GAS TURBINE MOVING BLADE HAVING A PLATFORM, A METHOD OF FORMING THE MOVING BLADE, A Sealing Plate, AND A GAS TURBINE HAVING THESE ELEMENTS

Inventors: Shunsuke Torii, Takasago-shi (JP); Friedrich Soechting, Miami, FL (US); Masanori Yuri, Takasago-shi (JP)

Correspondence Address:
WESTERMAN, HATTORI, DANIELS & ADRIAN, LLP
1250 CONNECTICUT AVENUE, NW
SUITE 700
WASHINGTON, DC 20036 (US)

Assignee: MITSUBISHI HEAVY INDUSTRIES, LTD., Tokyo (JP)

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ABSTRACT

A platform of a gas turbine moving blade suppresses the effects of thermal elongation and thus improves cooling performance. A structure is constituted by a peripheral edge of a platform of a gas turbine moving blade, a bottom of the platform, and a shank of the moving blade. A cavity is blocked by disposing a sealing plate so as to seal the recessed section, while a supply route is formed for supplying air from cooling passages through an interior of the shank to the cavity, each of the passages being for air-cooling the interior of the gas turbine moving blade with air blown out from the cavity to a surface of the platform. A method of appropriately installing the sealing plate is also disclosed.
FIG. 11
PRIOR ART

(a)

122a

103

A

122d

117

122b

123

(b)

122a

122b

122d

103

171

172
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BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a gas turbine moving blade having a platform and is intended to suppress any effects of thermal elongation on the platform and thus to improve cooling performance thereof.

2. Description of the Prior Art

FIG. 9 is a perspective view of a typical platform 103 of a gas turbine moving blade 101 used primarily as a first-stage moving blade. Structurally, the moving blade has a platform integrated with a profile and profile-equipped root forming a blade 102. Below the platform, a blade root 151 of a Christmas-tree shape is formed and, as shown in FIG. 10, engaged to a groove 162 formed into the same shape as that of a rotor disc 161. Such plural moving blades are fixed in a parallel fashion to the grooves provided in the rotor disc, and there is a cavity 117 formed by a platform of the same stage and a shank 104 of the moving blade. The cavity is provided to supply cooling air from the rotor side and thus to prevent high-temperature combustion gas from leaking from a gas path thereof through clearances present between platforms. One means of cooling the platform is described below. In an embodiment according to conventional technology, as shown in U.S. Pat. No. 6,196,799 (Japanese Laid-Open Patent Publication No. JP11-236805), a platform 103 of the gas turbine moving blade is shown in FIGS. 11(a) and 11(b). FIG. 11(a) is a plan of the platform 103, and FIG. 11(b) is a cross-sectional view of section A-A in FIG. 11(a).

Numeral 117 denotes an internal cavity of the platform 103, and the cavity is formed at one side of the platform. Numeral 123 also denotes cavities, which are formed on the other side of the platform 103. Numerals 122a, 122b, 122c, and 122d each denote a row of multiple cooling holes. These rows of cooling holes individually communicate with the respective cavities and are each bored obliquely on the periphery of the platform 103 on one side thereof. These rows of cooling holes are provided to obtain an oblique flow of air in an upward direction and diffuse the air as sealing air for cooling the surface of the platform. In this embodiment, the sealing air is used for cooling, and in each of the cavities 117, 123 on a lower face of the platform 103, an impingement plate 171 is installed to block the cavity 117, 123. The sealing air is introduced as cooling air from a large number of impingement holes 172 within the impingement plate 171, into the cavity in order to provide impingement cooling.

It produces a certain effect to cool the surface of the platform in this way by introducing sealing air into the cavity at the bottom of the platform and allowing the air to flow from the cavity further to the surface of the platform via the cooling holes provided on the surface.

Sealing air is intended to prevent the main stream of high-temperature gas from leaking, and it usually does not control temperature. In addition, it is not advisable for a large quantity of sealing air to be used for other purposes. The air used to cool the blade, however, is supplied to the blade independently of the sealing air and, when necessary, after being cooled. Compared with the sealing air, therefore, the cooling air has the advantages that it can be used for cooling-temperature control purposes and that its flow rate can be adjusted.

