This invention relates to a rotor assembly reinforced with a filament wound composite ring. The rotor assembly comprises a rotatable member having an annular cavity concentric to the member's axis. The composite ring is positioned within the cavity and has an inner diameter somewhat larger than the diameter of the rotor surface about which the ring is disposed. During rotor operation the rotor surface diameter increases and comes into centrifugal load bearing relationship to the composite ring, whereupon the ring carries a portion of the centrifugal loads thus reducing the strength requirement of the rotatable member.
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FILAMENT REINFORCED ROTOR ASSEMBLY

BACKGROUND OF THE INVENTION

1. Field of Invention
This invention relates to the use of circumferentially wound filaments to reinforce a rotor assembly.

2. Description of the Prior Art
The use of circumferentially wound filaments to reinforce a rotor assembly is well known in the prior art as evidenced by U.S. Pat. No. 3,393,436 to Blackhurst, et al., and British Patent No. 1,252,544 issued Apr. 9, 1970 to General Motors Corporation. The chief advantage of these filaments is their high tensile strength and lightweight; when these filaments are circumferentially wound about a rotatable body their high tensile strength translates into a high hoop strength giving the filaments the ability to carry large centrifugal loads.

Two basic problems are encountered with the use of these filaments. One is the difference in thermal and centrifugal expansion rates between the filaments and noncomposite materials; the other problem is that many of these filaments, depending upon the material from which they are made, deteriorate in certain environments, such as in a high temperature oxygen environment as is present in gas turbine engines.

SUMMARY OF THE INVENTION

An object of the present invention is a lightweight rotor assembly having high strength.

Another object of the present invention is a rotor assembly with the ability to withstand a contaminating environment such as a high temperature oxygen environment.

Accordingly, the present invention contemplates a rotor assembly comprising a rotatable member having an annular cavity therein and an annular filament wound composite ring located within said cavity and radially spaced from a radially outwardly facing annular surface of said cavity and adapted to carry a portion of the centrifugal loads of said rotor assembly during operation. Having the filaments located within the annular cavity protects them from direct exposure to whatever environment happens to surround the rotatable member. When the rotor assembly reaches operating temperatures and speeds, the ring carries a portion of the assembly centrifugal loads.

More particularly, flexible positioning means, such as springs, may be positioned about the inner diameter of said ring to locate said ring concentrically with respect to said rotatable member and to allow differential growth between the ring and rotatable member. Also, if required, the annular cavity may be filled with an inert gas to further protect the filaments from contaminating substances.

The foregoing and other objects, features and advantages of the present invention will become more apparent in the light of the following detailed description of preferred embodiments thereof as illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a sectional view of a portion of a turbine rotor assembly.

FIG. 2 is a sectional view of the rotor assembly of FIG. 1 with the blades and blade locks removed, taken along the line 2—2 of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

As an example of a rotor assembly embodying the features of the present invention consider the turbine rotor assembly shown in FIG. 1 and generally represented by the numeral 10. The turbine rotor assembly 10 is suitably mounted within the turbine section (not shown) of a gas turbine engine by means (not shown) well known to one skilled in the art. The present invention is particularly suited to use in a turbine rotor assembly due to the extremely high temperatures and corrosive environment to which a turbine rotor assembly is exposed; however, it should be obvious that this invention may be useful in a compressor rotor assembly, or for that matter in any rotor assembly subjected to any combination of high temperatures, a corrosive environment and high centrifugal loads.

Referring now to FIGS. 1 and 2, the rotor assembly 10 comprises a rotatable member or disc 12 and a plurality of radially extending circumferentially spaced blades 14 attached by suitable means to the periphery 16 of said disc 12 such as by the use of a fir tree root 18 and corresponding fir tree slots 20 shown in drawing and well known in the art. Blade locks 22 or other suitable blade retention means are also generally required. The blade attachment means is simply a matter of choice and is not a part of the present invention.

The disc 12 includes an annular cavity 24 formed therein. Positioned within the annular cavity 24 is an annular filament reinforced composite ring 26. The composite ring 26 comprises one or more circumferentially wound filaments embedded in a matrix material. In this embodiment it is contemplated that the filaments be made from carbon and that the matrix material be made from carbon. The filaments and matrix materials are a matter of choice and depend on several factors such as maximum strength requirements, maximum temperature requirements, and filament/matrix thermal and stiffness compatibility. Examples of other possible filament-matrix combinations are sapphire-nickel, boron-titaniuim, and graphite-graphite; the present invention, however, is not limited to any particular filament-matrix combination. By positioning the ring 26 within the cavity 24 the filaments and matrix material are protected from direct contact from contaminants which may surround the rotor assembly.

