(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 725 120 A1

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
30.04.2014 Bulletin 2014/18

(21) Application number: **13189647.4**

(22) Date of filing: **22.10.2013**

(51) Int Cl.:
C23C 24/08 (2006.01) *C23C 28/00 (2006.01)*
F01D 5/28 (2006.01) *F01D 5/18 (2006.01)*
C23C 4/08 (2006.01)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(30) Priority: **24.10.2012 JP 2012234278**

(71) Applicant: **Hitachi Ltd.**
Tokyo (JP)

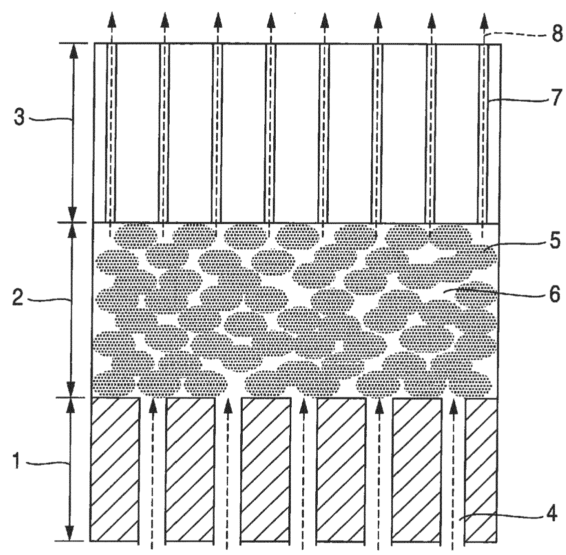
(72) Inventors:
- **Arikawa, Hideyuki**
  Tokyo, 100-8280 (JP)
- **Kojima, Yoshitaka**
  Tokyo, 100-8280 (JP)
- **Kasuya, Tadashi**
  Tokyo, 100-8280 (JP)
- **Mebata, Akira**
  Tokyo, 100-8280 (JP)
- **Ichikawa, Kunihiro**
  Tokyo, 100-8280 (JP)
- **Endo, Hiroyuki**
  Tokyo, 100-8280 (JP)
- **Endo, Takao**
  Tokyo, 100-8280 (JP)

(74) Representative: **Beetz & Partner**
Patentanwälte
Steinsdorfstraße 10
80538 München (DE)

(54) **High temperature components with thermal barrier coatings for gas turbine**

(57) The most principal feature of the present invention is as follows: Namely, in the gas-turbine-use high-temperature component including the thermal barrier coating and a cooling structure, micro passages are provided inside an alloy bond-coat layer (2) and a thermal-barrier ceramic top-coat layer (3) of the thermal barrier coating, the micro passages being in communication from the substrate side to the surface side. Moreover, a partial amount of coolant of a coolant (8) for cooling the high-temperature component is caused to flow out to the outside of the high-temperature component via these micro passages. The employment of the structure like this makes it possible to expect the implementation of a high-temperature component's heat-resistant-temperature enhancement effect based on the transpiration cooling effect.

FIG.1



Printed by Jouve, 75001 PARIS (FR)

Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to gas-turbine-use high-temperature components such as rotor blade and nozzle guide vane, combustor, and shroud of a gas turbine. Here, each of these high-temperature components is equipped with a thermal barrier coating that is excellent in its heat resistivity.

[0002] The operation temperature of a gas turbine has been becoming increasingly higher year by year with the purpose of enhancing its efficiency. In order to address this high-temperature trend of the operation temperature, materials that are excellent in the heat resistivity are used for each of the gas-turbine-use high-temperature components. In addition, in each high-temperature component, the structure is employed where the opposite plane to a plane exposed to a high-temperature combustion gas is cooled using a fluid coolant such as air or steam. Moreover, with the purpose of relaxing the temperature environment, the thermal barrier coating (which, hereinafter, will be referred to as "TBC") composed of a low-thermal-conductivity ceramics is usually applied to the surface of each high-temperature component. This application of the TBC generally makes it possible to lower the substrate temperature by the amount of 50° to 100°C, although it depends on the usage conditions as well. For example, in documents such as JP-A-62-211387, there is disclosed a TBC where a thermal barrier layer is provided for the substrate with a MCrAlY alloy layer positioned therebetween. Here, this thermal barrier layer is composed of low-thermal-conductivity and excellent-heat-resistivity partially-stabilized zirconia. Furthermore, here, M denotes at least one species selected from a group of iron (Fe), Ni, and Co. Also, Cr, Al, and Y denote chromium, aluminum, and yttrium, respectively.

