 μm .

10. Procédé suivant la revendication 1, pour produire un revêtement sur un organe de turbine à gaz, qui comprend les stades :

1) de préparation de la surface de l'organe en vue du dépôt électrolytique,

2) de dépôt électrolytique, sur cette surface, jusqu'à une épaisseur de 0,076 à 0,127

Revendications

1. Procédé pour produire un revêtement sur un substrat, qui comprend les stades :

1) de formation, sur ce substrat, d'une couche de protection par dépôt composite électrolytique ou non électrolytique d'une matrice métallique M_1 contenant des particules de CrAlM_2 , où M_1 est Ni ou Co ou les deux et M_2 est un ou plusieurs d'entre Y, Si, Ti, Hf, Ta ou un élément des terres rares,

2) de formation, sur la couche de protection, d'une couche d'ancrage par dépôt composite électrolytique ou non électrolytique d'une matrice métallique contenant des particules d'une dimension supérieure à celle des particules de CrAlM_2 de la couche de protection, et ensuite

3) d'application par pulvérisation, sur la couche de protection, d'une barrière thermique d'une matière réfractaire par un procédé de



mm, d'une couche de protection de CoNi contenant des particules de CrAlY contenant 60 parties en poids de Cr, 40 parties d'Al et 1,7 partie de Y,

3) de dépôt électrolytique, sur la couche de protection, jusqu'à une épaisseur de 0,025 à 0,15 mm, d'une couche d'ancrage d'une matrice métallique contenant du cobalt qui contient des particules de CrAlY ayant une granulométrie supérieure à celle des particules de la couche de protection,

4) d'application par pulvérisation, sur la couche de protection, d'une barrière thermique d'une matière réfractaire par un procédé de dépôt sous plasma, et

5) après le stade le stade 3) ou après le stade 4), de traitement thermique de la pièce.

Patentansprüche

1. Verfahren zum Herstellen einer Oberflächenbeschichtung auf einem Substrat, welches folgende Schritte umfaßt:

1) Bilden einer Schutzschicht auf dem Substrat durch elektrolytische oder elektrolöse Abscheidung einer Metallmatrix M_1 , die Teilchen von $CrAlM_2$ enthält, wobei M_1 Ni oder Co oder beides und M_2 eines oder mehrere von Y, Si, Ti, Hf, Ta oder einem Element der seltenen Erden ist,

2) Bilden einer Verankerungsschicht auf der Schutzschicht durch kombinierte elektrolytische oder elektrolöse Abscheidung einer Metallmatrix, die Teilchen aufweist, die größer sind als die $CrAlM_2$ -Teilchen der Schutzschicht, und anschließendes

3) Aufsprühen einer Wärmebarriere eines feuerfesten Materials auf die Schutzschicht durch ein Plasmaabscheidungsverfahren.

2. Verfahren nach Anspruch 1, wobei die Teilchen der Verankerungsschicht von der gleichen Zusammensetzung aber von größerer Teilchengröße als die Teilchen der Schutzschicht sind.

3. Verfahren nach Anspruch 1 oder 2, wobei die Größenverteilung der Teilchen in der Schutzschicht ein Maximum von 5 Gew.-% von Teilchen unter 5 μm , zwischen 10 und 15 Gew.-% von Teilchen unter 10 μm und zwischen 35 und 55 Gew.-% von Teilchen unter 20 μm beträgt.

4. Verfahren nach Anspruch 3, wobei die Schutzschicht zwischen 0,076 und 0,127 mm dick ist.

5. Verfahren nach Anspruch 1 oder 2, wobei die Größenverteilung der Teilchen in der Schutzschicht ein Maximum von 7,7 Gew.-% von Teilchen unter 5 μm , 56 Gew.-% von Teilchen unter 10 μm , 94 Gew.-% von Teilchen unter 20 μm und 99 Gew.-% von Teilchen unter 30 μm beträgt.

6. Verfahren nach einem der Ansprüche 1 bis 5, wobei die Größenverteilung der Teilchen in der Verankerungsschicht ein Maximum von 1 Gew.-% von Teilchen über 150 μm und ein Maximum von 15 Gew.-% von Teilchen unter 38 μm beträgt.

7. Verfahren nach Anspruch 6, wobei die Verankerungsschicht zwischen 0,025 und 0,15 mm dick ist.

8. Verfahren nach einem der Ansprüche 1 bis 7, wobei die Wärmebarriere im wesentlichen aus mit Yttrium stabilisiertem Zirkonium besteht.

9. Verfahren nach Anspruch 8, wobei die Größenverteilung der Teilchen in der Wärmebarriere ein Maximum von 10 Gew.-% von Teilchen größer als 74 μm , zwischen 65 Gew.-% und 100 Gew.-% von Teilchen über 44 μm und nicht mehr als 25 Gew.-% von Teilchen unter 44 μm beträgt.

10. Verfahren nach Anspruch 1 zum Herstellen einer Oberflächenbeschichtung auf einem Gasturbinenmotorteil, welches folgende Schritte umfaßt:

1) Vorbereiten der Oberfläche des Teils für das Elektroplattieren;

2) Elektroplattieren einer Schutzschicht auf die Oberfläche bis zu einer Tiefe von 0,076 bis 0,127 mm, wobei diese Schutzschicht aus CoNi CrAlY-Teilchen aufweist, die 60 Gew.-% Cr, 40 Teile Al und 1,7 Teile Y aufweisen,

3) Elektroplattieren einer Verankerungsschicht auf die Schutzschicht bis zu einer Tiefe von 0,025 bis 0,15 mm, wobei die Verankerungsschicht eine Kobalt enthaltende Metallmatrix aufweist, die CrAlY-Teilchen mit einer größeren Teilchengröße als die der Schutzschicht aufweist,

4) Aufsprühen einer Wärmebarriere aus feuerfestem Material auf die Schutzschicht durch ein Plasma-Abscheidungsverfahren, und

5) Wärmebehandeln des Teils nach Schritt 3 oder Schritt 4.