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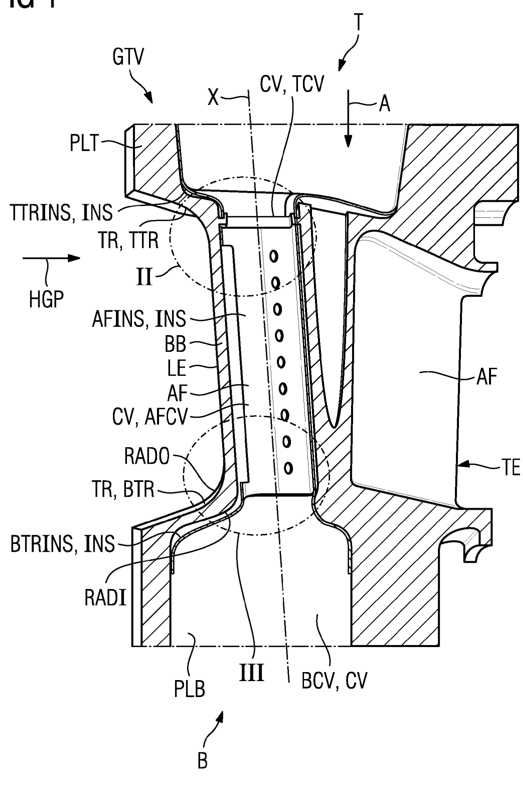
(54) **Gas turbine vane**

(57) The invention relates to a gas turbine vane (GTV) comprising an airfoil (AF) extending along a central axis (X), a top platform (PLT) and a bottom platform (PLB) of a basic body (BB), both platforms attached to said airfoil (AF) through transition portions (TTR,BTR), wherein said top platform (PLT) and said bottom platform (PLB) are both provided with a cavity (TCV,BCV) connected by an airfoil cavity (AFCV) provided in said airfoil (AF), wherein said cavities (AF,CV,TCV,BCV) are supplied with cooling air (A) for cooling said basic body (BB), wherein an airfoil insert (AFINS) is provided in the airfoil cavity (AFCV), said airfoil insert (AFINS) channels the cooling air (A) basically along said central axis (X) and is furnished with holes (IH) facing an inner surface (IS) of the basic body (BB) to cool said basic body (BB) by a jet of cooling air (A). To improve secondary air efficiency, the invention proposes that said inner surface (IS) of said basic body (BB) is provided with a defined convex radius (RADI) in at least one of said transition portions (TTR, BTR), that an insert (INS) extends along said inner surface (IS) of said transition portion (TR) and that the insert (INS) is provided with impingement holes (IH) facing said inner surface (IS) to cool said basic body (BB) by a jet of cooling air (A).

FIG 1



EP 2 418 355 A1

Description

[0001] The invention relates to a gas turbine vane comprising an airfoil extending along a central axis from a bottom to a top, a top platform and a bottom platform of a basic body, wherein said top platform and said bottom platform are both attached to said airfoil through a transition portion respectively, a top transition portion and a bottom transition portion, wherein said top platform and said bottom platform are both provided with a cavity connected by an airfoil cavity provided in said airfoil, wherein said cavities are supplied with cooling air for cooling said basic body, wherein an airfoil insert is provided in the airfoil cavity, said airfoil insert channels at least a portion of the cooling air basically along said central axis and is furnished with holes facing an inner surface of the basic body to cool said basic body by jets of cooling air.

[0002] A gas turbine vane of the incipiently design-type is for example disclosed in US 7,674,092 B2, which document relates to the cooling of a gas turbine blade or vane by means of specific cooling channel geometry in the airfoil. Modern gas turbines are aiming for increasing efficiency also by increased hot gas temperature. Hot gas, generated by a combustor of a gas turbine is discharged into a hot gas path of an aerodynamics turbine section of the gas turbine provided with vanes and blades to transfer the thermodynamic energy into a kinetic momentum. An essential perception is that an increased hot gas temperature leads to a higher efficiency according to thermodynamic principals. The limiting factors to an umlimited temperature increase are the material properties of components exposed to the hot gas in the hot gas path. Modern gas turbines are operated with hot gas temperatures, which already exceed the material capabilities, which is made possible by extensive cooling of the hot gas components. Among other things the thermal capability of the hot gas components is increased by film cooling using cooling air, which is also sometimes called "secondary air". On the one hand the secondary air enables operation at higher temperatures but on the other hand the efficiency is lowered since the temperature is decreased by the desired cooling effect because the film cooling secondary air is injected into the hot gas path and therefore mixes with the combustion hot gas.

