

Description

Technical Field

This invention relates to gas turbine engines and particularly to the rim configuration of the disk of the turbine rotor and retention means of the blades, seals and dampers.

Background of the Invention

With the advent of high speed aircraft with its advanced type of engines, in order to enhance the high cycle fatigue life of component parts, particularly the turbine rotor blades, it has become necessary to incorporate damping techniques so as to reduce vibratory stresses occasioned by the higher speeds. For turbine rotors that utilize fir tree attachments to secure the blades to the disk, such dampers have been incorporated in the space between blades at the blade root/disk attachment sections. Examples of dampers of this sort are disclosed in US-A-4,182,598, 4,101,245, 4,455,122 and 3,887,298.

The turbine blade damper of US-A-4,182,598 referred to (on which the two-part form of independent claim 1 is based) is mounted in a cavity between the neck portions of adjacent blades. A toggle damper is mounted in a slot of the cover plate of the turbine rotor. The damper disclosed in US-A-3,887,298 has a seal plate extension on the high pressure side of the rotor and a damper support has a seal plate extension on the low pressure side of the rotor. The seal plate extensions fit into spaces between the rotor disk and side plate fixed thereto.

While those embodiments exemplified in the above noted patents disclose means for achieving damping, they all to some extent require complex means of assembly and disassembly necessitating the removal of more than one blade to replace another blade or component in the disk/blade assembly, or to install a blade, damper and/or seal.

Disclosure of the Invention

According to the invention there is provided a rotor assembly for a gas turbine engine, having a disk, said disk having a rim portion and radially outwardly extending disk lugs in said rim portion, defining disk slots therebetween, said disk lugs each having a front face and a rear face, a plurality of blades, each blade having a root section and a neck section radially outwardly of the root section, each blade having its root section received in a corresponding one of said disk slots, there being formed a dead rim cavity radially outwardly of each disk lug between the neck sections of adjacent

blades, said rotor assembly further having means for absorbing excessive vibratory motions occasioned by the rotation of the turbine, said means including a damper formed from a weighted element having a radial inner end portion and a radial outer end portion in its assembled position and opposing side edges, a rotor seal adjacent said disk and extending radially adjacent said neck sections of the blades, the radial inner end portion of said weighted element being trapped in a space bounded on one side by a radially extending annular portion of said rotor seal, characterized in that the other side of said space is bounded by the front face of the disk lug and each blade root section has a portion extending axially beyond the front face of said disk lugs toward the rotor seal and under a portion of said radial inner end portion of said weighted element radially inwardly thereof, said axially extending root portions of two adjacent blades defining with the annular portion of the rotor seal and the front side of the disk lug between said two adjacent blades a pocket for receiving and positioning the inner end portion of said weighted element, the side edges at the radial outer end portion of the element being received in opposing pockets formed in the blade neck sections.

In one embodiment there can be provided an improved retention system for the turbine rotor components by incorporating a unique rim configuration that employs snap rings to secure the blades in the disk. To this end, rearward retention of the blades is by a snap ring supported by hooks integral to the rear of the disk, and forward blade retention is by an inverted snap ring supported by a lug integral to the front of the disk lug. In this configuration the axial retention of the blades is provided by this snap ring and not the TOBI (Tangential On Board Injector) rotor seal which has been the common heretofore practice. To have designed the system incorporating heretofore design practices would have added an intolerable amount of weight to be capable of absorbing these axial loads. Among the advantages afforded by this inverted snap ring are:

- (1) improved producibility of the snap ring groove,
- (2) lighter weight than heretofore known retention systems, and
- (3) full ring support for the snap ring for improved durability, leakage control and life.

In another embodiment of this invention an improved means is provided for supporting an interplatform seal adjacent the undersurface of the blade platforms to extend across the gap between platforms. Nubs cast on the underside of the platform and a buttress on the rear of the platform provide a retention and orientation system for the seal which may be assembled and disassembled

from either the front and rear end of the disk.

Thus, this invention contemplates an easily accessible damper and interstage platform seal to facilitate the assembly and disassembly of those components without the necessity of removing more than one blade. Hence, individual blades can be installed and removed without disrupting the rotor or changing the dynamics of the rotor. By virtue of this invention, a significant improvement in turbine maintainability and assembly is evidenced coupled with a reduction in tooling requirements and a less complex rim assembly.

The foregoing and other features and advantages of the present invention will become more apparent from the following description and accompanying drawing.

Brief Description of the Drawings

FIG 1 is a view in elevation of the blade.

