ABSTRACT: A turbomachine for an elastic fluid, having a rotor cooled by an elastic fluid which in the region of the roots of the rotor blades comprises cooling ducts, and a supply duct to supply coolant to said cooling ducts, which is formed by a section of the rotor shaft situated at the high pressure side of the blading and by a part of the housing. In the hub of the rotor on the high pressure side of the first rotor blade ring, as viewed in the direction of the pressure gradient, a number of feed ducts, corresponding to the number of said cooling ducts, is provided, said feed ducts being connected to said cooling ducts and having a cross section by a multiple greater than that of said cooling ducts, the inlet-side mouths of said feed ducts being situated in the region of the outlet-side mouth of said supply duct.
TURBOMACHINE WITH COOLED ROTOR

BACKGROUND OF THE INVENTION

In modern thermal turbomachines, more particularly in the case of gas turbines having a high rotational speed and/or a high working medium temperature, the cooling ducts must be kept small in cross section for strength reasons in the region of the blade roots. In conventional installations the coolant is supplied to the cooling ducts through an annular supply duct bounded by the rotor shaft and a housing part. In a supply duct of this kind the coolant has approximately half the peripheral speed of the rotor shaft and, therefore, has an inclined direction of arrival flow relatively to the cooling ducts. This causes a considerable throttling effect, which can limit to an undesirable or intolerable extent the quantity of coolant flowing through the cooling ducts. The same difficulty occurs to an even greater extent in the known installations wherein the coolant is supplied through stationary nozzles.

SUMMARY OF THE INVENTION

The object of the invention is to obviate these difficulties. For this purpose a turbomachine of the type described initially is so constructed according to the invention that a section of the rotor hub situated at the high pressure side of the first ring of rotor blades, as viewed in the direction of the pressure gradient, comprises a number of feed ducts corresponding to the number of cooling ducts 7, the said feed ducts being connected to the said cooling ducts and being arranged parallel to the rotor axis, and their cross section being for example five times greater than that of the cooling ducts 7 along a section at the high pressure side corresponding to approximately half of their axial extent, the inlet-side mouths 14 of the said feed ducts being situated in the region of the outlet-side mouth 15 of the supply duct 8.

Owing to the measures described, when the coolant is transferred from the supply duct 8 through the feed ducts 13 to the cooling ducts 7, no throttling effect occurs. On the contrary, despite oblique incident flow from the supply duct 8 a sufficient quantity of coolant can pass into the feed duct 13, in which it assumes the peripheral speed of the cooling ducts 7. Thus the measures proposed by the invention guarantee that an adequately large quantity of coolant will flow through the cooling ducts which are kept small in cross section for strength reasons.

In the illustrated example the inlet-side mouths 16 of the cooling ducts 7 on the one hand and the outlet-side mouth 15 of the supply duct 8 on the other hand have radiating form from one another. The radial extent of the feed ducts 13 along the section thereof at the high pressure side corresponds to the aforesaid radial spacing. The increase in the cross section of the feed ducts 13 relatively to that of the cooling ducts 7 is obtained exclusively by the greater extent of the feed ducts in the radial direction. This kind of construction achieves a satisfactory use of the space available.

The cooling ducts 7 are arranged radially inwardly of the blade roots 6 and adjoining the latter. The feed ducts 13 extend from the radial region of the radially inner surfaces of the blade roots 6 radially inwardly. The section 11 of the rotor hub 12 which is provided with the feed ducts 13 comprises grooves 19 which are in alignment with the axial grooves 20 receiving the blade roots 6, of the first rotor disc 18, as viewed in the direction of the pressure gradient, the said grooves receiving feet 20 of cover segments 21. The feed ducts 13 are arranged radially inwardly of these feet 20 and adjoining the latter. This kind of construction has the advantage that the grooves 19 can be machined together with the grooves 17 in a single working operation. Since the section 11 of the rotor hub is subdivided at the periphery by the grooves 13, 19, dangerous temperature stresses at this region are obviated.

The first rotor disc 18 has a larger radius than the section 11 of the rotor hub 12 which is provided with the feed ducts 13. A ring 22 is provided which surrounds this section 11 of the rotor hub 12 and is connected at the high pressure side to the housing 1 and whose low-pressure outer edge 23 is in axial alignment with the high-pressure outer edge 24 of the first rotor disc 18, and whose outer generated surface forms an axial section of the inner boundary surface of the working medium duct 25. The inner generated surface of the ring 22 bounds together with the generated surface of the aforesaid section 11 of the rotor hub 12, or with the outer surfaces of the cover segments 21, an angular sealing gap 26 which has sealing labyrinth. The ring 22 described hereinbefore affords the advantage that for sealing the coolant-conducting passage 8, 13 relatively to the working medium passage 25 a sealing gap 26 of considerable axial extent is obtained which gives an adequate sealing effect even with the tolerances necessary in view of the different thermal expansion of the rotor and housing. Since the cover segments 21 are subjected to less considerable forces than the blade roots 6, the feet 20 can be shorter and comprise fewer teeth than the blade roots 6.

