TURBINE ROTORS

FIG. 1

FIG. 2

FIG. 3

FIG. 4

Inventor
G. B. R. FEILDEN

By
Wilkinson & Mankin

Attorney
United States Patent Office

2,743,080

TURBINE ROTORS


Application April 26, 1950, Serial No. 158,233

Claims priority, application Great Britain April 29, 1949

2 Claims. (Cl. 253—39.15)

This invention relates to rotors of axial flow turbines having two or more stages, with especial reference to rotors for gas turbines.

In axial flow turbines with two or more stages designed to operate at high speeds entailing high centrifugal stresses, and especially in gas turbines, in which the operating temperatures of the blading and at the periphery of the rotor are high, it is usual to mount each row of blading on a separate wheel or disc rather than mount all the rows of blading on a common drum. In the type of construction having separate wheels or discs for the several rows of blading, the shrouding of the tips of intermediate rows of stator blading presents difficult problems. If shroud rings are provided which are supported on the tips of the stator blades, axial clearances must be provided between these shroud rings and the rings of the turbine rotor wheels; and it has been found difficult in practice to maintain these clearances sufficiently small to prevent a leakage of the moving fluid which seriously impairs the efficiency of the blading.

Similar problems arise in axial flow compressors, of which a solution has been found by filling the gaps between the individual wheels carrying the moving blading with rings which are flanged at their edges to engage under the rims of adjacent wheels and whose outer surface is flush with the outer surfaces of the adjacent wheel rims so that the wheel assembly with its intermediate rings presents the external form of a complete drum. The temperature variations in a compressor are small compared with those in a turbine and expansion effects are of minor importance. The construction described in the preceding paragraph would be unsuitable for a turbine operating under any considerable loading, owing to creep stress considerations.

The achievement of a more satisfactory solution of this problem of shrouding the tips of intermediate rows of stator blading of turbines is an object of the invention.

According to the best modern practice, at least in gas turbines, the turbine rotor blades are usually mounted in the rims of the turbine wheels by means of serrated roots, sometimes known as "fir-tree" and the invention makes use of this type of construction.

According to the invention the axial widths of the rims of mutually adjacent turbine wheels or discs are greater than the axial widths of the blades mounted in them so that the serrations of the roots of the blades do not occupy the whole axial length of the serrated slots in the rims of the wheels; and the gap between mutually adjacent wheel rims is filled by dummy platforms corresponding in number to the blades in each wheel and having serrated roots supported at each end in the parts of the serrated slots of the adjacent wheel rims unoccupied by the blade roots.

The surfaces of these platforms may be shaped to an arc struck from the axis of the turbine shaft so that when assembled they form a complete ring flush with the blade platforms of the adjacent turbine wheels. In some cases, for ease of manufacture, the outer surfaces of the platform may be left flat, in which case the complete ring has a polygonal contour, approximating very nearly to a circle. The circumferential dimensions of the dummy platforms are such that there is a small clearance between each dummy platform and the next. Owing to expansion these clearances tend to close as the temperature rises and the circumferential dimensions of the dummy platforms are so chosen that, even under the severest temperature conditions, these clearances never completely close, thus ensuring that the dummy platforms do not throw additional thermal stresses on the turbine wheels. Subject to this consideration, however, the clearances are kept as small as possible.

A further object of the invention is the provision of adequate cooling of the opposed faces of mutually adjacent turbine wheels or discs, when the space between their rims is filled by a substantially continuous ring of dummy platforms.

This object is achieved by a feature of the invention, according to which each of the dummy platforms is provided with a small slot or notch at or near one corner providing an opening between it and the next dummy platform through which cooling air, fed into the space between the mutually adjacent turbine wheels for cooling the latter, can escape. The escaping air forms a layer of cooling air over the blade roots and blade platforms of the blade-row downstream of the ring of dummy platforms. Thus, the provision of these notches not only enables cooling air to be circulated through the spaces between adjacent turbine wheels for cooling the wheels themselves, but also provides a flow of cooling air over the platforms and inner ends of the blades of the second stage (and later stages, if any) of rotor blading. The outer faces of the wheels carrying the first and last stages of blading are air-cooled in the usual way, the air escaping through the clearance between the nozzle ring and the first row of moving blading and the clearance between the last row of moving blading and the exhaust cone; and the air escaping through the first of these clearances cools the platforms and inner ends of the blades of the first stage of rotor blading. Furthermore, the circulation of air through the spaces between mutually adjacent turbine wheels serves to cool the underfaces of the dummy platforms themselves.

The accompanying drawings illustrate a specific embodiment of the invention by way of example and the following description is without implied limitation of the scope of the invention as defined in the appended claims.