SUMMARY OF THE INVENTION

Briefly, the present invention was made in order to provide a method and means suitable for cooling a moving blade having a platform and not dependent on platform cooling with sealing air only.

As described above, in the moving blades of a gas turbine, cooling air is supplied to cool each of the blades and a platform and thus to suppress increases in the temperatures of the respective metals due to a high-temperature combustion gas. In the moving blades of the gas turbine, a significant difference in mass exists between the platform and a profile section of each blade, and if a significant temperature difference occurs between both, this will cause a great thermal stress. The occurrence of a great thermal stress between the platform and the profile section of the blade makes cracking prone to occur particularly at sections exposed to the most thermally-severe conditions. These sections include, for example, the blade and a hub located at the trailing edge where the platform is planted. The present invention focuses particularly on the thermal stress of the platform and on the burned portions. Such damage is caused by a combination of creep rupture based on many years of high-temperature, high-stress operation, and fatigue-based destruction due to the stresses repeatedly applied with each start/stop operation. To prevent the damage, therefore, it is necessary to reduce to the lowest possible level the temperatures of and (thermal) stresses on sections prone to have concentrated stresses (i.e., the platform base sections at leading and trailing edges of the blade).

Accordingly, the present invention was made with the aim of providing a gas turbine moving blade whose reliability can be improved by introducing modifications in structural sections particularly susceptible to thermal stresses (i.e., a cooling structure of sections distanced from internal cooling passages of the blade), suppressing the occurrence of cracking and thermal damage due to thermal stresses, and extending the service life of the platform.

In order to solve the foregoing problems, the present invention may be embodied as follows:

In one embodiment of the present invention, a gas turbine moving blade having a platform has a recessed section constituted by a peripheral edge of a platform, a bottom, and a shank of a moving blade, the recessed section being formed with a cavity closed by disposing a sealing plate between the peripheral edge of the platform and the shank; the cavity being formed with a supply route for supplying air from cooling passages, through the interior of the shank to the cavity, each of the cooling passages configured for air-cooling the interior of the gas turbine moving blade; and the cavity being provided with a plurality of cooling passage holes each for allowing air to flow from said cavity to a surface of said platform. The above structure is effective in that it suppresses cracking and thermal damage due to thermal stresses, extends the service life of the platform, and improves reliability thereof.

The sealing plate may be fixed at least at one end to either a groove provided at a lower end of the peripheral
edge of the platform or to a groove provided in the shank. A cavity effective for cooling is thus formed.

[0013] Each of the cooling passages may be bored for the air to flow from the surface of the platform radially in a direction away from the blade. Platform cooling is thus made more effective.

[0014] At a longitudinal cross section of the cavity, the width of the cross section may be narrowed along the peripheral edge of the platform. Thus, cooling is conducted with minimum cooling air.

[0015] The sealing plate may be inserted into the grooves and then welded or brazed for fixing. This yields a positive effect in a process of making installation of the sealing plate in a cavity easy and reliable.

[0016] The sealing plate may be inclined toward the peripheral edge of the platform. Thus, cooling is conducted with minimum cooling air.

[0017] A dimpled plate may be used as the sealing plate. Thus, there arises an effect that gives strength to the sealing plate and minimizes runout thereof due to thermal elongation.

[0018] The sealing plate may have a dimple of a thin and long shape. This arrangement has the effect that structurally, strength of the sealing plate, runout thereof due to thermal elongation, and the like can be matched to a shape of the sealing plate.

[0019] The sealing plate has a plurality of dimples independent of one another. This produces the effect that structurally, strength of the sealing plate, runout thereof due to thermal elongation, and the like can be matched to a shape of the sealing plate.

[0020] The sealing plate is a plate formed by connecting a plurality of plates to one another in a lateral direction. This produces the effect that structurally, strength of the sealing plate, runout thereof due to thermal elongation, and the like can be matched to a shape of the sealing plate.