[0003] It is one object of the invention to decrease secondary air consumption while the thermal capability of the hot gas component remains untouched or is even increased, which is referred to in the following as secondary air efficiency.

[0004] To improve secondary air efficiency it is reasonable to concentrate on locations of the vane, which experience a higher thermal load than others. An insight underlying the invention is that one of these regions is the incipiently mentioned transition area between the vane platform and the airfoil at the bottom and at the top. A second approach of the invention is to concentrate on portions of the vane, where the secondary air efficiency of a conventional vane has not been optimal. Conventional vanes like in US 7,674,092 B2 show that at least the bottom transition portion seems to have an insufficient cooling since the thickness of the wall between the hot gas path and the bottom cavity is increased with respect to the airfoils wall thickness, which leads to a heat concentration due to insufficient cooling. This "cooling bottle neck" has conventionally to be compensated by increased secondary air consumption to guarantee an adequate lifetime of the vane.

[0005] It is therefore another object of the invention to increase secondary air efficiency and to optimize cooling of the vane.

[0006] These and other objects are achieved by a gas turbine vane of the incipiently defined type, which is characterized in that said inner surface of said basic body is provided with a defined convex radius in at least one of said top transition portion or bottom transition portion, and that said insert extends along said inner surface of said transition portion provided with the insert and that said insert is provided with impingement holes facing said inner surface to cool said basic body by a jet of cooling air.

[0007] The defined radius according to the invention of convex shape follows the outer contour of the basic body in the transition portion, which leads to a defined wall thickness in the transition portion, which is significantly thinner than the wall thickness in this area of the conventional blade according to the above US document. Further the extension of the insert along this part of the inner surface in combination with the impingement holes leads to a concentrated cooling, where conventionally heat concentrations occurred. The distribution of the impingement holes can be adjusted to the temperature profile to be expected in the transition portion. Since according to improved distribution of cooling the temperature distribution in the basic body is more uniform and thermal stresses are reduced, which increases the expected lifetime of the component.

[0008] A preferred embodiment of the invention is provided by a gas turbine vane, wherein a ratio of wall thicknesses of the basic body between the transition portion (top transition portion or bottom transition portion) and the airfoil along said central axis at the same circumferential position with regard to said central axis is below to point 2.0.

[0009] This design rule leads to an optimized stress distribution with regard to thermally induced stress and mechanically induced stress in the whole basic body.

[0010] Manufacturing and mounting is improved when said insert comprises an airfoil insert and a bottom transition portion insert, which are aligned to each other, wherein the airfoil insert extends along the airfoil and the bottom transition portion insert extends along the bottom transition portion. The airfoil insert is basically of cylindrical shape, while the bottom transition portion insert is of a complex geometry similar to a rotation of a progressivly inclining polynomial.

[0011] It is a further advantage, if said airfoil insert and said bottom transition portion insert are supported by the basic body at the location of their joint. This design guarantees the same relative positioning of all involved the components to each other.

[0012] To compensate thermal relative movement of the basic body and the inserts it is advantageous to slidingly connect said airfoil insert and said bottom transition portion insert to each other and to said basic body. This sliding connection should enable relative movement of the inserts and the basic body in the direction of said central axis since in this direction the highest relative thermal movements are to be expected.

[0013] A further preferred embodiment of the gas turbine vane provides an insert comprising a top transition portion insert, which extends along the top transition portion and is aligned to the airfoil insert. The provision of the top transition portion insert goes along with the same advantages as the bottom transition portion insert.

