

TURBINE AIRFOIL PLATFORM COOLING CIRCUIT

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BACKGROUND OF THE INVENTION

The present invention relates generally to gas turbine engines and more particularly to a cooling circuit for a platform of a turbine airfoil.

10 Turbine blades in a gas turbine engine extend outwardly from a turbine blade platform. In operation, the turbine blades are routinely exposed to temperatures well above their material limits. In existing engines, air from the compressor section of the turbine engine is used to cool the blade material. This cooling air is fed to the blade through a series of rotor cavities underneath the blade platform. The cooling
15 air is then injected into the hot mainstream flow through openings in the sealing area.

Without sufficient cooling of the platform, the platform walls may experience creep deformation. High temperature gradients in the platform may result in thermal-mechanical fatigue. Additionally, the high temperatures can cause
20 oxidation of the platforms.

SUMMARY OF THE INVENTION

The present invention provides a cooling circuit for a turbine airfoil platform. The cooling circuit permits higher inlet temperatures than the current airfoil
25 assembly designs.

In a disclosed embodiment of the present invention, the cooling circuit cools the pressure side of the platform, while another cooling circuit cools the suction side of the platform. In general, the inlet of each cooling circuit receives cooling air from the rotor cavity below the platform. The cooling air flows through each circuit and
30 cools the walls of the platform.

Optionally, at least the suction side of the cooling circuit includes a plurality of pedestals extending between top and bottom walls of the cooling circuit. The

pedestals are positioned inside the circuit to provide structural integrity and stiffness for the platform. The pedestals also turbulate the flow and enhance cooling by increasing the internal heat transfer coefficients. The pedestals also provide increased surface area for cooling and provide conduction paths between the outer and inner wall of the cooling circuit.

The exit of each cooling circuit drives the cooling air in such a way as to provide the film coverage on the platform. This film blanket of cooling air further protects the platform walls from the hot gas recovery temperatures.

BRIEF DESCRIPTION OF THE DRAWINGS

Other advantages of the present invention can be understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

FIGURE 1 is a schematic of a gas turbine engine incorporating one embodiment of an airfoil assembly of the present invention.

FIGURE 2 is a turbine blade of Figure 1.

FIGURE 3 is a plan view of the turbine blade of Figure 2.

FIGURE 4 is a perspective view of the suction side cooling circuit of Figure 3.

FIGURE 5 is a perspective view of the pressure side cooling circuit of Figure 3.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

Figure 1 shows a gas turbine engine 10, such as a gas turbine used for power generation or propulsion, circumferentially disposed about an engine centerline or axial centerline axis 12. The engine 10 includes a fan 14, a compressor 16, a combustion section 18 and a turbine 11. As is well known, air compressed in the compressor 16 is mixed with fuel that is burned in the combustion section 18 and expanded in turbine 11. The turbine 11 includes rotors 13 and 15 that rotate in response to the expansion, driving the compressor 16 and fan 14. The turbine 11 compresses alternating rows of turbine blades 20 and vanes 19. Figure 1 is a somewhat schematic presentation for illustrative purposes only and is not a

limitation on the instant invention, which may be employed on gas turbines for electrical power generation, aircraft, etc. Additionally, there are various types of gas turbine engines, many of which could benefit from the present invention, which is not limited to the design shown.

5 A turbine blade 20 is illustrated in Figure 2 having a platform 32 and an airfoil 34 extending outwardly away from the platform 32. While the present invention can be described with respect to its application in a turbine blade 20, the invention could also be utilized in a static structure such as a vane 19 (Figure 1). The turbine blade 20 includes a pressure side 36 of the airfoil 34. A pressure side
10 cooling circuit exit 38 is formed in the platform 32 on the pressure side 36 of the airfoil 34. A rotor cavity 39 is defined below the platform 32.

 The turbine blade 20 further includes a suction side 40 of the airfoil 34 opposite the pressure side 36, as shown in Figure 3. Figure 3 is a plan view of the turbine blade 20, schematically showing the location of a pressure side cooling
15 circuit 42 and a suction side cooling circuit 46 which are contained within the platform 32 and lead to a pressure side cooling circuit exit 38 and suction side cooling circuit exit 54 on the upper surface of the platform 32. As shown in Figure 3, the pressure side cooling circuit 42 further includes a pressure side cooling circuit inlet 44. The suction side cooling circuit 46 includes an inlet 50 opposite the exits
20 54. The suction side cooling circuit 46 may further include a plurality of pedestals 56.

 Figures 4 and 5 are perspective views of the suction side cooling circuit 46 and the pressure side cooling circuit 42, respectively. The cooling circuits 46, 42 in the embodiment shown are metal cores that are separately molded, cast and/or
25 machined to the configurations shown and subsequently insert-cast into the platform 32 (Figures 2 and 3).

 Referring specifically to the suction side cooling circuit 46 in Figure 4, the core includes an outer wall 60 spaced above an inner wall 62. The outer wall 60 and inner wall 62 are connected by side walls 64. A cooling air path is defined between
30 the outer wall 60, inner wall 62 and side walls 64 from the downwardly directed inlet 50 to the upwardly directed exits 54. A plurality of pedestals 56 connect the outer wall 60 and inner wall 62. The pedestals 56 increase the structural integrity

and stiffness of the cooling circuit 46. The pedestals 56 also turbulate the flow and enhance the cooling by increasing the internal heat transfer coefficients. The pedestals 56 also provide increased surface area for cooling and provide conduction paths between the outer wall 60 and the inner wall 62 of the cooling circuit 46. The exits 54 from the cooling circuit 46 extend upwardly at an angle in order to provide the film coverage on the outer surface of the platform 32 (Figure 2). The film blanket will protect the platform 32 from the hot gas recovery temperatures.