[0003] Each gas-turbine-use high-temperature component like this, which is equipped with the TBC and the cooling structure, exhibits the excellent heat resistivity. Nevertheless, with an intention of enhancing the gas turbine's performance even further, it is desired to employ a transpiration cooling scheme that allows implementation of a higher cooling efficiency. The transpiration cooling is a method for allowing the cooling to be performed with the higher efficiency in accordance with the following manner: Namely, in this transpiration cooling, the uniform transpiration of a slight amount of cooling medium is caused to occur from the entire surface of each high-temperature component via micro flow channels (i.e., porous material in general). For example, in JP-A-10-231704 and JP-A-2010-65634, there are disclosed gas-turbine-use high-temperature components where the transpiration cooling structure based on a porous ceramic layer is employed on a porous metal. Also, in JP-A-2005-350341, there is disclosed the following gas-turbine-use high-temperature component: The transpiration cooling structure is employed in the structure where a porous ceramic and a heat-resistant alloy substrate are integrated at the time of the casting.

SUMMARY OF THE INVENTION

[0004] In the above-described conventional technologies, the thermal-barrier ceramic top-coat layer of the TBC is employed partially. In whatever of the above-described patent publications, however, the layer corresponding to an alloy bond-coat layer of the TBC is not a coating film, but is alternatively replaced by the porous metal. Otherwise, the very layer corresponding to the alloy bond-coat layer is omitted. This is because it is difficult to form the micro passages, which become the flow channels of the cooling medium, with the use of the conventional film-forming methods for forming the alloy bond-coat layer. In the TBC, the thermal-barrier ceramic top-coat layer is put in charge of a role of becoming a barrier to the heat from the high-temperature combustion gas. Accordingly, this ceramic top-coat layer can be expected to exhibit an effect of suppressing the apparent thermal conductivity down to a low value, and further, an effect of relaxing the thermal stress. For this reason, the porous ceramic layer is employed as this ceramic top-coat layer. Meanwhile, the alloy bond-coat layer is put in charge of a role of ensuring the close contact between the ceramic top-coat layer and the substrate. Simultaneously, the alloy bond-coat layer is put in charge of a role of protecting the substrate from the oxidization and corrosion due to the combustion gas. For these reasons, more densely-packed organizations are employed as the alloy bond-coat layer. On account of these circumstances, the implementation of each high-temperature component where the TBC and the transpiration cooling are combined with each other requires implementation of the following alloy bond-coat layer: Namely, an alloy bond-coat layer is required which is equipped with the cooling medium's flow channels that are different from the ones in the conventional technologies. In view of this situation, an object of the present invention is as follows: Namely, an alloy bond-coat layer is implemented which is equipped with the cooling medium's micro flow channels that are appropriate and suitable for the transpiration cooling. Moreover, there is provided each excellent-heat-resistivity gas-turbine-use high-temperature component that is equipped with the transpiration-cooling function and the thermal barrier coating where this alloy bond-coat layer is employed.

[0005] In view of the above-described problem, the most principal feature of the present invention is as follows: In a gas-turbine-use high-temperature component including a thermal barrier coating, and a cooling structure based on a fluid coolant, the thermal barrier coating being formed by providing an alloy bond-coat layer on a substrate's surface exposed to a high-temperature combustion gas, and further, by providing a thermal-barrier ceramic top-coat layer on the surface of the alloy bond-coat layer, micro passages are provided inside the alloy bond-coat layer and the thermal-barrier ceramic top-coat layer, the micro passages being in communication from the substrate side to the surface side, a partial amount of fluid coolant of the fluid coolant for cooling the high-temperature component being caused to flow out to the outside of the high-temperature component via these micro passages.

[0006] In the present invention, the micro passages are provided inside the alloy bond-coat layer and the thermal-barrier ceramic top-coat layer of the TBC, the micro passages being in communication from the substrate side to the surface side. Moreover, a partial amount of fluid coolant of the fluid coolant for cooling the high-temperature component is caused to flow out to the outside of the high-temperature component via these micro passages. This feature makes it possible to cool the TBC, and the alloy bond-coat layer in particular, with a higher efficiency. Also, the uniform transpiration of the coolant is caused to occur from the entire surface of the high-temperature component. This feature makes it possible to expect the implementation of a uniform and efficient film-cooling effect. On account of these effects, there exists an advantage of becoming capable of using the component even under such a hash and severe condition that the application of the conventional technologies becomes difficult due to a rise in the component temperature in accompaniment with the higher-temperature implementation of the combustion-gas temperature. Also, in the gas turbine that uses the gas-turbine-use high-temperature component including the thermal barrier coating and the cooling structure of the present invention, there exists an advantage of being capable of operating the gas turbine at a higher temperature, and of becoming able to enhance the efficiency.