[0014] Since the thermal relative movement of the inserts in the cavities with regard to the basic body and said central axis can be already compensated by a sliding connection between the bottom transition portion insert and the airfoil insert, a fixed connection between the basic body, the top transition portion insert and the airfoil insert at the position of there alignment to each other is very functional.

[0015] To established film cooling of the basic body the basic body maybe provided with holes connecting the airfoil cavity with a hot gas path. These holes should not face the holes of the airfoil insert directly opposing to increase cooling efficiency of the basic body due to the jet of cooling air first hitting the inner surface of the basic body and downstream discharging through holes into the hot gas path for the purpose of film cooling.

[0016] The above mentioned attributes and other features and advantages of this invention and the manner of attaining them will become more apparent and the invention itself will be better understood by reference to the following description of the currently best mode of carrying out the invention taken inconjunction with the accompanying drawings, wherein

Figure 1 shows a schematic three-dimensional depiction of a cross section through a vane according to the invention along its central axis,

Figure 2 shows a detail indicated by II in figure 1 and

Figure 3 shows a further detail indicated by III in figure 1.

[0017] Figure 1 shows a vane GTV of a gas turbine in a longitudinal cross section along a central axis X. To one end of the vane GTV is assigned the attribute "top" T and to the opposite and of the GTV is assigned the attribute "bottom" B, which attribute is not referred necessarily to the direction of gravity and could also be named differently. Beginning at the top T the vane GTV comprises a top platform PLT, a top transition portion TTR an airfoil AF, a bottom transition portion BTA, and a bottom platform PLB. The transition portions TR, the airfoil RF and the platform PLT, PLB belong to a basic body BB of the vane GTV. The basic body BB is preferably made of casted steel alloy. The airfoil RF of the basic body BB comprises a trailing edge TE and a leading edge LE is near the location, which is indicated in figure 1 but is not depicted correctly in figure 1 due to the cross section, which cuts away the real leading edge LE. Both platforms PLT, PLB are provided with a cavity CV, a top cavity TCV and a bottom cavity BCV. The top cavity TCV is connected with the bottom cavity BCV by an airfoil cavity AFCV. For cooling purpose cooling air A, which often is also named secondary air, enters the top cavity TCV, passes the airfoil cavity AFCV and enters the bottom cavity BCV while during the passage through these cavities CV a part of the airflow is consumed for being discharged into a hot gas path AGP surrounding the airfoil AF for the purpose of film cooling through holes not shown in the figure 1 of the basic body BB.

[0018] The invention focusses on the cooling air A distribution in the cavity CV to cool the basic body BB from the inside. For this purpose the cooling air A is directed by means of inserts INS directly on the inner surface IS of the basic body BB.

[0019] An insert INS extends basically along the central axis X from the top cavity TCV through the airfoil cavity AFCV down to the bottom cavity BCV. This insert INS is devided into three parts, a top transition portion insert TTRINS an airfoil insert AFINS and a bottom transition portion insert BTRINS.

[0020] As depicted in figure 2 and figure 3 in more detail the top transition portion insert TTRINS is fixed to the inner surface IS of the top cavity TCV of the top platform TCV, wherein it is aligned with the adjacent end of the airfoil insert AFINS. At the location of the joint between the top transition portion insert TTRINS and the airfoil insert AFINS both inserts INS are fixedly connected to the basic body by means of a protrusion on the inner surface IS of the basic body BB.

[0021] At the bottom transition portion BTR the airfoil insert AFINS is slidingly connected to the bottom transition portion insert BTRINS by means of a sliding connection SLC, which gives the airfoil insert AFINS freedom to move basically in the direction of the central axis X. This freedom of relative movement allows different thermal expansion between the basic body BB and the insert INS. The sliding connection SLC allows relative movement between the airfoil insert AFINS and the basic body and the bottom transition portion insert BTRINS, which is fixedly connected to the basic body BB in the area of the transition portion BTR.