[0021] The sealing plate is a plate of a curved shape. This produces the effect that structurally, strength of the sealing plate, runout thereof due to thermal elongation, and the like can be matched to a shape of the sealing plate.

[0022] In another embodiment of the invention, a sealing plate for a gas turbine moving blade cavity has a plurality of protruding pieces on peripheral sections of the sealing plate. The sealing plate may include a through-hole in each of the plural protruding pieces. The sealing plate may also include a notch outside each of the plurality of holed protruding pieces. This arrangement makes installation of the sealing plate in a cavity easy and reliable.

[0023] In another embodiment of the invention, a method for forming a gas turbine moving blade having a platform includes: forming a recessed section by using a peripheral edge of the platform, a bottom thereof, and a shank of the moving blade; inserting at least one end of a sealing plate having protruding pieces into a groove previously provided in either a lower end portion of a platform peripheral edge or in the shank section of the moving blade; fixing each of the protruding pieces to the groove and fixing a peripheral edge of the sealing plate. This platform-forming method has improved workability. A notch formed in each of the protruding pieces may be cut open and spread outward for fixing. Based on this arrangement, the sealing plate can be installed easily and reliably.

[0024] In another embodiment of the invention, a gas turbine using a gas turbine moving blade having a platform includes: a recessed section constituted by a peripheral edge of the platform, a bottom thereof, and a shank of the moving blade, the recessed section being formed with a cavity closed by disposing a sealing plate between the peripheral edge of the platform and the shank; the cavity being formed with a supply route for supplying air to cooling passages through the interior of the shank to the cavity, each for air-cooling the interior of the gas turbine moving blade; and the cavity being provided with a plurality of cooling passage holes, each for allowing air to flow from the cavity to a surface of the platform.

[0025] In the above gas turbine structure, the entire gas turbine can effectively use cooling air.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] FIG. 1(a) shows a longitudinal section of a gas turbine moving blade according to Embodiment 1 of the present invention, and FIG. 1(b) is a cross-sectional view of section A-A in FIG. 1(a);

[0027] FIG. 2 shows cross section B-B of the platform in FIG. 1;

[0028] FIG. 3 shows an enlarged cross section of a platform bottom cavity enclosed in dotted line C of FIG. 2;

[0029] FIG. 4 is a semi-cutaway of the major sections viewed in perspective from the bottom of the platform in Embodiment 1 of the present invention;

[0030] FIG. 5 is a partly enlarged cross-sectional view of section D-D in FIG. 4;

[0031] FIG. 6 is a partly enlarged cross-sectional view showing a sealing plate of another embodiment;

[0032] FIGS. 7(a) to 7(g) are plans of various sealing plates used in the present invention;

[0033] FIGS. 8(a) to 8(c) show, in a partly enlarged form, a manner of installing a sealing plate in a cavity according to the present invention, wherein FIG. 8(a) is a plan of the sealing plate, FIG. 8(b) a cross-sectional view of an installation section, and FIG. 8(c) a partly enlarged view showing a step of forming a major section in cross section C-C of FIG. 8(b);

[0034] FIG. 9 shows a perspective view of a general gas turbine moving blade;

[0035] FIG. 10 shows a cavity at a blade-installed section in a parallel arrangement of gas turbine moving blades; and

[0036] FIGS. 11(a) and 11(b) show the cooling structure of a gas turbine moving blade platform according to an embodiment of conventional technology.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0037] Embodiments of a gas turbine moving blade platform according to the present invention are described below on the basis of the accompanying drawings.
Embodiment 1

[0038] FIG. 1(a) shows a longitudinal section of, for example, a first-stage gas turbine moving blade according to Embodiment 1 of the present invention, and FIG. 1(b) is a cross-sectional view of section A-A in FIG. 1(a).

