TURBINE WHEEL ASSEMBLY


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4 Claims. (Cl. 253--77)

This invention relates generally to gas turbine engines or the like and to turbine wheels for use therein. More particularly, the instant invention relates to a new and advantageous elastic fluid turbine wheel construction and to a method for making the same.

One type of gas turbine wheel constructions which are known to persons skilled in the elastic fluid art include various forms of fabricated metal blade and rotor hub assemblies, various forms of welded assemblies, and various types of cast assemblies. Still other constructions make use of cast blade sections or segments which may either be mechanically secured to a fabricated or forged wheel hub structure or welded thereto.

The higher thermal and dynamic stress requirements of recent turbine wheel designs and the even increasing importance of dimensional accuracy at high temperatures have given rise to a present need for a new and improved turbine wheel construction. The turbine wheel construction of the present invention will meet higher operating requirements by virtue of a unique relationship between the constituent portions to provide for a strategic distribution of the dynamic and thermal stresses.

It is commonly known that certain metals which have good heat and corrosion resistance have also relatively low yield stresses and poor ductility and are relatively expensive. Conversely, the metals which do have high strength properties and good ductility usually have relatively poor heat and corrosion resistance. The turbine wheel construction of the present invention is adapted to make use of two dissimilar metals and takes advantage of only the more desirable physical properties of each metal. Further, the present design calls for a highly efficient and economical use of each of the metals and it may be readily adapted to commercial or quantity production.

Accordingly it is an object of the present invention to provide a new and improved turbine wheel for use with elastic fluid turbine engines comprising a hub structure and an integrally cast peripheral blade portion.

Another object of the present invention is to provide a turbine wheel of the type set forth above wherein the hub structure and the cast peripheral blade portion are formed of dissimilar metals.

Another object of the present invention is to provide a turbine wheel comprising a hub structure formed of a metal having a relatively high ductility and a peripheral rim structure formed of a heat-resistant and corrosion-resistant metal, the rim structure having an annular row of blades formed integrally thereto.

Another object of the present invention is to provide a turbine wheel as set forth in the preceding object wherein the rim structure is brazed to the outer perimeter of the hub.

Another object of the present invention is to provide a turbine wheel of the type set forth in the preceding object wherein the rim structure is brazed to the outer periphery of the hub.

Another object of the present invention is to provide a turbine wheel comprising a hub structure formed of a metal having relatively high ductility and a relatively high melting point and having a cast metal annular rim with integrally cast blades, the cross sectional area of the rim at the base of the blades being reduced to form a radial web structure.

Another object of the present invention is to provide a turbine wheel as set forth in the preceding object wherein reinforcing ribs are disposed at spaced intervals along the rim web structure.

Another object of the present invention is to provide a new and improved method for constructing a turbine wheel of the type set forth above.

For the purpose of particularly describing the present invention reference will be made to the accompanying drawings wherein:

Figure 1 is a side view of a turbine wheel according to one form of the present invention;

Figure 2 is a sectional view of the turbine wheel of Figure 1 taken along the section line 2--2 of Figure 1;

Figure 3 is a partial diametral sectional view of a second form of the present invention;

Figure 4 is a partial diametral sectional view of a modification of the turbine wheel shown in Figures 1 and 2;

Figure 5 is a partial diametral sectional view of another modification of the turbine wheel shown in Figures 1 and 2;

Figure 6 is a partial diametral sectional view of a third form of the present invention showing a webbed rim for supporting the blades; and

Figure 7 is a side view of a portion of the turbine wheel of Figure 6.

Referring first to the form of the invention shown in Figures 1 and 2, the turbine wheel is seen to comprise a disc type hub 10 having a centrally disposed aperture 12 for receiving a turbine wheel shaft upon which the turbine wheel may be secured in any known manner.

The disc 10 is preferably formed with a transverse thickness which becomes progressively smaller at radially outward locations for the purpose of improving the stress distribution therein. If desired, a suitable annular shoulder may be provided at 14 for the purpose of facilitating the mounting of the turbine wheel on an appropriate mounting structure.