[0022] Both transition portions TR are provided with a concave radius at the outer surface of the vane GTV and a convex radius on the inner surface IS of the basic body. Said radii are designed in such a way that following a path along the central axis X at the leading edge LE of the vane GTV the wall thickness in the area of the radii does not increase more than double of the wall thickness of the airfoil along its extension in direction of the central axis X.

[0023] The airfoil insert AFINS is provided with impingement holes IH facing the inner surface IS of the basic body. As well are said top transition portion insert TTRINS and the bottom transition portion insert BTRINS provided with impingement holes IH to provide a jet of cooling air to the inner surface IS of the basic body in this area. To allow for a best cooling effect a gap GA is provided between the insert INS and the inner surface IS of the basic body BB.

Claims

1. Gas turbine vane (GTV) comprising an airfoil (AF) extending along a central axis (X) from a top (T) to a bottom (B) comprising a top platform (PLT) and further comprising a bottom platform (BLP) of a basic body (BB), wherein said top platform (PLT) and said bottom platform (BLP) are both attached to said airfoil (AF) through a transition portion (TR), a top transition portion (TTR) and a bottom transition portion (BTR), wherein said top platform (PLT) and said bottom platform (PLB) are both provided with a cavity (CF, TCV, BCV) connected by an airfoil cavity (AFCF) provided in said airfoil (AF), wherein said cavities (CF, AF, CV, TCV, BCV) are supplied with cooling air (A) for cooling said basic body (BB), wherein an airfoil insert (AFINS) is provided in the airfoil cavity (AFCV), said airfoil insert (AFINS) channels the cooling air (A) basically along said central axis (X) and is furnished with holes (H) facing an inner surface (IS) of the basic body (BB) to cool said basic body (BB) by a jet of cooling air (A), **characterized in that**
said inner surface (IS) of said basic body (BB) is provided with a defined convex radius (RADI) in at least one of said transition portions (TR, TTR, BTR) and that said insert (INS) extends along said inner surface (IS) of said transition portion (TR) provided with the insert (INS) and that the insert (INS) is provided with impingement holes (IH) facing said inner surface (IS) to cool said basic body (BB) by a jet of cooling air (A).

2. Gas turbine vane (GTV) according to claim 1, wherein a ratio of wall thicknesses of the basic body (BB) between the top transition portion (TTR) or the bottom transition portion (BTR) and the airfoil (AF) along said central axis (X) at a leading edge (LE) with regard to a flow direction of a hot gas path (HGP) around a basic body (BB) is below 2.0.

3. Gas turbine vane (GTV) according to claim 1 or 2, wherein said insert (INS) comprises an airfoil insert (AFINS) and a bottom transition portion insert (BTRINS), which are aligned to each other, wherein the airfoil insert (AFINS) extends along the airfoil (AF) and the bottom transition portion insert (BTRINS) extends along the bottom transition portion (BTR).

4. Gas turbine vane (GTV) according to claim 3, wherein said airfoil insert (AFINS) and said bottom transition portion insert (BTRINS) are supported by the basic body at the location of their joint.

5. Gas turbine vane (GTV) according to claim 4, wherein said airfoil insert (AFINS) and said bottom transition portion insert (BTRINS) are slidingly connected to each other.