FIG 2 is a perspective view of the damper.

FIG 3 is a partial view in section and elevation showing the disk, blade, TOBI seal, rotor and retention system.

FIG 4 is a sectional view taken substantially along the lines 4-4 of FIG 3 with the damper shown in full.

FIG 5 is a perspective view of the interstage seal.

FIG 6 is a partial rear end view of the rim and assembled rotor.

Best Mode for Carrying Out the Invention

For an understanding of the invention, reference is being made to FIGS 1-6 of the drawings. As is well known, the turbine of a gas turbine engine is comprised of a disk supported to the engine shaft that supports a plurality of radially projecting turbine blades uniformly mounted about the circumference of the disk and supported thereto in fir tree broaches formed in the disk. The blade 10 itself, as shown in FIG 1, consists of a root generally illustrated by reference numeral 12 having a conventional fir tree shaped root section 14 extending radially in the neck 16 of the blade 10 and configured to fit into the fir tree broach in the disk. A depression 18 in the neck 16 of the blade 10 adjacent the rim of the disk defines a dead rim cavity which is directly under the platform 20. The platform 20 extends circumferentially and axially from the airfoil 22 of the blade 10 and overlies the rim of the disk. The platform of the next adjacent blade abuts the side surface of the platform of its adjacent blade and leaves a laterally extending gap which is sealed by sealing mechanism to be described hereinbelow.

As noted from FIG 1, the blade 10 has cast therein a pocket 24 adapted to receive the radial outer end portion of damper 26 (FIG 2). Each of the blades has identical pockets cast on the forward and rearward faces of the neck. The side edges 28 and 30 of damper 26 are adapted to fit into these pockets which provide axial and circumferential positioning of the radial outer end portion of the damper 26 (see FIGS 3 and 4). The inner leg 32 of damper 26 is captured between the annular shaped TOBI seal rotor 34 which is secured in any well-known manner to the disk 36, or splined to the shaft common to the shaft to which disk 36 is mounted. Suffice it to say TOBI seal rotor 34 and disk 36 rotate at the same RPM. The outer diameter of TOBI seal rotor 34 carries a rim 44 that has a rear face 42 that bears against the side face of disk 36, but is designed so as not to absorb the loads generated by the blades. Extending from the rim but spaced from the rear face 42 is a radially extending annular portion 44 that, together with the end face 46 of disk 36 and the extended portion 48 formed on the side face of lug 50 of the fir tree 14 of blade 10, defines a pocket receiving the inner leg of damper 26. This pocket, provided by the TOBI rotor seal and extended blade lug, provides axial and circumferential positioning of the radial inner end portion of damper 26. This method of retention allows the damper to seat freely on pocket base 77 without restraint to achieve effective damping, thus dissipating the energy of the vibrations of the blades, but still prevents the damper from separating from the rotor or locking up. The damper 26 is contoured to include central extensions 27 that provide sufficient mass in the proper location to attain the desired centrifugal load, which in conjunction with the friction induced component damps out vibratory stresses produced by the blades.

As mentioned above, the gap between the platform 20 is sealed by a relatively thin, generally flat member 52 that is contoured to fit and be trapped on the underside of the platform by using a cast seal finger 53 extending radially downwardly from the platform and leading edge nub 54 and trailing edge nub 56. The seal member 52 (see FIG 3) is installed from the front of the disk 36 through a gap formed between the seal finger 53 and platform 20 and slides along the platform until it strikes the rear buttress nub 56. The trailing edge nub 56 prevents seal 52 from leaving the rear of the blade. With the platform seal 52 against the rear buttress, an installation pressure exerted outwardly against the forward edge of seal 52 will seat the seal member 52 to the inner surface of the platform 20. Likewise, the leading edge nub 54 prevents the seal member 52 from coming out the front of the platform 20.

Removal of the seal member 52 is a relatively simple procedure. It requires sliding a tool between the blade platform that flexes the forward edge of the seal member 52 over the leading edge nub 54. The seal member 52 can then be easily gripped and removed by the operator.

As is apparent from the foregoing, retaining the seal member 52 and damper 26 in the manner described hereinabove allows installation and removal of individual blades and greatly reduces the effort necessary to maintain the turbine since the tooling requirements are reduced and the rim assembly is less complex than heretofore known systems.

