This invention relates to turbine and compressor blades, more particularly to blades of the above type arranged in annular groups and connected to each other by circular shrouds, and has for an object to provide an improved method of manufacture and resulting product.

Another object is to provide an improved method of manufacturing a shrouded compressor or turbine blade structure of the type wherein the blade has a tenon formed with at least two parallel sides received in a similarly shaped mating hole in the shroud and fastened thereto by deformation of the tenon (as by riveting).

A further object is to provide an improved and more reliable shrouded blade structure of the above type.

Still another object is to provide a shrouded blade structure of the above type that can be more economically, yet more precisely manufactured.

Shrouded blades for axial fluid flow machines, such as turbines and compressors, are usually connected to each other by circular shroud members for well known reasons. In such arrangements, it is desirable to provide a tenon on the end of each blade, a group of spaced holes in the shroud member to receive the blade tenons, and to tightly secure the blade to the shroud member by an autogenous bead formed on the tenon (such as by riveting).

Also, to minimize the concentration of stresses at the base of the tenon, the base is relieved by curved surface portions, and the edges of the holes in the shroud are relieved such as by chamfering or beveling to prevent interference or formation of excessive compressive stresses therebetween when the tenon is riveted to the shroud.

When the tenon is of cylindrical or circular cross-section and received in a mating hole of circular cross-section, the chamfering of the hole may be accomplished and expeditiously provided by a rotatable conventional countersink bit or chamfer bit.

However, the cylindrical tenon is costly to manufacture and in many instances a stronger tenon is required. Accordingly, a more economical and stronger tenon is obtained by cutting away a portion of the airfoil portion of the blade in such a manner that the tenon has a cross-sectional area defined by a first pair of opposed parallel sides and a second pair of opposed sides including a convex side and a concave side. The holes in the shroud may be easily punched to properly mate with the tenons.

Since the mating holes are not circular, chamfering cannot be done by the usual rotatable chamfering tool, and must be done by a hand operation, whereby leading to wide variations in the resulting chamber. If insufficient chamfering is provided by the above hand operation, it is difficult to detect and correct, and after the blade is compressively secured to the shroud by riveting, interference between the inadequate chamfered surface and the curved base portions of the tenon induce large localized stresses at the base of the tenon which may result in premature failure of the blade in operation.

In accordance with the invention, a longitudinal groove of uniform cross-sectional area is machined in the shroud and the holes for the tenons are punched in spaced relation with each other along the groove. The parallel sides of the holes substantially coincide with the side walls of the groove and the groove is preferably formed with oppositely beveled side walls spaced sufficiently to form the required chamfer and provide the relief at the curved base portions of the tenons.

The above and other objects are effected by the invention as will be apparent from the following description and claims taken in connection with the accompanying drawing, forming a part of this application, in which:

FIGURE 1 is a view of a portion of a shrouded blade turbine rotor having the invention incorporated therein;

FIG. 2 is an enlarged radial sectional view taken along line II—II of FIG. 1;

FIG. 3 is a developed view of one of the shrouded blade groups and taken along line III—III of FIG. 1;

FIG. 4 is a cross-sectional view of a shrouded member;

FIG. 5 is a greatly enlarged fragmentary sectional view of a shroud member and blade tenon before riveting;

FIG. 6 is a view similar to FIG. 5, but illustrating another form of the invention;

FIG. 7 is a fragmentary cross-sectional view showing the invention applied to another form of shroud member; and

FIG. 8 is a cross-sectional view illustrating a shroud strip of the type shown in FIG. 7 during fabrication.

Referring to the drawing in detail, in FIG. 1 there is shown a portion of a turbine rotor comprising a rotor spindle 11 having an array of radially extending blades 12 supported therein and connected to each other in groups (four, as illustrated) by arcuate shroud members 13. Although the entire rotor 10 is not shown, it will be understood that the spindle 11 is of circular cross-section and the blades 12 are arranged in an annular array about the rim 14 of the rotor.

The blades 12 may be connected to the rotor rim 14 in any desired manner. However, as best illustrated in FIG. 4, the blades are formed from a core stock T shaped roots 15 received in a mating peripheral groove 16 formed in the rotor rim 14.

The blades 12 are provided with airfoil vane portions 17 extending radially outwardly from the roots 15 and are further provided with tenons 18 extending through holes 19 formed in the shroud members 13 and secured thereto by autogenous beads 20 formed by deformation of the tenons 18, as by riveting.

As thus far described, the structure is substantially conventional.

In accordance with the invention, the method of manufacturing and the resulting tenon and joint structure will now be described. Since all of the blades 12 are substantially identical and are joined to the shroud 13 in the same manner, only one of the blades will be described.