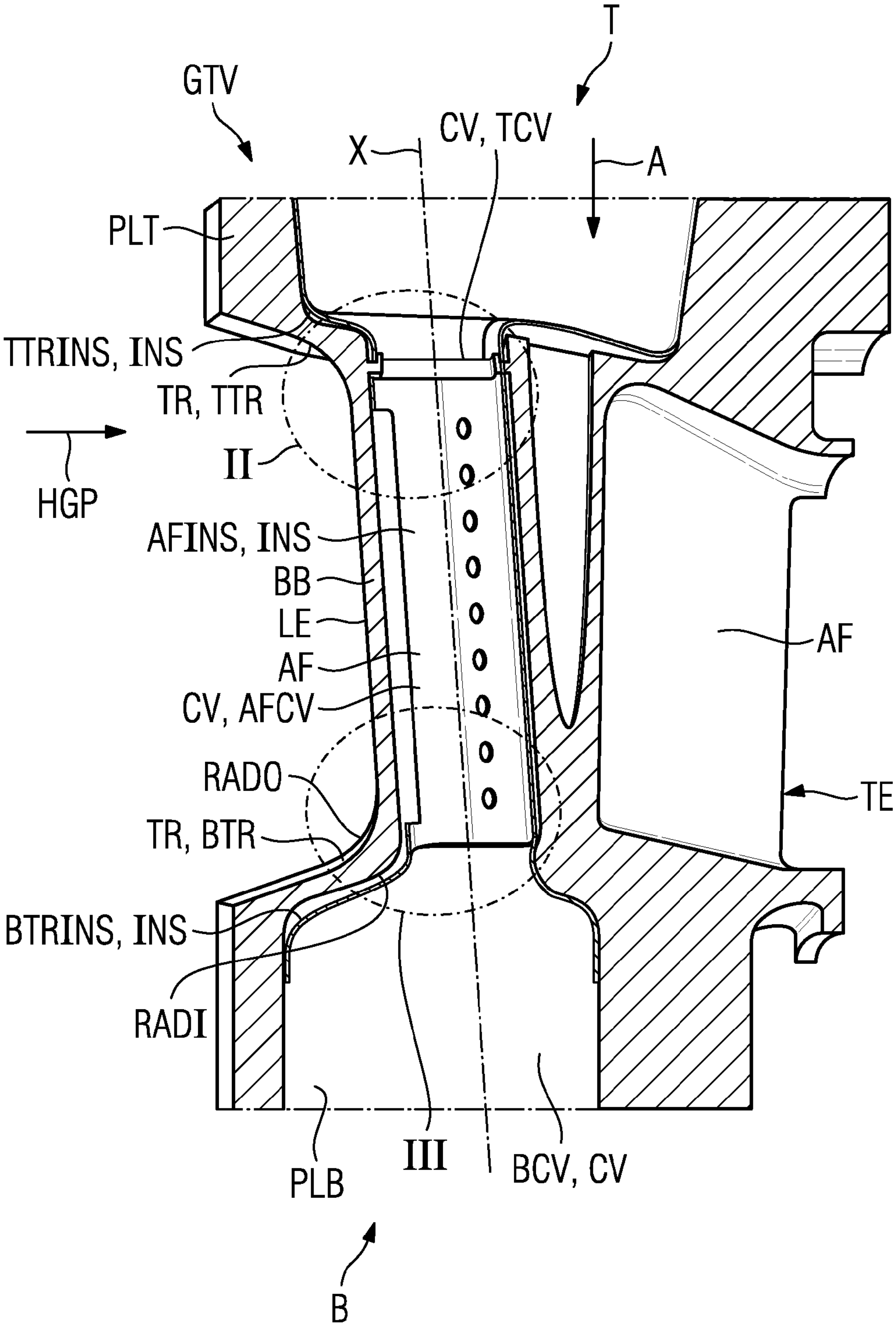
6. Gas turbine vane (GTV) according to claim 5 wherein said bottom transition portion insert (BTRINS) is fixedly connected to said basic body (BB).

7. Gas turbine vane (GTV) according to claim 3, wherein said insert (INS) comprises a top transition portion insert (TTRINS), which extends along the top transition portion (TTR) and is aligned to the airfoil insert (AFINS).

8. Gas turbine vane (GTV) according to at least one of the previous claims,
wherein said top transition portion insert (TTRINS) and said airfoil insert (AFINS) are both fixed to said basic body (BB) at the position of their alignment to each other.

9. Gas turbine vane (GTV) according to at least one of the previous claims,
wherein the basic body (BB) is provided with holes connecting said airfoil cavity (AFCV) with a hot gas path (HGP) for the purpose of film cooling of the vane (GTV).