Referring specifically to the pressure side cooling circuit 42 in Figure 5, the core includes an outer wall 66 opposite an inner wall 70 and connected by opposed side walls 68 to define a cooling path from a downwardly directed inlet 44 along a serpentine path to an upwardly directed exit 38. Although shown without pedestals, the pressure side cooling circuit 42 could optionally include the pedestals similar to those in the suction side cooling circuit 46 of Figure 4. Again, the exit 38 on the pressure side cooling circuit 42 is directed upwardly at an angle and is elongated in order to provide film coverage on the outer surface of the platform 32 (Figure 2).

Referring to Figures 2-5, in operation, cooling air from the rotor cavity 39 passes into the inlets 44, 50 of the cooling circuits 42, 46. The cooling air then travels through the cooling circuits 42, 46 in a direction generally parallel to the outer walls 60, 66 and inner walls 70, 62 to cool the platform 32. The air then exits the cooling circuits 42, 46 via the exits 38, 54 and forms a film blanket along the exterior surface of the blade platform 32.

The cooling circuits 42, 46 increase the thermal convective efficiency for increased heat pick-up. The internal heat transfer coefficients are increased as the metal temperature is decreased. The optional microcircuit pedestals 56 increase the stiffness and resistance to shear by improving rigidity of the turbine assembly and turbulate the cooling air flow. The slot exits 38, 54 provide improved film coverage of the platform 32. The platform 32 has increased material capability and resistance to creep deformation.

In accordance with the provisions of the patent statutes and jurisprudence, exemplary configurations described above are considered to represent a preferred embodiment of the invention. However, it should be noted that the invention can be

practiced otherwise than as specifically illustrated and described without departing from its spirit or scope.

CLAIMS

1. An airfoil assembly comprising:
an airfoil having a base end, an outer end, a pressure side and a suction side; and
a platform connected to the base end of the airfoil, the platform including a cooling circuit having an inlet on the platform and an exit on the platform, wherein the cooling circuit includes a separately formed hollow core insert-cast into the platform.
2. The assembly of claim 1 wherein the cooling circuit is a pressure side cooling circuit on the pressure side of the airfoil.
3. The assembly of claim 2 further including a suction side cooling circuit on the suction side of the airfoil.
4. The assembly of claim 1 wherein the cooling circuit is on the suction side of the airfoil.
5. The assembly of claim 1 wherein the cooling circuit includes a plurality of pedestals.
6. The assembly of claim 1 wherein the platform includes an outer surface, the exit formed through the outer surface of the platform.
7. The assembly of claim 1 wherein the cooling circuit includes a plurality of exits, including the exit.
8. The assembly of claim 7 wherein the cooling circuit is on the suction side of the airfoil.
9. The assembly of claim 8 wherein the cooling circuit includes a plurality of pedestals.
10. The assembly of claim 1 wherein the cooling circuit includes a passage extending parallel to an upper surface of the platform between the inlet and the exit.
11. The assembly of claim 10 wherein the cooling circuit includes a plurality of pedestals.

12. A cooling circuit for an airfoil platform comprising:
an outer wall;
an inner wall spaced away from the outer wall to define a cooling airflow passage therebetween;
an inwardly directed inlet in communication with the cooling airflow passage; and
an outwardly directed exit in communication with the cooling airflow passage, the cooling circuit adapted to be mounted into a platform of an airfoil.
13. The assembly of claim 12 wherein the cooling circuit includes a plurality of pedestals extending between the outer wall and the inner wall, the pedestals each including a passageway connecting an opening through the outer wall and an opening through the inner wall.
14. An airfoil platform assembly including the cooling circuit of claim 13, the assembly further comprising:
a platform having an outer surface with a pressure side and a suction side; and
the cooling circuit at least partially within the platform, the cooling circuit having the inlet on the platform and the exit through the outer surface of the platform.
15. The assembly of claim 14 wherein the cooling circuit is on the pressure side of the outer surface of the platform.
16. The assembly of claim 14 wherein the cooling circuit is on the suction side of the outer surface of the platform.
17. The assembly of claim 14 wherein the cooling circuit includes a plurality of pedestals extending between an outer wall and an inner wall.
18. The assembly of claim 14 wherein the cooling circuit is a hollow core formed separately from the platform.

19. The assembly of claim 18 wherein the cooling circuit is cast into the platform.
20. The assembly of claim 19 wherein the cooling circuit is a hollow metal core.
21. A method of cooling a turbine airfoil including the steps of:
- a) forming a cooling circuit having an outer wall, an inner wall spaced away from the outer wall to define a cooling airflow passage therebetween, an inwardly directed inlet in communication with the cooling airflow passage, an outwardly directed exit in communication with the cooling airflow passage;
 - b) after said step a), positioning the cooling circuit within a platform of a turbine airfoil assembly;
 - c) passing a cooling fluid into the inlet in the platform of the turbine airfoil assembly;
 - d) directing the cooling fluid through the cooling circuit through the platform; and
 - e) exhausting the cooling fluid from the exit in the platform.
22. The method of claim 21 wherein the platform includes an outer surface, the exit extending through the outer surface of the platform.
23. The method of claim 22 further including a turbine blade extending outwardly from the outer surface of the platform, the method further including the step of passing the cooling fluid out through the exit and then along the outer surface of the platform.