In the drawings,

Figure 1 is an axial section of a two-stage axial flow turbine rotor;

Figure 2 is a broken plan view taken in the direction of arrow 2 of Figure 1;

Figure 3 is a section on the line 3—3 of Figure 1 of a single dummy platform on an enlarged scale;

Figure 4 is a broken view on an enlarged scale similar to Figure 3 of a single turbine blade.

The turbine rotor comprises two discs 10, 11 secured to a journal member 12 by means of a retaining stud 13 and nut 14, the discs being keyed to one another by dowels 15 and to the journal 12 by dowels 16.

Disc 10 carries a row of blades 17, and disc 11 a row of blades 18. The blade roots 17a, 18a are of fir-tree form (see Figure 4) and each blade includes an integral platform 17b or 18b. The rims 10b and 11b of the discs 10, 11 are axially slotted at 10a, 11a (Figure 2) to receive the fir-tree blade roots. Each disc has an equal number of blades and the blade roots 17a, 18a of the discs 10, 11a are of the same fir-tree section, the slots 10a, 11a being in mutual register circumferentially, i.e. so that when viewed endwise each slot 10a exactly coincides with a slot 11a.
The axial width of the blade platforms 17b is the same as that of the blade roots 17a and is less than the axial width of the rim of disc 10; and the same is true of blade roots 18a, blade-platforms 18b and disc 11, so that when the blades are assembled on the discs as shown in Figures 1 and 2 the mutually adjacent ends of the slots 10a and 11a are unfilled. The two turbine discs 10, 11 are axially spaced at their periphery by gaps corresponding approximately to the axial width of the blades.

The blade-platforms 17a are substantially contiguous circumferentially, and so are the blade-platforms 18a; just sufficient clearance being allowed between them to allow for expansion, so that the blade-platforms of each row of blades presents a continuous annular drum-shaped surface.

The axial gap between these surfaces is filled by a row of dummy platforms 19 having fin-tree roots 19a, which are exactly similar to those of the blades and are inserted into the open or unformed ends of the slots 10a, 11a. The dummy platforms 19 substantially fill the gap between the blade-platforms 17a, 18a and are substantially contiguous circumferentially, just sufficient clearance both axially and circumferentially being provided to allow for expansion. The ring of dummy platforms 19 thus forms with the blade-platforms 17a, 18a a substantially continuous annular drum-shaped surface which constitutes the inner wall of the turbine annulus and from which the blades extend.

For cooling the mutually opposed faces 19a and 11a of the discs 10, 11 air is admitted to the space 21 between them by means of clearances 22, 23, 24, 25 and an opening 26 in the journal member 12. The air thus admitted to space 21 escapes by way of radially extending slots 20 cut in the dummy platforms 19 through which it passes into the space 21b between the blades 17 and 18 and into the turbine annulus and serves to cool the platforms 17a and the inner ends of the blades 17 of the second stage of the turbine.

This method of constructing the part of the inner wall of the turbine annulus intermediate between mutually adjacent rows of blade-platforms avoids the imposition of additional thermal stresses on the discs, the elements comprising the intermediate part of the annulus-wall itself being also substantially free from thermal stressing.

I claim: 1. In an axial flow turbine having at least two stages, blade-supporting discs having axially enlarged hubs secured together and having rims axially spaced apart, a row of blades on each disc, each blade having a fin-tree root and a blade platform and the rims of the discs having axially extending fin-tree slots receiving the blade roots, the blade platforms of each row being substantially contiguous circumferentially and the platforms and roots of the blades in each row being narrower axially than the axial width of the disc rims and their fin-tree slots, and a row of dummy platforms having fin-tree roots, the ends of which are supported in the fin-tree slots of mutually adjacent discs, the blade platforms and the dummy platforms being located entirely beyond the outer peripheries of the disc rims, the dummy platforms being substantially contiguous circumferentially and substantially filling the axial gap between mutually adjacent rows of blade platforms so that the blade platforms and dummy platforms together present a continuous drum-shaped surface, only sufficient clearance being allowed between the platforms to allow for expansion of the platforms.

2. A construction as claimed in claim 1, wherein the blades and the faces of adjacent discs are axially spaced apart, means having fluid connection with the axial space between the faces of adjacent discs for supplying cooling air to the axial space between the faces of adjacent discs and each dummy platform is provided inwardly of one axial end thereof with a slot which opens into the axial space between the faces and the axial space between the blades for conducting the cooling air between said spaces.

References Cited in the file of this patent

UNITED STATES PATENTS

2,430,185 Prescott Nov. 4, 1947
2,461,402 Whitehead Feb. 8, 1949
2,497,151 Clark Feb. 14, 1950

FOREIGN PATENTS

319,622 Great Britain Dec. 8, 1930
599,809 Great Britain Mar. 22, 1948
612,097 Great Britain Nov. 8, 1948