The disc 10 is provided with a flanged peripheral edge portion having a flat annular peripheral surface 16 about which an integrally cast rim structure 18 may be disposed. The rim structure 18 comprises a circular base portion 20 to which a peripheral row of turbine blades 22 is integrally formed. The unitary rim structure 18 may be formed of a suitable heat-resistant, corrosion-resistant and durable material such as stellite.

The disc structure 10 may be formed of any suitable metal having relatively high ductility and a high yield stress, such as a forged alloy metal. The cast rim 18 may preferably be secured to the periphery of disc 10 by nickel brazing. This brazing process, which is commonly referred to as "microbrazing," produces a permanent alloy joint in the vicinity of the weld which may be stronger than either of the parent metals.

The integral and unitary construction of the rim and blade readily adapts the same for manufacture by an investment casting process thereby making it possible to reduce manufacturing tolerances to a minimum. Also, the brazed assembly of the rim 18 and disc 10 results in a turbine wheel structure which not only has a relatively high yield strength at the locations of maximum stress by virtue of the physical properties of the ductile material used in forming the disc, but which also has
good heat-resistant properties and durability in the regions subjected to the high operating temperatures by virtue of the physical properties of the material used to casting the rim and blades. Thus, the more desirable physical properties of two different metals are utilized to advantage to produce a turbine wheel assembly capable of operating at higher temperatures and at higher speeds than the corresponding operating temperatures and speeds of a turbine wheel assembly formed with a single type of metal. It is contemplated that a turbine wheel of the type herein disclosed, having an outer diameter of approximately 10 to 12 inches, may operate satisfactorily at speeds up to 50,000 r.p.m. and at temperatures up to 2,922,619°F.

Referring next to Figure 3, a modified form of the invention is illustrated and as readily observed from the drawing, the outer periphery of the turbine wheel hub disc, shown at 20, is formed with conical surface 24 and a mating conical surface is formed on the inner periphery of the cast rim which is shown at 28. This construction greatly facilitates the brazing operation in that the rim member may be placed gently on the conical surface 24 with a minimum of clearance therebetween during the brazing operation. If the rim expands slightly during the brazing operation, the rim may be made free to move axially without a clearance of clearance.

Referring next to Figure 4, a turbine wheel hub disc 30 is formed in which the flanged peripheral edge thereof is provided with circular shoulders 34 and 36 which serve to extend the width of the peripheral surface 32 thereof. Matting shoulders are formed on the base portion 40 of the rim structure 48 which may be brazed on the disc 30 by the "nicro brazing" operation previously referred to. When the wheel is rotated during operation of the engine, the radial stresses transmitted through the welded area to the disc 30 will be primarily concentrated at a central location intermediate the axial sides of the peripheral rim. Since the stresses in the vicinity of the shoulders 34 and 36 are therefore reduced, the tendency for cracks to form in the vicinity of the edges of the brazed surfaces is also reduced. Since cracks normally originate at the edges of the brazed areas, the strength of the unit therefore may be increased in this manner.

Referring now to Figure 5, another form of the invention which includes a means for reducing the tendency for cracking at the edge of the welded surfaces. The rim base portion, shown at 58, which may be "nicro brazed" to the peripheral surfaces of a forged alloy disc 60, may be provided with circular grooves 52 on the radial-side thereof. These circular grooves 54 may be provided on the peripheral edges of the disc 50, as shown. It is thus apparent that the radial stresses transferred to the disc 50 during the operation of the turbine wheel assembly of Figure 5 will also be primarily concentrated intermediate the edges of the brazed surfaces thereby reducing the tendency for cracks to originate at these points.