[0007] Other objects, features and advantages of the invention will become apparent from the following description of the embodiments of the invention taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008]

Fig. 1 is a cross-sectional schematic diagram for illustrating the structure of a gas-turbine-use high-temperature component including the thermal barrier coating and the cooling structure of the present invention; and

Fig. 2 is a cross-sectional schematic diagram for illustrating the structure of a gas turbine.

DETAILED DESCRIPTION OF THE EMBODIMENT

[0009] Hereinafter, referring to the drawings, the detailed explanation will be given below concerning the present invention.

[0010] As illustrated in Fig. 1, the configuration of the present invention is as follows: Namely, an alloy bond-coat layer 2 is provided on a substrate 1. Moreover, a thermal-barrier ceramic top-coat layer 3 is provided on this alloy bond-coat layer 2. In the substrate 1, a plurality of cooling holes 4, which penetrate the substrate 1, are provided in the direction from cooling-medium passages of the substrate 1 to the surface of the substrate 1 on which the alloy bond-coat layer 2 is provided. The alloy bond-coat layer 2 is characterized by being equipped with the following structure: Namely, in this structure, a large number of basically-spherical alloy powder particles 5 are accumulated. Moreover, there exist among-particles clearances 6 that are in communication from the side of the substrate 1 to that of the coating surface. Furthermore, the thermal-barrier ceramic top-coat layer 3 is provided on the surface of the alloy bond-coat layer 2. The thermal-barrier ceramic top-coat layer 3 is equipped with a large number of vertical-direction cracks 7. A fluid coolant 8 reaches the alloy bond-coat layer 2 from the cooling-medium passages of the substrate 1 via the cooling holes 4. Subsequently, the fluid coolant 8 flows upward onto the surface side of the alloy bond-coat layer 2, and reaches the thermal-barrier ceramic top-coat layer 3, while diffusing inside the alloy bond-coat layer 2 via the among-particles clearances 6 inside the layer 2. Finally, the fluid coolant 8 flows out from the surface of the thermal-barrier ceramic top-coat layer 3 via the vertical-direction cracks 7 inside the thermal-barrier ceramic top-coat layer 3.

[0011] The substrate 1 can be composed of a heat-resistant alloy of Ni-base, Co-base, or Fe-base. The alloy bond-coat layer 2 can also be composed of the Ni-base, Co-base, or Fe-base heat-resistant alloy. Preferably, however, it is desirable to use the MCrAlY (M denotes whatever of, or plural pieces of Fe, Ni, and Co) alloy. The MCrAlY alloy is preferable, because it is excellent in the oxidation-resistant property.

[0012] Also, the alloy bond-coat layer 2 is equipped with the following structure: Namely, the large number of basically-spherical alloy powder particles 5 are accumulated therein. Moreover, there exist the among-particles clearances 6 that are in communication from the side of the substrate 1 to the surface of the alloy bond-coat layer 2. In order to form the coating film of the structure like this, it is preferable to use the following method, for example: Namely, the basically-spherical alloy powder produced using the gas atomization method is employed as the raw material. Then, the alloy powder is accumulated by being caused to collide with the substrate surface at a high velocity. Concretely, the usable methods are ones such as, e.g., the plasma spray method, the high-velocity oxy-fuel spray (HVOF) method, and the cold spray method. Of these methods, the cold spray method is used most preferably.

[0013] The feature of the present invention is the alloy bond-coat layer 2 that is equipped with the structure where there exist the among-particles clearances 6. Here, the among-particles clearances 6 are in communication from the side of the substrate 1 to the coating surface. In order to form this alloy bond-coat layer 2, consideration is given to the following case: The method such as the electric arc spray or flame spray is used, where the alloy powder particles are accumulated by being melted at a high temperature, and by being caused to collide with the substrate. In this case, however, pores (i.e., the so-called "closed pores") that are not in communication become likely to be formed. This is because the melted alloy powder particles are accumulated in a manner of becoming significantly flattened when these particles collide with the substrate. Also, in the alloy powder that is heated up to the temperature at which the alloy powder is melted in the atmosphere, its oxides are produced on its surface. These oxides are mixed into the coating film, thereby lowering the oxidation-resistant property of the coating film. Also, there occurs a problem that the coupling among the particles is obstructed by the oxides, and that the strength of the coating film is lowered thereby.