FIG 1



T
GTV
X
CV, TCV
A
PLT
TTRINS, INS
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FIG 2

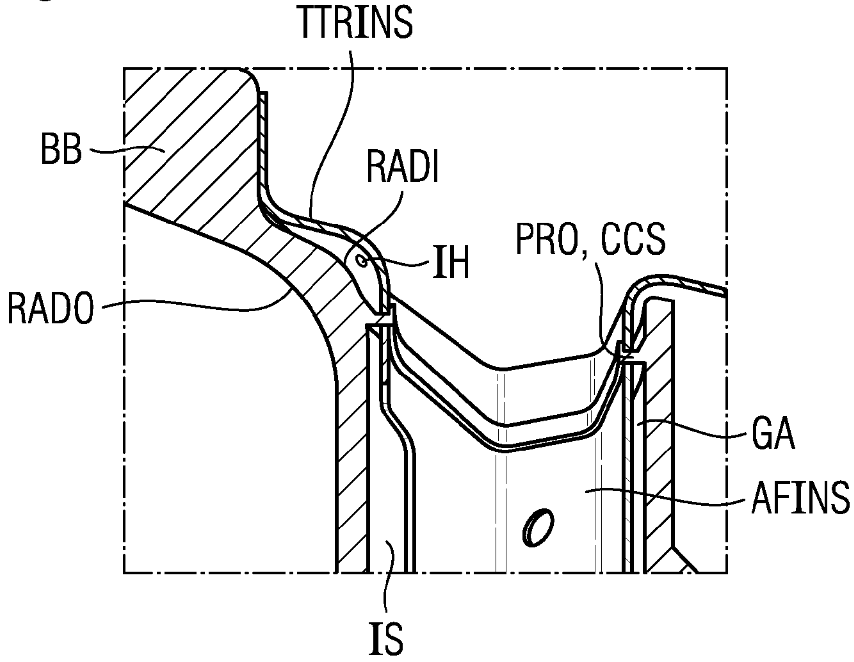
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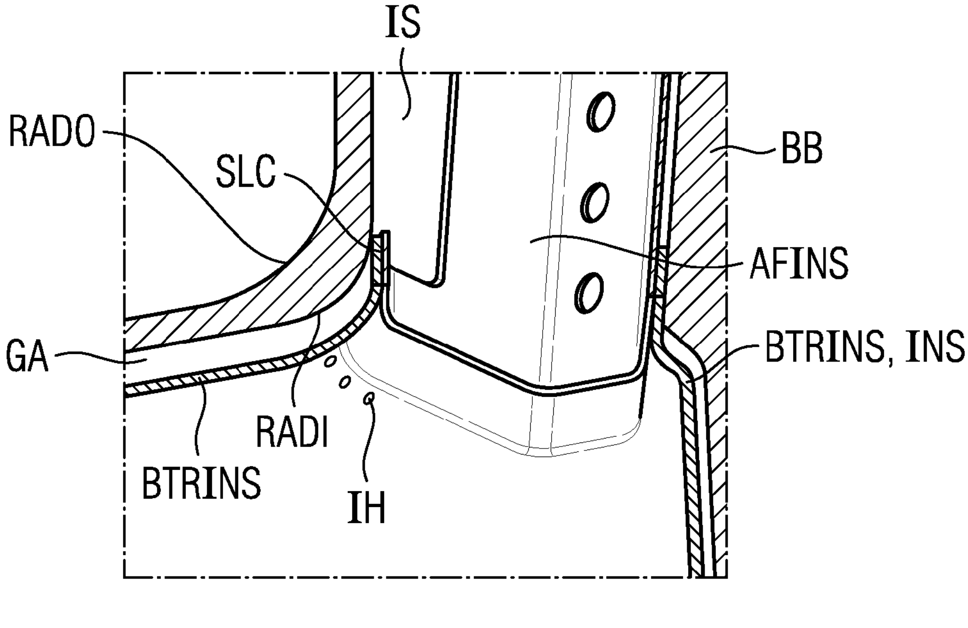
FIG 3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EUROPEAN SEARCH REPORT

Application Number
EP 10 17 2775

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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	27 January 2011	Robelin, Bruno

CATEGORY OF CITED DOCUMENTS

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