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(54) **POWER PLANT COMPONENT AND METHOD FOR MANUFACTURING SUCH COMPONENT**

(57) The invention relates to a power plant component (10), comprising a substrate (11) the surface of which is coated with a functionally graded coating (12) of a predetermined thickness, with anti-erosion, anti-corrosion and anti-fouling properties.

Improved operation properties are achieved by said functionally graded coating (12) comprising a corrosion resistant first means, and an erosion resistant and hydrophobic second means, whereby that said functionally graded coating is a composite coating (12) consisting of a single layer, whereby the concentration of said corrosion resistant first means and the concentration of said erosion resistant and hydrophobic second means vary gradually along the thickness (x) of said composite coating (12), whereby the concentration of said corrosion resistant first means varies gradually from a high concentration (c3) at the inner side (x1) of said composite coating (12) to a low concentration (c4) at the outer side (x2) of said composite coating (12), and that the concentration of said erosion resistant and hydrophobic second means varies gradually from a low concentration (c1) at the inner side (x1) of said composite coating (12) to a high concentration (c2) at the outer side (x2) of said composite coating (12).

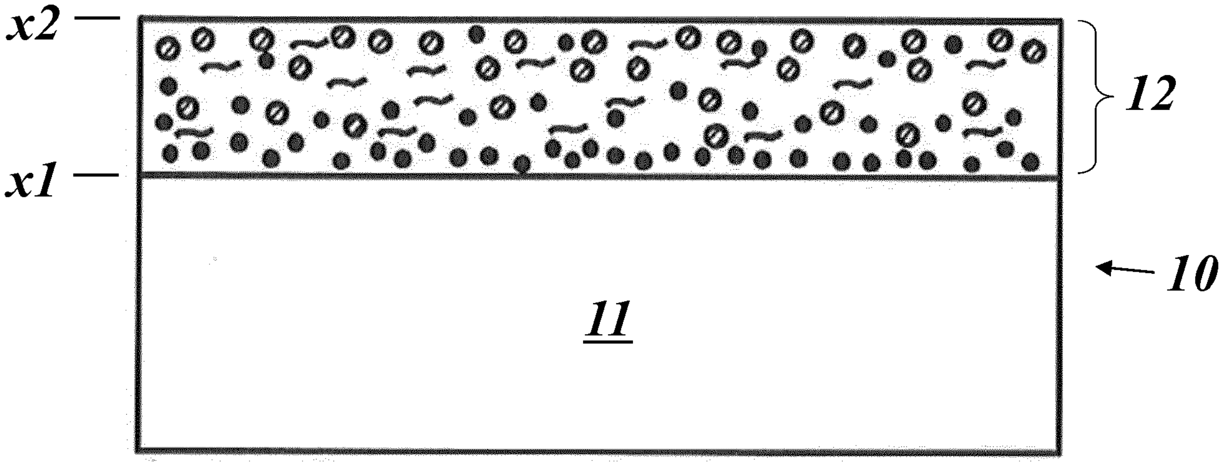

Fig.1

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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to the technology of power plants. It refers to a power plant component according to the preamble of claim 1.

[0002] It further refers to a method for manufacturing such component.

PRIOR ART

[0003] Several power plant components such as compressor blade, steam turbine blade and wind blade undergo water droplet erosion, corrosion and fouling. The best way of protection against these damages is protecting blades (or other components) using multi-function composite coatings.

[0004] The steel material that is used for compressor blades in gas turbines suffers from water droplet erosion and corrosion pitting induced cracking as well as fouling.

[0005] On-line and off-line washings are performed in required intervals in order to improve the performance of the turbine. By applying functional composite coatings on compressor blades, the off-line washing intervals can be extended; less blade erosion occurs during on-line washing and in high fogging systems compressor efficiency is increased.

[0006] In addition gas turbines are used in environments, which are highly corrosive for instance in industrial areas or coastlines and therefore undergo a heavy pitting corrosion.

[0007] The presence of aerosols and soot in atmosphere causes fouling formation on the blades that worsens the corrosion.

[0008] The existing solutions do not address the main three properties of erosion, corrosion and fouling, especially fouling is not addressed or it is very vague. Or the coating considered as anti-fouling is not erosion resistant and therefore anti-fouling property will be lost during operation. Or coating application methods such as sputtering or CVD and PVD are used which are not cost effective or difficult to apply.