[0014] Consequently, when forming the alloy bond-coat layer 2 of the thermal barrier coating of the present invention, the following accumulation method is desirable: Namely, the basically-spherical alloy powder to be used as the raw material is accumulated without melting and oxidizing the basically-spherical alloy powder, i.e., while maintaining its shape as it is that is close to the spherical shape. The method preferable for this accumulation method is the cold spray method, which allows the film formation to be performed at a lower temperature. Even at the lower temperature, however, if the velocities of the powder particles become too high, the flattening of the powder particles is caused to occur when these particles collide with the substrate. As a result, the coating film becomes densely-packed, and thus the number of the communication pores is decreased. This undesirable situation makes it impossible to form the alloy bond-coat layer 2 of the present invention, thereby making it necessary to adjust the film-forming conditions properly. Incidentally, by adjusting the film-forming conditions similarly depending on the requirements, it also becomes possible to use the methods such as the plasma spray method and the high-velocity oxy-fuel spray (HVOF) method.

[0015] It is preferable that the in-coating-film volume's partial ratio of the communication clearances of the alloy bond-coat layer 2 of the present invention falls into a range of 30% to 70%. Here, the alloy bond-coat layer 2 is formed using the above-described film-forming method, and is equipped with the among-particles clearances 6 that are in communication from the side of the substrate 1 to the side of the coating surface. If the volume's partial ratio of the clearances is less than 30%, the cooling-medium amount being in communication becomes smaller. Accordingly, the effect of the transpiration cooling cannot be obtained sufficiently. Meanwhile, if the volume's partial ratio of the clearances increases, the coating-film strength is lowered, although the cooling effect is enhanced. If the volume's partial ratio of the clearances exceeds 70%, the damage to the coating becomes likely to occur while operating gas turbine. It is more preferable that the volume's partial ratio of the clearances falls into a range of 40% to 60%.

[0016] Also, it is preferable that, in association with the thermal barrier coating of the present invention, a thermal processing is applied to both of the alloy bond-coat layer 2 and the thermal-barrier ceramic top-coat layer 3 after the film formation is over. In the alloy bond-coat layer 2, the coating-film strength can be enhanced by strengthening the coupling among the particles through the thermal-processing-based solid-phase diffusion. Also, in the thermal-barrier ceramic top-coat layer 3, it can be expected to make the circulation of the cooling medium smoother by positively permitting the vertical-direction cracks 7 to be implemented as wider apertures. It is desirable that the heat treatment is performed in vacuum in order to prevent the oxidation of the alloy bond-coat layer 2. Furthermore, it is preferable that the heat treatment conditions are maintained, approximately, at a 1000°C-or-higher temperature and during a 2 hour-or-longer time-interval. These conditions, however, depend on the coating and the substrate material as well. Incidentally, it is preferable that the structure of the thermal-barrier ceramic top-coat layer 3 includes the large number of vertical-direction cracks 7. It is also possible, however, that a porous structure, to which ventilation is imparted by a large number of pores, is employed as the structure of the layer 3.

[0017] Hereinafter, the explanation will be given below concerning embodiments of the present invention.

(Embodiment 1)

[0018] A gas-turbine first-stage rotor blade, which includes cooling-air passages in its inside, is prepared as the base substrate. Here, this rotor blade is formed of a Ni-base heat-resistant alloy IN738 (: 16% Cr - 8. 5% Co - 3. 4% Ti - 3. 4% Al - 2. 6% W - 1. 7% Mo - 1. 7% Ta - 0. 9% Nb - 0. 1% C - 0.05% Zr - 0. 0 1 % B - the remaining portion: Ni, weight%). In the rotor blade, pluralities of cooling pores, which penetrate the base substrate from its surface to the internal cooling-air passages, are machined using discharge machining. Also, basically-spherical and about-40 μm-average-diameter CoNiCrAlY alloy powder (: Co - 32% Ni - 21% Cr - 8% Al - 0. 5% Y, weight%), which is produced using the gas atomization method, is prepared as the raw-material powder. Moreover, using a cold spray device, the raw-material powder is film-formed onto the combustion-gas passage surface of the rotor blade. This film formation is carried out until the thickness of the alloy bond-coat layer 2 becomes equal to about 0. 3 mm. The film-forming conditions set at this time are as follows: Nitrogen gas as the operating gas, 3 MPa gas pressure, 800°C gas temperature, 20 g/min powder feed rate, and 15 mm spray distance. After that, the thermal-barrier ceramic top-coat layer 3 is provided above the substrate 1 on which the alloy bond-coat layer 2 is provided, using yttria partially-stabilized zirconia (: ZrO_2 - 8-wt% Y_2O_3) powder, and the in-atmosphere plasma spray (whose plasma output is equal to about 100 kW) method. Here, this thermal-barrier ceramic top-coat layer 3 is so provided as to become about 0.6 mm thick, and as to include the about-8%-pore-ratio vertical-direction cracks. The film-forming conditions set at this time are as follows: About-800°C residual-heat temperature, 30 m/min spray gun's transverse speed, 90 mm spray distance, and about-0.4 MW/m^2 heat flux. Furthermore, with respect to the rotor blade on which the film formation of the thermal-barrier ceramic top-coat layer 3 is completed, 1120°C x 2 h and 840°C x 24 h heat treatments are carried out in vacuum.