The annular cavity 24 has a radially outwardly facing surface 32 which in this exemplary embodiment is interrupted by a plurality of circumferentially spaced slots 34 whose function will hereinafter be made clear; however, for the purpose of this invention the annular surface 32 may be continuous.

The composite ring 26 includes an inner annular surface 36 having a diameter slightly larger than the diameter of the annular surface 32. This difference in diameters is necessary to account for the differences in thermal and centrifugal growth rates between the disc 12 and the composite ring 26; the composite ring 26 expands considerably less than the disc 12 during operation, and the difference in diameters is chosen such that the ring 26 will come into centrifugal load bearing relationship to the disc 12 at operating speeds and temperatures. In the present embodiment the surface 36 will come into direct contact with the surface 32; however, it is possible that some other hardware may be located between the two surfaces.
To prevent unbalance within the rotor assembly 10 during transient conditions (that is, until the ring 26 comes into centrifugal load bearing relationship to the disc 12) flexible positioning means such as a plurality of circumferentially spaced springs 38 locates the ring 26 concentric to the annular surface 32. The springs 38 are of the well known Belleville type, and at least three of said springs, equally spaced about the inner annular surface 36 of said ring 26 are required to assure concentric positioning of the ring 26.

One requirement of the flexible positioning means is that it permits essentially unhampered growth between the disc 12 and the ring 26 until the ring comes into centrifugal load bearing relationship to said disc 12; another requirement is that the flexible positioning means does not operate to create unacceptable stress concentrations within the composite ring. As regards the latter requirement, the springs 38 are positioned within the slots 34 and are sized such that when fully compressed by the composite ring 26 the ends 40, 42 of the spring 38 about the sides 44, 46, respectively, of the slot 34; if there were a gap between these surfaces the composite material would tend to enter that gap and the filaments might be damaged to the point of failure of the composite ring. Additionally, the thickness of the spring 38 is the same as the depth of the slot 34. Thus during operating conditions, when the spring is fully compressed, the radially outwardly facing surface 48 of the spring is flush with the surface 32 of the annular cavity to form a substantially continuous annular surface with no sharp edges to damage the composite ring 26.

As shown in FIG. 1 the disc 12 comprises left and right annular rings 50, 52, respectively. Each of said annular rings 50, 52 has an annular groove 54, 56, respectively. The annular rings 50, 52 are joined together by suitable means such as diffusion bonding at 58 and 60; it is also contemplated that the rings may be mechanically joined. The grooves 44, 46 cooperate to form the annular cavity 24.

Depending upon the particular materials chosen for the filaments and the matrix material, it may be necessary or desirable to fill the cavity 24 with an inert gas to assure that the filaments and matrix material are not exposed to any contaminating substances inside the cavity; in that case it is mandatory that the cavity be airtight. Additionally, some filament and matrix materials may react chemically with the disc material, damaging the filaments and reducing the effective hoop strength of the composite ring. If that is the case, it is desirable to insulate the composite ring from the disc material. This might be accomplished in serveral ways, one of which would be to encapsulate the composite ring within a tube (not shown); another method might be to coat or line the walls of the annular cavity with a suitable material.

Although the invention has been shown and described with respect to a preferred embodiment thereof, it should be understood by those skilled in the art that various changes and omissions in the form and detail thereof may be made therein without departing from the spirit and the scope of the invention.

Having thus described typical embodiments of our invention that which we claim as new and desire to secure by Letters Patent of the United States is:

1. A filament reinforced rotor assembly comprising:
   an annular rotatable member including a plurality of blade receiving slots circumferentially spaced about its periphery and having an axis and having an annular cavity therein concentric with said axis, said cavity including a radially outwardly facing annular surface concentric with said axis, said annular surface being interrupted by a plurality of circumferentially spaced slots;
   an annular filament reinforced composite ring located within said cavity and having an inner diameter slightly larger than the diameter of said annular surface when said rotor is at rest, the difference in diameters being adapted to assure that said ring comes into centrifugal load bearing relationship to said rotatable member at rotor assembly operational speeds and temperatures due to the different centrifugal and thermal growth rates of said rotatable member and said composite ring; and
   a plurality of circumferentially spaced Belleville springs disposed within said slots, each of said springs having a radially outwardly facing surface, said springs being compressed by said composite ring during rotor assembly operation, and when compressed said outwardly facing surface being flush with said annular surface and defining a substantially smooth continuous annular surface therewith with substantially no gaps and no sharp edges to damage the composite ring.

2. The filament reinforced rotor assembly according to claim 1 wherein said rotatable member comprises two joined annular rings cooperating to form said annular cavity.

3. The filament reinforced rotor assembly according to claim 2 wherein said annular cavity is airtight and filled with inert gas to prevent contamination of said ring.

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