In FIG. 3 the arrow 27 indicates the direction of rotation of the rotor 3. At the high-pressure mouths 14 of the feed ducts 13 the edges between the wall surfaces 28 of the feed ducts directed oppositely to the direction of the rotor and housing. Since the cover segments 21 are rotated-off, they could also be bevelled. This measure serves to improve the inflow conditions in the coolant entering the feed ducts.

BRIEF DESCRIPTION OF THE DRAWING

An embodiment example of a turbomachine with a cooled rotor according to the invention is represented in simplified form in the drawing, in which

FIG. 1 shows a fragmentary axial sectional view through a gas turbine,

FIG. 2a shows a fragmentary view in section taken at right angles to the axis through the rotor of the turbine on the line 2a-2a of FIG. 1,

FIG. 2b shows a fragmentary section similar to FIG. 2a, but taken on the line 2b-2b of FIG. 1,

FIG. 3 shows a fragmentary view from a development on the section taken on the line 3-3 in FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The illustrated gas turbine comprises a housing 1 having guide blades 2, of which two rings of guide blades are visible, and also a rotor 3 having rotor blades 4, two rings of rotor blades being visible. The arrow 5 shows the direction of the pressure gradient and at the same time the direction of flow of the driving medium. The first ring of rotor blades, or the blades thereof, as viewed in the direction of the pressure gradient, are designated as 41. In the region of the blade roots 6 of the rotor blade rings 4, 4 there are provided cooling ducts 7, 7 which are parallel to the rotor axis. A supply duct 5 serving to supply coolant to the ring of rotor blades 4 is surrounded by a housing part 10 and by a section 9 of the rotor shaft situated at the high pressure side and at the same time the inlet-side of the blade 2, 4 and is constructed as an annular gap. The rotor 3 can be mounted for example at the inlet-side outside the turbine in a compressor for the driving medium, the said compressor being assembled with the said turbine, cool-driving medium flowing between the shaft and the housing from the compressor to the first ring of rotor blades of the turbine. However, it is also known to introduce an elastic coolant from any desired source of suitable pressure and suitable temperature into the supply duct 8.

According to the invention a section 11 of the rotor hub 12 situated at the high pressure side of the first ring of rotor blades 4, as viewed in the direction 5 of the pressure gradient, comprises a number of feed ducts 13 corresponding to the number of cooling ducts 7, the said feed ducts being connected to the said cooling ducts and being arranged parallel to the rotor axis, and their cross section being for example five times greater than that of the cooling ducts 7 along a section at the high pressure side corresponding to approximately half of their axial extent, the inlet-side mouths 14 of the said feed ducts being situated in the region of the outlet-side mouth 15 of the supply duct 8.

Owing to the measures described, when the coolant is transferred from the supply duct 8 through the feed ducts 13 to the cooling ducts 7, no throttling effect occurs. On the contrary, despite oblique incident flow from the supply duct 8 a sufficient quantity of coolant can pass into the feed duct 13, in which it assumes the peripheral speed of the cooling ducts 7. Thus the measures proposed by the invention guarantee that an adequately large quantity of coolant will flow through the cooling ducts which are kept small in cross section for strength reasons.

In the illustrated example the inlet-side mouths 16 of the cooling ducts 7 on the one hand and the outlet-side mouth 15 of the supply duct 8 on the other hand have radiating form from one another. The radial extent of the feed ducts 13 along the section thereof at the high pressure side corresponds to the aforesaid radial spacing. The increase in the cross section of the feed ducts 13 relatively to that of the cooling ducts 7 is obtained exclusively by the greater extent of the feed ducts in the radial direction. This kind of construction achieves a satisfactory use of the space available.

The cooling ducts 7 are arranged radially inwardly of the blade roots 6 and adjoining the latter. The feed ducts 13 extend from the radial region of the radially inner surfaces of the blade roots 6 radially inwardly. The section 11 of the rotor hub 12 which is provided with the feed ducts 13 comprises grooves 19 which are in alignment with the axial grooves 20 receiving the blade roots 6, of the first rotor disc 18, as viewed in the direction of the pressure gradient, the said grooves receiving feet 20 of cover segments 21. The feed ducts 13 are arranged radially inwardly of these feet 20 and adjoining the latter. This kind of construction has the advantage that the grooves 19 can be machined together with the grooves 17 in a single working operation. Since the section 11 of the rotor hub is subdivided at the periphery by the grooves 13, 19, dangerous temperature stresses at this region are obviated.