[0019] The rotor blade manufactured in this way is cut off, and then its cross-sectional organization is confirmed. This confirmation result shows that, as illustrated in Fig. 1, the alloy bond-coat layer 2 presents the following organization: Namely, the large number of basically-spherical alloy powder particles 5 are accumulated therein. Moreover, there exist the among-particles clearances 6 that are in communication from the side of the substrate 1 to the surface of the alloy bond-coat layer 2. Measuring the volume's partial ratio of the pores from the relative density results in the value of about 50%.

[0020] A different test rotor blade manufactured in accordance with the above-described processing steps is integrated into the gas turbine, and then a 1-year test operation thereof is performed. At this time, an orifice is provided at a cooling-air entrance of the blade, thereby reducing the cooling-air amount by 30% as compared with the conventional designs. In the after-test-operation rotor blade on which the TBC of the present invention is set up, the damage has been seldom recognized in both the outer appearance and the cut-off check. Meanwhile, in a comparison-dedicated rotor blade on which the TBC of the conventional technologies is set up, and whose operation is performed simultaneously with the cooling-air amount reduced, exfoliation of the TBC has been partially recognized from the outer appearance. Furthermore, in the cut-off check, the oxidization and damage of the alloy bond-coat layer 2 has been recognized in portions other than the exfoliated portion. From these results, it has been confirmed that each gas-turbine-use high-temperature component on which the TBC of the present invention is set up exhibits the excellent heat resistivity.

(Embodiment 2)

[0021] Fig. 2 is a cross-sectional schematic diagram for illustrating the main part of a power-generation-use gas turbine. This gas turbine includes, inside a turbine casing 48, a turbine rotor 49 in its center, and a turbine unit 44. Moreover, this turbine unit 44 is equipped with turbine rotor blades 46 which are set up in the surroundings of the turbine rotor 49, and turbine nozzle guide vanes 45 and turbine shrouds 47 which are supported onto the side of the turbine casing 48. The gas turbine further includes a compressor 50 and a combustor 40. The compressor 50 is connected to this turbine unit 44, and absorbs the atmosphere, thereby obtaining a combustion-use and cooling-medium-use compressed air. The combustor 40 is equipped with a combustor nozzle 41 for mixing with each other the compressed air supplied from the compressor 50 and a (not-illustrated) fuel supplied, and for injecting this mixed gas. The combustor 40 combusts this mixed gas inside a combustor liner 42, thereby generating a high-temperature and high-pressure combustion gas. This high-temperature and high-pressure combustion gas is supplied to the turbine unit 44 via a transition piece 43. This supply of the combustion gas allows the turbine rotor 49 to be rotated at a high speed. Furthermore, a partial portion of the compressed air outlet from the compressor 50 is used as an inside-cooling air for cooling the combustor liner 42, the transition piece 43, the turbine nozzle guide vanes 45, and the turbine rotor blades 46. The high-temperature and high-pressure combustion gas generated inside the combustor 40 is smoothly flown by the turbine nozzle guide vanes 45 via the transition piece 43, then being injected onto the turbine rotor blades 46. This injection of the combustion gas allows the implementation of the rotational driving of the turbine unit 44. In addition, although not illustrated, the power-generation-use gas turbine is so configured as to serve the power generation using a power generator that is connected to the end portion of the turbine rotor 49.

[0022] The present embodiment is configured as follows: Namely, the TBC of the present invention, which is explained in the first embodiment described earlier, is added to the rotor blades 46. Moreover, the TBC is provided on the nozzle guide vanes 45 and the combustion-gas passage surface of the first-stage shroud 47, using a method in accordance with the method explained in the first embodiment. Concretely, a plurality of cooling holes , which penetrate the base substrate from its surface to the internal cooling-air passages, are machined onto the combustion-gas passage surface of each gas-turbine component, using the discharge machining. Also, basically-spherical and about-50 μm-average-diameter NiCoCrAlY alloy powder (: Ni -23% Co - 17% Cr - 12. 5% Al - 0. 5% Y, weight%), which is produced using the gas atomization method, is prepared as the raw-material powder. Moreover, using the cold spray device, the raw-material powder is film-formed onto the combustion-gas passage surface of each gas-turbine component. This film formation is carried out until the thickness of the alloy bond-coat layer 2 becomes equal to about 0. 3 mm. The film-forming conditions set at this time are as follows: Nitrogen gas as the operating gas, 3 MPa gas pressure, 900°C gas temperature, 15 g/min powder feed rate, and 20 mm film-forming distance. After that, an about-0.3 mm-thick and ventilation-imparted porous thermal-barrier ceramic top-coat layer is provided above the substrate 1 on which the alloy bond-coat layer 2 is provided, using yttria partially-stabilized zirconia (: ZrO_2 - 8-wt% Y_2O_3)