The form of the invention illustrated in Figures 6 and 7 includes a cast rim structure in which the constituent material is stellite or a similar alloy metal, said rim structure also including a base portion 68 and an integrally formed row of blades 62. The base portion 68 may be brazed to the periphery of a hub disc 60 in a manner similar to that of the previously described embodiments. The base portion 68 is formed with a radially disposed web 64 and axially flanged inner and outer peripheral edges 66 and 70, respectively. A series of radially extending ribs 72 are integrally formed with the base portion and are situated transversely to the web portion 64 for the purpose of increasing the structural rigidity of the rim. One such rib may be disposed below each of the blades 62 as shown in Figure 7. It is apparent that the radial cross sectional area of the rim, as shown in Figure 6, may be considerably reduced by virtue of its webbed construction. This causes a reduction in the stresses in the rim structure and in the hub disc as explained in the following paragraph.

When the rim portion of the turbine wheel of any of the above described embodiments is heated to an elevated temperature range which approaches the operating temperature, expansion of the same takes place. Since the rim portion is integrally secured to the hub disc, radial displacement of the rim portion is restrained thereby causing a thermal radial stress component. Because of the restraints offered to the thermal strain in the rim portion, the material of which the rim portion is formed will be stressed beyond the elastic limit and plastic deformation will occur. Upon a subsequent reduction in temperature, the rim portion will contract and cause portions of the same, especially the outermost fibers, to be stressed with a tangential tensile stress. When the turbine wheel is again subjected to operating temperatures and speeds, the residual or pre-load stresses in the rim must be relieved before compressive stresses can be produced therein. At some particular temperature and operating speed, the pre-load stresses in the outermost fibers of the rim portion exactly counter-balance or cancel the dynamic and thermal compressive stresses produced during operation of the engine. It therefore follows that the maximum stress produced in the rim portion will be less than that resulting from being produced if such a preload did not exist. The stresses transmitted to the hub disc are also correspondingly lower.

In the embodiment of the invention shown in Figures 6 and 7, the cross sectional area of the outer rim portion is considerably reduced, and therefore the total tangential force which exists during operation of the turbine engine as the outer fibers of the rim portion approach the yield stress is also reduced proportionately. The thermal stresses which are transferred to the hub disc 60 by the rim portion are therefore correspondingly reduced.

In order that the radial stresses may be transferred from the rim portion 68 to the hub disc 60, the ribs 72 are provided at appropriately spaced intervals. It is contemplated that certain forms of integrally cast turbine wheel structures, which necessarily would be formed of a single type of casting alloy, might also be adapted to the method herein described in Figures 6 and 7. The maximum operating stress which would be produced in the hub disc of such an integrally cast turbine wheel would be lower by virtue of the webbed rim construction since the thermal component of the operating stresses would be reduced as explained above. Although certain preferred embodiments of the invention have been specifically described as required by the patent statutes, it is contemplated that variations thereof of may be made without departing from the scope of the instant invention as defined by the following claims.

I claim:

1. A turbine wheel assembly comprising a circular hub, a rim disposed about the periphery of said hub, said rim having axially flanged inner and outer peripheral edges and a radially extending annular web connecting said inner and outer peripheral edges, said web between said edges having a portion of axial transverse thickness smaller than the axial transverse thickness of said hub, said outer peripheral edge having a plurality of blades cast integrally therewith, said inner peripheral edge being secured to the outer peripheral edge of said hub, and a plurality of circumferentially spaced ribs disposed substantially transversely to said radially extending web and interconnecting said inner and outer peripheral edges.

2. A turbine assembly as set forth in claim 1 wherein one of said circumferentially spaced ribs is disposed radially inward of each of said plurality of blades.

3. A turbine assembly as set forth in claim 2 wherein said circumferentially spaced ribs, said radially extending web, said upper and lower axially flanged peripheral edges and said plurality of blades constitute a single integrally cast subassembly.
4. A turbine wheel assembly comprising a circular hub, a rim disposed about the periphery of said hub and having a plurality of blades carried thereby, said rim having axially flanged inner and outer peripheral edges and a radially extending annular web connecting said inner and outer peripheral edges, said web between said edges having a portion of axial transverse thickness smaller than the axial transverse thickness of said hub, and a plurality of circumferentially spaced ribs disposed substantially transversely to said radially extending web and interconnecting said inner and outer peripheral edges.

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