[0039] A gas turbine moving blade 1 includes a blade 2 that forms a profile, a platform 3 bonded with a root section of the blade 2, and a shank 4 located under the platform 3. The interior of the blade 2 is constructed so that cooling air is first supplied from a blade root (Christmas-tree-like shape not shown here) that leads to a rotor (not shown) disposed under the blade, to cooling air passages 5. The cooling air is then supplied to a leading-edge passage 6 and serpentine fluid passages 7,8, each disposed inside the blade, so as to cool the blade interior. In a cooling passage 9, part of the cooling air is blown out from a trailing edge 10 to cool the edge 10, and the remainder of the cooling air is blown out from a blade top 11 into a gas path. In addition, the leading edge 6 lets cooling air flow from outflow holes located at a leading edge of the blade, and the remainder of the cooling air is discharged from the blade top 11 into the gas path. Furthermore, as shown in FIG. 1(b), at a blade head 12, blade convex portion 13, and blade concave portion 14 of the blade, a surface thereof has a plurality of outflow holes 15, whereby cooling is also effected.

[0040] FIG. 2 shows one form of the platform 3 when it is viewed from cross section B-B in FIG. 1(a). Under the platform 3, as shown in detail in FIG. 3 as an enlarged cross-sectional view of section C in FIG. 2, a peripheral edge 16 has, in the lower section of FIG. 3, a lower end 16a, and a cavity 17 is formed by the lower end 16a and the shank 4. A sealing plate 18 for closing the cavity is also installed. In order to retain this plate securely, the aforementioned shank and the aforementioned peripheral edge are provided with a groove 19a and a groove 19b, respectively, and the plate 18 is placed between the two grooves, while a peripheral edge of the plate is fixed by means of welding, brazing, or the like.

[0041] A cooling passage 20 to the cavity 17 communicates from any of the cooling passages 5 extending to the blade interior and cools a section 21 particularly prone to the accumulation of heat in the cavity and thus liable to suffer thermal damage. Cooling air from the cooling passage 20 passes through a plurality of cooling passages 22a, 22b, 22c, and 22d and then flows out from the platform to cool the surface thereof. In this case, one preferred embodiment may be formed with air flowing out radially air from each of the cooling passages. Cooling becomes more efficient when the cooling passages are distributed across the perimeter instead of being concentrated on the side.

[0042] Another cavity 23 in the platform is not equipped with a sealing plate, and it is adapted to use sealing air. In addition, a peripheral edge cooling passage 24 of the platform communicates with a passage 25. Furthermore, although other cooling passages 26 and 27 are also provided, these passages are configured differently from that of the cavities in the platform of the present invention. That is to say, neither of the two cavities 17,23 is blocked by a sealing plate.

[0043] FIG. 4 is a semi-cutaway of the major sections viewed in perspective from the bottom of the platform 3 in Embodiment 1 of the present invention. In FIG. 4, a structure with the sealing plate 18 installed to block the cavity 17 is shown, and the sealing plate 18 has four protruding pieces 18a, 18b, 18c, and 18d. The number of protruding pieces, however, is not limited to four.

[0044] FIG. 5 is a cross-sectional view of section D-D in FIG. 4, showing an installation state of the sealing plate 18 in the cavity 17. The sealing plate 18 is inserted between the groove 19a of the shank and the groove 19b at the peripheral edge of the platform via the protruding pieces 18a and 18b, with the peripheral of the plate fixed through welding or brazing. If, before the protruding pieces 18a and 18b are fixed to the grooves 19a and 19b by being inserted therein, the grooves are arranged to take an angle of α (where α is an appropriate angle from 90 to 135 degrees) with respect to the shank, workability with a tool used for welding, brazing, or the like, is enhanced since the tool can be easily used at a short distance from the shank and since the plate can be easily installed.

[0045] Since the platform surface of the gas turbine moving blade is a section through which combustion gas flows, it is exposed to a high temperature. The roots of the blade and the platform are also exposed to a high temperature, and their temperatures also increase, but the surface of the platform becomes most significantly hot. Compared with the platform surface and the roots of the blade and platform, the bottom of the platform and the shank are placed in a very low-temperature state. Accordingly, a thermal stress may arise on the platform, causing tension and hence, cracking. Therefore, it becomes necessary to cool these elements uniformly so as not to heat them to a temperature exceeding their thermal characteristics. In view of this, in the present invention, a cavity is formed at the bottom of the platform to improve cooling of this section.