powder, and the in-atmosphere plasma spray (whose plasma output is equal to about 50 kW) method. The film-forming conditions set at this time are as follows: About-150°C residual-heat temperature, 45 m/min spray gun's transverse speed, and 100 mm spray distance. Furthermore, an in-vacuum thermal processing in accordance with the thermal-processing conditions of the alloy used as the substrate of each gas-turbine component is carried out with respect to each component on which the film formation of the thermal-barrier ceramic top-coat layer is completed.

[0023] Incidentally, in the present embodiment, the configuration where the TBC of the present invention is provided is applied only to each first stage of the nozzle guide vanes 45, the rotor blades 46, and the shrouds 47 of the three-stage turbine unit 44. It is also possible, however, to apply this configuration further to the subsequent stages, i.e., the second and third stages. Furthermore, it is also possible to apply this configuration to every stage or selected stage of the turbine that is configured with another stage number, e.g., the turbine configured with two or four stages.

[0024] In the above-described-configuration-based gas turbine according to the present embodiment, the gas-turbine components where the TBC of the present invention is provided are operated with the cooling-air amount reduced by about 30%. After a 2 year operation thereof, each gas-turbine component is observed. This observation shows that, in the gas-turbine components where the TBC of the present invention is provided, the damage has been seldom recognized in the TBC, i.e., the TBC remains basically sound. Meanwhile, there has been an enhancement in the efficiency of the gas turbine because of the reduction in the cooling-air amount. Also, there has been an enhancement in the power-generation efficiency of a gas-turbine-combined power-generation plant where this gas turbine is set up.

[0025] From the above-described results, it has been found that the gas turbine according to the present embodiment is made operable at a high temperature by the excellent heat resistivity of its high-temperature components. As a consequence, this gas turbine is excellent in its economy and stable operability.

[0026] It should be further understood by those skilled in the art that although the foregoing description has been made on embodiments of the invention, the invention is not limited thereto and various changes and modifications may be made without departing from the spirit of the invention and the scope of the appended claims.

[0027] The above embodiments of the invention as well as the appended claims and figures show multiple characterizing features of the invention in specific combinations. The skilled person will easily be able to consider further combinations or sub-combinations of these features in order to adapt the invention as defined in the claims to his specific needs.

Claims

1. A gas-turbine-use high-temperature component, comprising:

    a thermal barrier coating;
    said thermal barrier coating being formed by providing an alloy bond-coat layer (2) on a substrate (1)'s surface exposed to a high-temperature combustion gas, and further, by providing a thermal-barrier ceramic top-coat layer (3) on the surface of said alloy bond-coat layer (2), wherein micro passages are provided inside said alloy bond-coat layer (2) and said thermal-barrier ceramic top-coat layer (3), said micro passages being in communication from said substrate (1) side to said surface side, a partial amount of coolant of a coolant (8) for cooling said high-temperature component being caused to flow out to the outside of said high-temperature component via these micro passages.

2. The gas-turbine-use high-temperature component according to Claim 1, wherein
said substarate (1) is composed of a heat-resistant alloy of Ni-base, Co-base, or Fe-base.

3. The gas-turbine-use high-temperature component according to Claim 1, wherein
said alloy bond-coat layer (2) is composed of a MCrAlY (M is at least one species selected from Fe, Ni, and Co) alloy.

4. The gas-turbine-use high-temperature component according to Claim 1, wherein
said alloy bond-coat layer (2) is equipped with an accumulated organization of alloy powder particles (5), the particle diameters' range of said alloy powder particles (5) being a 5 μm to 100 μm range,
the in-coating-film volume's partial ratio of said micro passages being equal to 30% to 70%, said micro passages being formed by clearances (6) among said accumulated particles (5), and being in communication.

5. The gas-turbine-use high-temperature component according to Claim 1, wherein
said alloy bond-coat layer (2) is formed using a method of causing alloy powder particles (5) to collide with said substrate (1)'s surface at a high velocity, and without being accompanied by the melting of said alloy powder particles (5),
said alloy powder particles (5) being caused to collide with said substrate (1)'s surface by accelerating said particles (5) with an action gas whose temperature is lower than the melting point of said alloy.

6. The gas-turbine-use high-temperature component

according to Claim 1, wherein said thermal-barrier ceramic top-coat layer (3) is formed of partially-stabilized zirconia.