[0009] Document US 2010/0247321 A1 presents an article including a metallic substrate. The article further includes a sacrificial layer disposed on a surface of the substrate and an anti-fouling layer disposed on the sacrificial layer. The anti-fouling layer includes a metal-polymer composite. An article including an anti-fouling layer having a nitride is also presented.

[0010] Document US 2009/0176110 A1 discloses a coating system and process capable of providing erosion and corrosion-resistance to a component, particularly a steel compressor blade of an industrial gas turbine. The coating system includes a metallic sacrificial undercoat on a surface of the component substrate, and a ceramic topcoat deposited by thermal spray on the undercoat. The undercoat contains a metal or metal alloy that is more active in the galvanic series than iron, and electrically contacts the surface of the substrate. The ceramic topcoat consists essentially of a ceramic material chosen from the group consisting of mixtures of alumina and titania, mixtures of chromia and silica, mixtures of chromia and titania, mixtures of chromia, silica, and titania, and mixtures of zirconia, titania, and yttria.

[0011] EP 2 374 916 A1 describes a process for providing a protective coating to a metal surface which comprises applying a nickel or tantalum plate layer to the surface and dispersing particles of a hard material such as diamond, alumina, vanadium nitride, tantalum carbide and/or tungsten carbide within the nickel or tantalum plate layer as the plating is occurring.

[0012] EP 2 060 328 A2 discloses a method of forming a composite powder coating which comprises depositing multiple layers of a powder coating composition onto a substrate, wherein adjacent layers are formed of a different powder coating composition; and curing the multiple layers of the powder coating composition in a single thermal curing step. The layers can be used to protect power generation equipment from aqueous corrosion, particle erosion, slurry erosion, fretting, and fouling.

[0013] US 8,007,246 B2 provides a method of fabricating a component for a gas turbine engine is provided. The method includes applying a bond coat to at least a portion of the component, applying a dense vertically cracked (DVC) thermal barrier coating to at least a portion of the bond coat using a spray mechanism positioned a first distance from the component, and overlying at least a portion of the DVC thermal barrier coating with a soft coat thermal barrier coating using a spray mechanism that is positioned a second distance away from the component, wherein the second distance is greater than the first distance to facilitate adherence of the soft coating thermal barrier coating to the DVC thermal barrier coating.

SUMMARY OF THE INVENTION

[0014] It is an object of the present invention to provide a power plant component with a functional surface with anti-erosion, anti-corrosion and anti-fouling properties.

[0015] It is another object of the invention to provide a power plant component with a composite coating system for providing metal and ceramic surfaces with improved water droplet erosion, enhanced corrosion resistance and enhanced anti-fouling properties.

[0016] It is another object of the invention to disclose a method for manufacturing such a component.

[0017] These and other objects are obtained by a power plant component according to Claim 1 and a method according to Claim 9.

[0018] The power plant component according to the invention comprises a substrate the surface of which is coated with a functionally graded coating of a predetermined thickness, with anti-erosion, anti-corrosion and anti-fouling properties.

[0019] It is characterized in that said functionally graded coating comprises a corrosion resistant first means, and an erosion resistant and hydrophobic second means, and that said functionally graded coating is a composite coating consisting of a single layer, whereby the concentration of said corrosion resistant first means and the concentration of said erosion resistant and hydrophobic second means vary gradually along the thickness of said composite coating, whereby the concentration of said corrosion resistant first means varies gradually from a high concentration at the inner side of said composite coating to a low concentration at the outer side of said composite coating, and that the concentration of said erosion resistant and hydrophobic second means varies gradually from a low concentration at the inner side of said composite coating to a high concentration at the outer side of said composite coating.

[0020] According to an embodiment of the invention said substrate is a metal or composite polymer substrate.

[0021] According to another embodiment of the invention said corrosion resistant first means comprises a metal, ceramic, cermet and/or polymer matrix, in which particles are embedded, whereby the concentration of said particles varies gradually from a high concentration at the inner side of said composite coating to a low concentration at the outer side of said composite coating.

[0022] Said particles may comprise micro or nano metal, ceramic and/or polymer materials, which provide corrosion protection by electronegativity and/or self-healing reaction.

[0023] According to a further embodiment of the invention said corrosion resistant first means comprise a Ni matrix with one of Al, Zn, Zr or Mg particles.