Embodiment 2

[0046] FIG. 6 shows a form of installation of a sealing plate according to another embodiment, with a curved sealing plate 18 installed between a platform peripheral edge lower end 16a and a shank groove 19a demonstrated. This installation form is suitable when a large cavity is to be formed, and when the lower end of the platform cannot be easily grooved.

Embodiment 3

[0047] FIGS. 7(a) to 7(g) show plane and lateral-face shapes of various types of sealing plates. FIG. 7(a) shows a flat type composed of one flat plate, and FIG. 7(b) shows an arch type of plate having a thin and long dimple 18-1 extending along almost the entire length of the plate. FIG. 7(c) shows a sealing plate provided with a container-type dimple 18-2 forming a flat recess in the center. Furthermore, FIG. 7(d) shows a recessed type of sealing plate having two independent, thin and long dimples 18-3 and 18-4 approximately in the center. Besides, FIG. 7(e) shows a recessed combination type of sealing plate having a thin and long dimple 18-5 or 18-6 on both the surface and reverse side of the plate. FIG. 7(f) shows a sealing plate having a plurality of independent, protruding spherical dimples on the surface or reverse side of the plate. FIG. 7(g) shows, as a modified type of plate in FIG. 7(a), a connected type of sealing plate constituted by several plates 18-8 and 18-9 bonded with one
another by means of welding, brazing, or the like. Each of these types prevents the deformation of the sealing plate due to thermal elongation thereof, and can have sufficient strength, even if the plate is thin.

Embodiment 4

[0048] FIGS. 8(a) to 8(c) show an installation process of a sealing plate. FIG. 8(a) is a plan of a flat plate 18 having protruding pieces 18a, 18b, 18c, and 18d in four peripheral sections. Referring to 18b as a typical one of the four protruding pieces, a hole is provided in an approximate center of the protruding piece, and a notch 18b-1, at a front end thereof. Next, as shown in FIG. 8(b), which is a partly enlarged view of the above-mentioned plate 18 with one end inserted into a groove 19b at the lower end of the platform, one end of peripheral edge 16 of platform 3 is to be fitted into the protruding piece 18b, and subsequently, partial sealing is provided from the interlocking of peripheral edge 16 and protruding piece 18b. Next, as shown in FIG. 8(c), which is a partly enlarged view of cross section C-C in FIG. 8(b), the ends of the notch in the protruding piece 18b-1 are spread to fully insert the plate into the groove. After this, the periphery of the plate is welded or brazed for fixing.

[0049] In a gas turbine moving blade according to the present invention, a recessed section constituted by a peripheral edge of a platform, the bottom thereof, and a shank of the moving blade, is formed at a section prone to damage due to thermal stress on the platform, while a cavity blocked by a sealing plate is disposed between the peripheral edge of the platform and the shank. With cooling air for cooling the interior of the moving blade supplied to the cavity through an interior of the shank and blown out from the cavity to the platform surface that becomes very hot, it is possible to prevent damage and cracks without causing temperature changes with respect to other sections. When using sealing air as in the conventional technology described above, achieving the intended purpose of sealing air prevents a large quantity of air from being used for cooling. Compared with the conventional technology, therefore, it is possible for the cooling air supplied from internal cooling passages of the gas turbine moving blade has sufficient cooling performance, being greatly effective for cooling.

[0050] Furthermore, in the present invention, when a cavity is formed, a sealing plate can be reliably fixed in place by welding or brazing after providing a groove at appropriate parts both the platform peripheral edge and the shank adjacent the cavity.

[0051] The present invention has another advantage: a more reliable method of fixing the above-mentioned sealing plate, i.e., interlocking of a protruding piece of the sealing plate so that workability for the plate is thereby enhanced.