7. The gas-turbine-use high-temperature component according to Claim 1, wherein said micro passages of said thermal-barrier ceramic top-coat layer (3) are formed of cracks (7).

8. The gas-turbine-use high-temperature component according to Claim 1, wherein said micro passages of said thermal-barrier ceramic top-coat layer (3) are formed of pores.

9. A gas turbine, comprising:

said gas-turbine-use high-temperature component as claimed in any one of Claims 1 through 8.

10. A gas-turbine-combined power-generation plant, comprising:

said gas turbine as claimed in Claim 9.

FIG.1

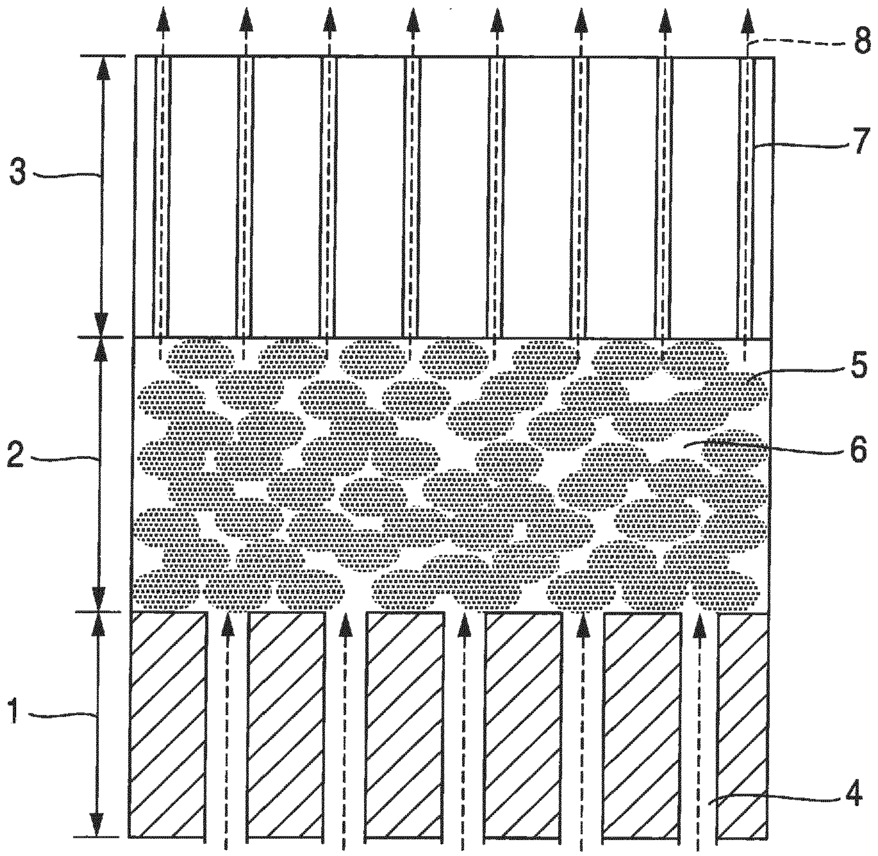
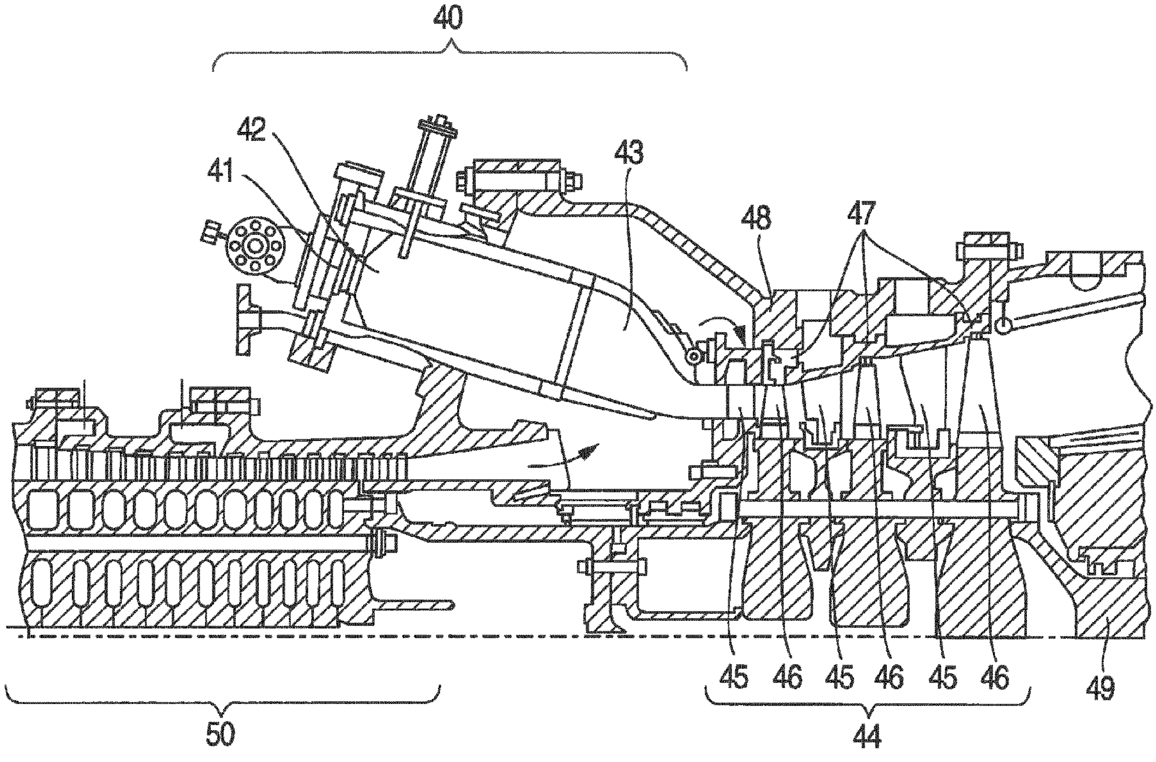