The vane portion 17 of the blade 12 is cut away at its radially outermost tip, as illustrated by the dot-dash lines in FIG. 3 to form the tenon 18 and the tenon extends perpendicularly outwardly from the outer tip surface 21 of the blade. The cross-sectional shape of the tenon is defined by a first pair of opposed parallel sides 22 and a second pair of opposed sides 23 and 24 of convex and concave shape, respectively, which are a continuation of the airfoil shaped vane portion 17. The sides 22 at the base of the tenon are formed with curved surface portions 25, smoothly blending with the blade tip surface 21, as best shown in FIG. 5, to minimize the concentration of strains induced in operation.

To prevent interference between the tenon surfaces 25 and adjacent sides 26 of the mating shroud hole 19, the arcuate shroud member 13 is provided with a longitudinal groove or recess 27 extending the full length of the shroud and the holes 19 are punched through the shroud 13 within the confines of the groove. As best shown in FIGS. 4 and 5, the groove 27 is of greater depth than the height of the curved portions 25 of the tenon, thereby positively providing clearance spaces 28 therebetween when the blade
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12 is secured to the shroud 13 by riveting or otherwise deforming the tenon 18.

Since the other two sides 23 and 24 are substantially flush with the vane portion 17 no further relief is required between the tenon and the shroud.

Although in the embodiment shown in FIGS. 1–5 the groove 27 is provided with oppositely beveled side walls 29, other shapes having convex or straight side walls may be provided. For example, as illustrated in FIG. 6, there is provided a blade tenon and shroud structure 32, before the riveting operation, generally similar to that of the first embodiment except that the shroud member 33 is provided with a groove 34 deeper than the curved tenon portions 35 and having parallel side walls 36 spaced from each other a distance X greater than the mean spacing Y between the curved portions 35.

In the embodiment shown in FIGS. 1–5 and described above, the shroud members 13 jointly define a hoop having an innermost surface of substantially cylindrical shape. However, in many instances the innermost surfaces of the shroud members jointly define a frustum of a cone.

FIG. 7 illustrates such an arrangement. In this embodiment, there is provided a blade 40, similar to the blade 12, (partially shown) in which the tip portion 41 is cut away at an angle to provide a tenon 42, and a shroud member 43 having a cylindrical outer surface 44 and a frusto conical inner surface 45.

In this arrangement, the machining of the shroud member 43 is facilitated by provision of a preliminary dual shroud strip 46 having a cross-section as illustrated in FIG. 8. The strip 46 comprises a left-hand portion 47 and a right-hand portion 48 which are mirror images of each other and are divided along a median plane M after the two grooves 49 and 50 are machined and the tenon holes 51 (only one shown) are punched. The grooves 49 and 50 are substantially identical to the grooves 27 in the shroud member 13 and need not be further described. However, by machining the two grooves 49, 50 simultaneously, in the symmetrical strip 46, variations in machining a single unsymmetrical shroud member such as the left-hand portion 47 or the right-hand portion to attain the shroud member 43 are obviated.

It will now be seen that with the invention, chamfering the edges of a hole of non-circular shape having at least two parallel sides to provide relief is simply yet effectively attained with a degree of precision not attainable with present methods and arrangements, and at a reduction in cost thereover.

Although several arrangements have been shown and described, it will be obvious to those skilled in the art that it is not limited, but is susceptible of various other changes and modification without departing from the spirit thereof.

I claim as my invention:

1. A shrouded blade group for an axial fluid flow machine, comprising

4. a plurality of blades having an air foil shaped portion, each of said blades having a tenon extending from said air foil shaped portion,
said tenon having a first pair of opposed sides substantially parallel to each other and a second pair of opposed sides,
said second pair of sides including a concave side and a convex side,
an elongated shroud member having a longitudinal groove of uniform cross-sectional area and of a mean width greater than the spacing between the parallel sides of said tenons,
said shroud member having a plurality of longitudinally spaced holes in said groove,
said holes having a cross-sectional area substantially equal in size and shape to the size and shape of the cross-sectional area of said tenons,
said tenons extending in a following manner through said grooves and said holes in said shroud thereby to form a clearance space between said tenons and said shroud, and means compressively securing said tenons to said shroud.

2. The structure in claim 1, in which:

the groove has oppositely forming beveled side walls forming said clearance space, and
the securing means is an autogenous head on each tenon.

3. The structure recited in claim 1, in which:

the parallel sides of the tenons have curved base portions, and
said curved base portions are disposed in the groove and in spaced relation with the side walls of the groove to jointly therewith form said clearance space.

4. The structure recited in claim 1, in which:

the groove has oppositely beveled side walls, the parallel sides of the tenons have curved base portions, the curved base portions are disposed in the groove and in spaced relation with said beveled side walls to jointly therewith form said clearance space, and the securing means is an autogenous head on each tenon.

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