[0052] The platform of a gas turbine moving blade according to the present invention is significantly meaningful for industrial applications in that the platform improves cooling performance and hence, service life performance, and in that it enhances the workability in its forming method.

[0053] While the present invention has been described with respect to the embodiments as illustrated, the invention is not limited thereto but may naturally include various structural modifications within the scope of the claims below.

What is claimed is:

1. A gas turbine moving blade having a platform, comprising:
   a recessed section constituted by a peripheral edge of said platform, a bottom thereof, and a shank of the moving blade, said recessed section being formed with a cavity closed by disposing a sealing plate between the peripheral edge of said platform and the shank;
   said cavity being formed with a supply route for supplying air from cooling passages through the interior of the shank to said cavity, each of said cooling passages configured for air-cooling the interior of the gas turbine moving blade; and
   said cavity being provided with a plurality of cooling passage holes, each of said cooling passage holes configured for allowing air to flow from said cavity to a surface of said platform.

2. A gas turbine moving blade having a platform according to claim 1, wherein said sealing plate is fixed at least at one end to either a groove provided at a lower end of the peripheral edge of said platform or to a groove provided in the shank.

3. A gas turbine moving blade having a platform according to claim 1 or 2, wherein each of said cooling passages is bored for the air to flow from the surface of said platform radially in a direction away from the blade.

4. A gas turbine moving blade having a platform according to claim 1 or 2, wherein, at a longitudinal cross section of said cavity, the width of said cross section is narrowed along the peripheral edge of said platform.

5. A gas turbine moving blade having a platform according to claim 2, wherein said sealing plate is inserted into grooves and then welded or brazed for fixing.

6. A gas turbine moving blade having a platform according to claim 1, wherein said sealing plate is inclined toward the peripheral edge of said platform.

7. A gas turbine moving blade having a platform according to claim 1, wherein a dimpled plate is used as said sealing plate.

8. A gas turbine moving blade having a platform according to claim 7, wherein said sealing plate has a dimple that has a thin and long shape.

9. A gas turbine moving blade having a platform according to claim 7, wherein said sealing plate has a plurality of dimples.

10. A gas turbine moving blade having a platform according to claim 1, wherein said sealing plate is a plate formed by connecting a plurality of plates to one another in a lateral direction.

11. A gas turbine moving blade having a platform according to claim 1, wherein said sealing plate is a plate that has a curved shape.

12. A sealing plate for a gas turbine moving blade cavity, comprising a plurality of protruding pieces on peripheral sections of said sealing plate.

13. A sealing plate for a gas turbine moving blade cavity according to claim 12, including a through-hole in each of said plurality of protruding pieces.

14. A sealing plate for a gas turbine moving blade cavity according to claim 13, having a notch outside each of said plurality of holed protruding pieces.

15. A method for forming a gas turbine moving blade having a platform, comprising:
forming a recessed section by using a peripheral edge of said platform, a bottom thereof, and a shank of the moving blade;

inserting at least one end of a sealing plate having protruding pieces into either a groove previously provided in a lower end portion of a platform peripheral edge or in said shank section of the moving blade;

fixing each of said protruding pieces to said groove; and

fixing a peripheral edge of said sealing plate.

16. The platform-forming method for a gas turbine moving blade having a platform according to claim 15, wherein, a notch formed in each of said protruding pieces is cut open and spread outward for fixing.

17. A gas turbine using a gas turbine moving blade, having a platform, comprising:

a recessed section constituted by a peripheral edge of said platform, a bottom thereof, and a shank of the moving blade, said recessed section being formed with a cavity closed by disposing a sealing plate between the peripheral edge of said platform and the shank;

said cavity being formed with a supply route for supplying air from cooling passages through the interior of the shank to said cavity, each of said cooling passages configured for air-cooling the interior of the gas turbine moving blade; and

said cavity being provided with a plurality of cooling passage holes, each of said cooling passage holes configured for allowing air to flow from said cavity to a surface of said platform.