FIG.2



Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 13 18 9647

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 Y	US 6 511 762 B1 (LEE CHING-PANG [US] ET AL) 28 January 2003 (2003-01-28) * column 5, line 38 - column 6, line 45; figures 1,2 * * column 7, line 31 - column 8, line 14; figures 6-8 *	1-3,6-10 4,5	INV. C23C24/08 C23C28/00 F01D5/28 F01D5/18 C23C4/08
X Y	US 2002/102360 A1 (SUBRAMANIAN RAMESH [US] ET AL) 1 August 2002 (2002-08-01) * the whole document *	1-3,5-10 4	
Y	EP 2 072 634 A2 (UNITED TECHNOLOGIES CORP [US]) 24 June 2009 (2009-06-24) * column 2, paragraph 6 - column 3, paragraph 9; figure 1 * * column 4, paragraph 12 * * column 5, paragraph 14 *	4,5	
X	US 6 617 003 B1 (LEE CHING-PANG [US] ET AL) 9 September 2003 (2003-09-09) * column 5, line 46 - column 6, line 5 * * column 6, line 31 - line 48 * * column 7, line 40 - line 60 * * column 8, line 26 - line 45 *	1-3,6-9	TECHNICAL FIELDS SEARCHED (IPC) C23C F01D
X	EP 1 496 140 A1 (SIEMENS AG [DE]) 12 January 2005 (2005-01-12) * the whole document *	1-3,6-9	
A	EP 1 903 127 A1 (SIEMENS AG [DE]) 26 March 2008 (2008-03-26) * column 1 - column 5; figures 3-4 *	1-9	
A	EP 1 398 394 A1 (HOWMET RES CORP [US]) 17 March 2004 (2004-03-17) * column 2, paragraph 10 - column 5, paragraph 22 * * column 7, line 29 *	1-5	

The present search report has been drawn up for all claims

4

Place of search	Date of completion of the search	Examiner
Munich	22 January 2014	Tsipouridis, P

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
& : member of the same patent family, corresponding document

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 13 18 9647

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
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

22-01-2014

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 6511762 B1	28-01-2003	US 6511762 B1	28-01-2003
		US 2003021905 A1	30-01-2003
US 2002102360 A1	01-08-2002	US 2002102360 A1	01-08-2002
		WO 02061177 A2	08-08-2002
EP 2072634 A2	24-06-2009	EP 2072634 A2	24-06-2009
		SG 153768 A1	29-07-2009
		US 2011305892 A1	15-12-2011
		US 2012196151 A1	02-08-2012
US 6617003 B1	09-09-2003	NONE	
EP 1496140 A1	12-01-2005	CN 1816646 A	09-08-2006
		EP 1496140 A1	12-01-2005
		EP 1641959 A1	05-04-2006
		ES 2287758 T3	16-12-2007
		US 2006153685 A1	13-07-2006
		WO 2005005688 A1	20-01-2005
EP 1903127 A1	26-03-2008	NONE	
EP 1398394 A1	17-03-2004	CA 2433613 A1	13-02-2004
		EP 1398394 A1	17-03-2004
		JP 2004076157 A	11-03-2004

EPO FORM P0459

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

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 62211387 A **[0002]**
- JP 10231704 A **[0003]**
- JP 2010065634 A **[0003]**
- JP 2005350341 A **[0003]**