[0024] According to just another embodiment of the invention said erosion resistant and hydrophobic second means comprises a metal, ceramic, cermet and/or polymer matrix, in which hard ceramic, metallic and/or polymer nano or micro materials are included, whereby the concentration of said materials varies gradually from a low concentration at the inner side of said composite coating to a high concentration at the outer side of said composite coating.

[0025] According to a further embodiment of the invention said erosion resistant and hydrophobic second means comprises ceramic, metallic or intermetallic particles coated with ceramic or polymer material, whereby said ceramic, metallic or intermetallic particles are erosion resistant and said ceramic or polymer coating material is anti-fouling.

[0026] Said ceramic, metallic and/or polymer nano or micro particles or fibers may comprise one of SiC, Al_2O_3, SiO_2, WC, BN, MAX phases (e.g. Ti_3SiC_2, Ti_2AlC, Cr_2AlC), carbon nanotubes (CNTs), graphene oxide and hydrophobic particles, especially of PTFE.

[0027] The inventive method for manufacturing a power plant component according to the invention is characterized in that the surface of said substrate is activated and prepared with a thin bonding layer and chemical or mechanical treatments.

[0028] According o an embodiment of the inventive method said composite coating is applied by spraying process, especially Atmospheric Plasma Spraying (APS), cold spray, High Voltage Oxide Fuel (HVOF) process, or electro and electroless plating and electrophoretic process.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] The present invention is now to be explained more closely by means of different embodiments and with reference to the attached drawings.

Fig. 1 shows the surface structure with a graded composite coating of a component according to an embodiment of the invention;

Fig. 2 shows a diagram of the thickness-dependant concentration of an erosion resistant material within said graded composite coating of Fig. 1; and

Fig. 3 shows a diagram of the thickness-dependant concentration of a corrosion resistant material within said graded composite coating of Fig. 1.

DETAILED DESCRIPTION OF DIFFERENT EMBODIMENTS OF THE INVENTION

[0030] The present invention is about producing engineered functional coatings and surfaces for power plant components for example gas turbine compressor blades using new materials, design and processing. New functional surfaces are provided with anti-erosion, anti- corrosion and anti-fouling properties.

[0031] The present invention presents a composite coating system for providing metal and ceramic surfaces with improved water droplet erosion, enhanced corrosion resistance and enhanced anti-fouling properties.

[0032] The coating comprises only one functionally graded layer, where the required properties of corrosion resistance and erosion resistance and hydrophobic properties are varied gradually along the thickness of the layer.

[0033] According to Fig. 1-3 the power plant component 10, e.g. a turbine blade, comprises a substrate 11 made of a metal or a composite polymer the surface of which is covered with composite coating 12. Thickness x of the coating begins at coordinate x1 (inner side) and ends at coordinate x2 (outer side). Composite coating 12 contains corrosion resistant first particles (corrosion resistant first means; small circles in Fig. 1) and erosion resistant and hydrophobic second particles/fibers (erosion resistant and hydrophobic second means; larger circles and tildes in Fig. 1) with different profiles of their concentration c. As shown in Fig. 2 the concentration c of the erosion resistant and hydrophobic particles increases from a low concentration c1 at x1 (inner side) to a high concentration c2 at x2 (outer side). On the other hand (see Fig. 3), the concentration c of the corrosion resistant particles decreases from a high concentration c3 at x1 to a low concentration c4 at x2.

[0034] Said substrate 11 may be a metal or composite polymer substrate.

[0035] Said corrosion resistant first means may comprise a metal, ceramic, cermet and/or polymer matrix, in which particles/fibers are embedded, whereby the concentration of said particles varies gradually from a high concentration at the inner side of said composite coating to a low concentration at the outer side of said composite coating.

[0036] Especially, said particles/fibers may comprise micro or nano metal, ceramic and/or polymer materials, which provide corrosion protection by electronegativity and/or self-healing reaction.

[0037] Furthermore, said corrosion resistant first means may comprise a Ni matrix with one of Al, Zn, Zr or Mg particles.

[0038] Said erosion resistant and hydrophobic second means may comprise a metal, ceramic, cermet and/or polymer matrix, in which hard ceramic, metallic and/or polymer nano or micro materials are included, whereby the concentration of said materials varies gradually from a low concentration at the inner side of said composite coating to a high concentration at the outer side of said composite coating (see Fig. 2).