The first rotor disc 18 has a larger radius than the section 11 of the rotor hub 12 which is provided with the feed ducts 13. A ring 22 is provided which surrounds this section 11 of the rotor hub 12 and is connected at the high pressure side to the housing 1 and whose low-pressure outer edge 23 is in axial alignment with the high-pressure outer edge 24 of the first rotor disc 18, and whose outer generated surface forms an axial section of the inner boundary surface of the working medium duct 25. The inner generated surface of the ring 22 bounds together with the generated surface of the aforesaid section 11 of the rotor hub 12, or with the outer surfaces of the cover segments 21, an angular sealing gap 26 which has sealing labyrinth. The ring 22 described hereinbefore affords the advantage that for sealing the coolant-conducting passage 8, 13 relatively to the working medium passage 25 a sealing gap 26 of considerable axial extent is obtained which gives an adequate sealing effect even with the tolerances necessary in view of the different thermal expansion of the rotor and housing. Since the cover segments 21 are subjected to less considerable forces than the blade roots 6, the feet 20 can be shorter and comprise fewer teeth than the blade roots 6.

In FIG. 3 the arrow 27 indicates the direction of rotation of the rotor 3. At the high-pressure mouths 14 of the feed ducts 13 the edges between the wall surfaces 28 of the feed ducts directed oppositely to the direction of the rotor and housing. Since the cover segments 21 are rotated-off, they could also be bevelled. This measure serves to improve the inflow conditions in the coolant entering the feed ducts.
In the region of the outflow-side ends of the feed ducts 13 there are provided radial bores 30 which connect the feed ducts with the working medium duct 25. Any particles of dust which get into the feed ducts with the coolant are removed by the action of centrifugal force through the bores 30 out of the feed ducts and do not get into the narrow cooling ducts 7, so that the risk of blockage of the cooling ducts 7 is reduced.

The measures according to the invention are not limited to a gas turbine but may also be used in the case of steam turbines and turbocompressors.

We claim:

1. An axial flow turbomachine for an elastic fluid of the type including a housing (1); a plurality of axially spaced, coaxial, circular series of guide blades (2) carried by and extending inward from said housing; a rotor (3) mounted for rotation in said housing; a plurality of axially spaced, coaxial, circular series of rotor blades (4, 41) (25) defined between the housing and the rotor and into which said blades project, recesses formed in said rotor and arranged to receive and confine therein the root portions of corresponding rotor blades, the improvement which comprises means to supply coolant to the region of the roots of the rotor blades of at least the series of rotor blades nearest the high pressure end of the machine and comprising a three part flow path extending in the direction of the pressure gradient through the machine, the three parts being respectively an annular inlet section (8) defined between a portion of the housing and the rotor, and extending inward from the high pressure end of the housing, an intermediate section including a plurality of substantially axially extending feed ducts (13) each formed in the rotor, and an end section comprising a like plurality of axially extending cooling ducts (7') formed in the rotor in the region of the root portions of the blades, each cooling duct being aligned with a corresponding feed duct, the cross section of each feed duct being a multiple of the cross section of each cooling duct.

2. The improvement defined in claim 1 in which the outlet of the inlet section is spaced radially inward from the cooling ducts, the feed ducts extending radially a distance corresponding to said radial spacing.

3. The improvement defined in claim 1 in which said rotor includes axial grooves 17 formed therein, each groove receiving the root portion of a rotor blade, said cooling ducts being formed in said grooves beneath the root portion therein; said feed ducts comprising axial feed grooves formed in said rotor in alignment with the blade root portion-receiving grooves and cover segments having projecting feet received in said feed ducts to hold said cover segments in place and enclose said feed ducts.

4. The improvement defined in claim 1 in which said feed ducts are bounded, at least in part, by parallel plane walls radiating from axis of rotation of the rotor and in which the trailing corner formed at the inlet ends of the feed ducts is chamfered.

5. The improvement defined in claim 2 and radial bores formed in the cover segments near their outlet ends, said radial bores opening into said working medium duct.
UNited States Patent Office
Certificate of Correction

Patent No. 3,582,230 Dated June 1, 1971

Inventor(s) David Schmidt and Paul Moser

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 3, line 17 after 

\[(4,4)\] and before 

\[
(25) \text{there should appear --carried by and extending radially outward from said rotor, the series of guide blades being intercalated with said series of rotor blades, an annular working medium duct--}
\]

Column 4, line 26 for "2" read --3--

Signed and sealed this 31st day of August 1971.

(SEAL)

Attest:

Edward M. Fletcher, Jr.
Attesting Officer

Robert Gottschalk
Acting Commissioner of Patents