[0039] On the other hand, said erosion resistant and hydrophobic second means may comprise ceramic, metallic or intermetallic particles coated with ceramic or polymer material, whereby said ceramic, metallic or intermetallic particles are erosion resistant and said ceramic or polymer coating material is anti-fouling.

[0040] Especially, said ceramic, metallic and/or polymer nano or micro particles or fibers may comprise one of SiC, Al_2O_3, SiO_2, WC, BN, MAX phases (e.g. Ti_3SiC_2, Ti_2AlC, Cr_2AlC), carbon nanotubes (CNTs), graphene oxide and hydrophobic particles, especially of PTFE.

LIST OF REFERENCE NUMERALS

[0041]

10	power plant component
11	substrate
12	composite coating
c,c1,c2,c3,c4	concentration
x,x1,x2	coating thickness (coordinate)

Claims

1. Power plant component (10), comprising a substrate (11) the surface of which is coated with a functionally graded coating (12) of a predetermined thickness, with anti-erosion, anti-corrosion and anti-fouling properties, **characterized in that** said functionally graded coating (12) comprises a corrosion resistant first means, and an erosion resistant and hydrophobic second means, and that said functionally graded coating is a composite coating (12) consisting of a single layer, whereby the concentration of said corrosion resistant first means and the concentration of said erosion resistant and hydrophobic second means vary gradually along the thickness (x) of said composite coating (12), whereby the concentration of said corrosion resistant first means varies gradually from a high concentration (c3) at the inner side (x1) of said composite coating (12) to a low concentration (c4) at the outer side (x2) of said composite coating (12), and that the concentration of said erosion resistant and hydrophobic second means varies gradually from a low concentration (c1) at the inner side (x1) of said composite coating (12) to a high concentration (c2) at the outer side (x2) of said composite coating (12).

2. Power plant component as claimed in Claim 1, **characterized in that** said substrate (11) is a metal or composite polymer substrate.

3. Power plant component as claimed in Claim 1, **characterized in that** said corrosion resistant first means comprises a metal, ceramic, cermet and/or polymer matrix, in which particles are embedded, whereby the concentration of said particles varies gradually from a high concentration at the inner side of said composite coating to a low concentration at the outer side of said composite coating.

4. Power plant component as claimed in Claim 3, **characterized in that** said particles comprise micro or nano metal, ceramic and/or polymer materials, which provide corrosion protection by electronegativity and/or self-healing reaction.

5. Power plant component as claimed in Claim 1, **characterized in that** said corrosion resistant first means comprise a Ni matrix with one of Al, Zn, Zr or Mg particles.

6. Power plant component as claimed in Claim 1, **characterized in that** said erosion resistant and hydrophobic second means comprises a metal, ceramic, cermet and/or polymer matrix, in which hard ceramic, metallic and/or polymer nano or micro materials are included, whereby the concentration of said materials varies gradually from a low concentration at the inner side of said composite coating to a high concentration at the outer side of said composite coating.

7. Power plant component as claimed in Claim 1, **characterized in that** said erosion resistant and hydro-

phobic second means comprises ceramic, metallic or intermetallic particles coated with ceramic or polymer material, whereby said ceramic, metallic or intermetallic particles are erosion resistant and said ceramic or polymer coating material is anti-fouling.

8. Power plant component as claimed in Claim 4, **characterized in that** said ceramic, metallic and/or polymer nano or micro particles or fibers comprises one of SiC, Al_2O_3, SiO_2, WC, BN, MAX phases (e.g. Ti_3SiC_2, Ti_2AlC, Cr_2AlC), carbon nanotubes (CNTs), graphene oxide and hydrophobic particles, especially of PTFE.

9. Method for manufacturing a power plant component according to one of the claims 1 to 8, **characterized in that** the surface of said substrate (11) is activated and prepared with a thin bonding layer and chemical or mechanical treatments.

10. Method as claimed in Claim 9, **characterized in that** said composite coating (12) is applied by spraying process, especially Atmospheric Plasma Spraying (APS), cold spray, High Voltage Oxide Fuel (HVOF) process, or electro and electroless plating and electrophoretic process.

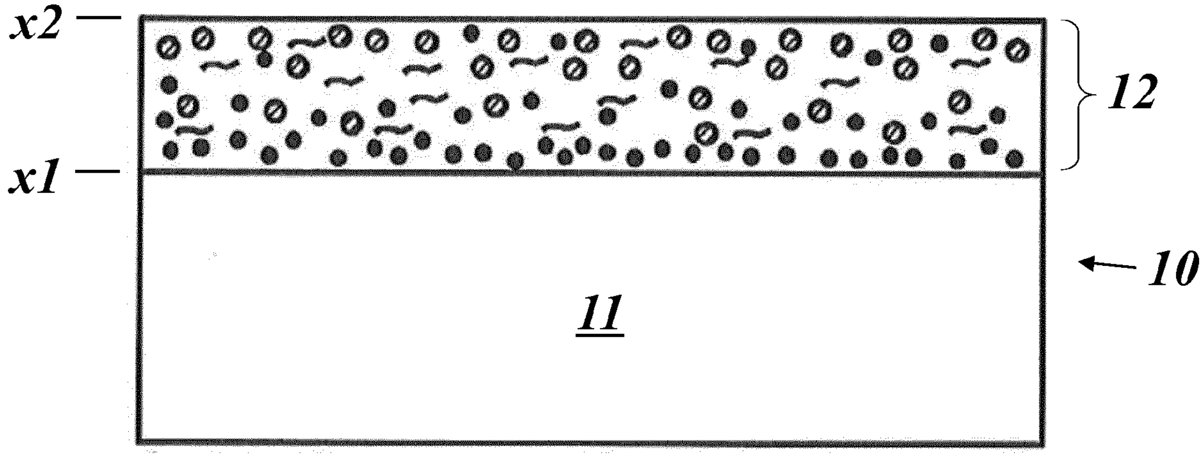

Fig.1

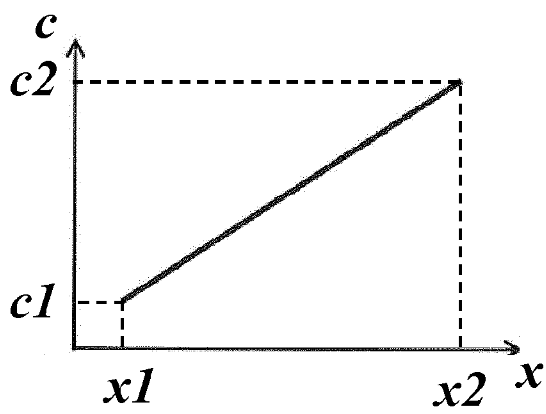

Fig.2

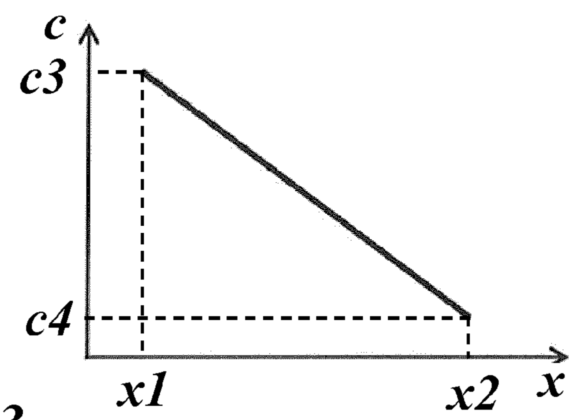

Fig.3

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EUROPEAN SEARCH REPORT

Application Number
EP 15 19 4434

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 2 388 354 A1 (UNITED TECHNOLOGIES CORP [US]) 23 November 2011 (2011-11-23) * paragraphs [0008] - [0009], [0011], [0016] - [0018], [0021] - [0022]; claims 1-2; figure 2 * -----	1-7,9,10	INV. C23C4/08 C25D21/14 C23C24/04 C23C30/00 F01D5/28
X	US 2006/166019 A1 (SPITSBERG IRENE [US] ET AL) 27 July 2006 (2006-07-27) * paragraphs [0018] - [0022]; claims 1-17 * -----	1,3,6-10	
A,D	US 2011/165433 A1 (PABLA SURINDER S [US] ET AL) 7 July 2011 (2011-07-07) * claims 1-17; figure 2 * -----	1-10	
			TECHNICAL FIELDS SEARCHED (IPC)
			C25D C23C F01D

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	17 March 2016	Ruiz Martinez, Maria

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 15 19 4434

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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17-03-2016

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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- US 20090176110 A1 **[0010]**
- EP 2374916 A1 **[0011]**
- EP 2060328 A2 **[0012]**
- US 8007246 B2 **[0013]**