As was described above, the retention system for securing the blades 10 to the disk 36 is designed so that any load imposed by the blades is not absorbed by the TOBI rotor seal 34, but rather is absorbed by the snap ring assembly generally illustrated by reference numeral 70. In this assembly, an interrupted annular lug 72 with a complete groove cross-section 74 is integral to the front face of each disk lug 99. A full ring 76 fits into this complementary groove 74 and bears against the side face of the fir tree root section 14 of blade 10. The full ring is retained radially by the rim 40 of the TOBI rotor seal 34 overlying the groove 74 and is designed to resist the loads imparted by the rotating blades 10. As is apparent from the drawing, the groove 74 faces away from the engine's center line and hence is viewed as being inverted since it is typical to orient the slots and grooves to face the center line of the engine. This serves to improve producibility of the grooves since it facilitates the manufacturing thereof, reduces weight, and improves the life of the assembly since the ring supports the blades over the entire circumference.

Sealing of the dead rim cavity adjacent the juncture of the blade roots and disk rim is by use of a plurality of individual seal plates 80 (FIGS 3 and 6) supported on the rear face of disk 36. Each plate is contoured to fit into the space adjacent the root of blades 10 and are retained by hooks 82 integral to the rear face of disk lugs 99 of disk 36. The hooks' slots support the full split snap ring 86 which bear against each of the plates 80. This system supports the aerodynamic thrust load of the blades 10, while sealing up the dead rim cavity. To remove dampers 26, this snap ring 86 and seal plates 80, need not be disturbed.

On the other hand in the preferred instances it may be advantageous to view into the dead rim cavity or cooling air supply slot 100 by removing snap ring 86 and seal plates 80 without disturbing the dampers 26 or TOBI seal rotor 34 such as may be required for trim balance operations. This seal plate installation is highly advantageous at a 0° fir tree broach angle, i.e. fir tree slot is perpendicular

to disk face 46, since the seal plate is of lightest weight design. However, it is to be understood and as will be apparent to those skilled in the art, this invention can be employed where the broach angle is greater than 0°.

It is apparent from the foregoing that the rim configuration as described serves to allow individual blade installation and removal, blade-to-blade damping and platform sealing of an extended neck blade. In addition, and without limitation, this invention improves high cycle fatigue life while at the same time decreases weight over other heretofore known disk rim configurations.

Claims

1. Rotor assembly for a gas turbine engine, having a disk (36), said disk (36) having a rim portion and radially outwardly extending disk lugs (99) in said rim portion, defining disk slots therebetween, said disk lugs (99) each having a front face and a rear face, a plurality of blades (10), each blade (10) having a root section (14) and a neck section (16) radially outwardly of the root section (14), each blade (10) having its root section (14) received in a corresponding one of said disk slots, there being formed a dead rim cavity radially outwardly of each disk lug (99) between the neck sections of adjacent blades (10), said rotor assembly further having means for absorbing excessive vibratory motions occasioned by the rotation of the turbine, said means including a damper (26) formed from a weighted element having a radial inner end portion and a radial outer end portion in its assembled position and opposing side edges (28, 30), a rotor seal (34) adjacent said disk (36) and extending radially adjacent said neck sections (16) of the blades (10), the radial inner end portion of said weighted element being trapped in a space bounded on one side by a radially extending annular portion (44) of said rotor seal (34),

characterized in that the other side of said space is bounded by the front face of the disk lug (99) and each blade root section (14) has a portion (48) extending axially beyond the front face of said disk lugs (99) toward the rotor seal (36) and under a portion of said radial inner end portion of said weighted element radially inwardly thereof, said axially extending root portions (48) of two adjacent blades (10) defining with the annular portion (44) of the rotor seal (34) and the front side of the disk lug (99) between said two adjacent blades (10) a pocket for receiving and positioning the inner end portion of said weighted element, the side edges (28, 30) at the radial outer end portion



of the element being received in opposing pockets (24) formed in the blade neck sections (16).

2. Rotor assembly according to claim 1, characterized in that said weighted element includes a front face and rear face, centrally disposed axially extending portions (27) on said element adding weight thereto in a given amount and location to absorb the energy induced by said rotating rotor assembly. 5
3. Rotor assembly according to claim 1 or 2, characterized in that said pockets (24) are cast into said blades (10). 10 15
4. Rotor assembly according to claim 1, characterized in that said blades (10) are axially retained in the rotor disk slots by a first retaining ring (76) supported by first hooks (72) formed on the front face of said disk lugs (99) and a second retaining ring (86) supported by second hooks (82) formed on the rear face of said disk lugs (99), and that the first hooks (72) formed on the front face of the rotor disk (36) are radially outwardly directed and the first retaining ring (76) received in grooves (74) defined between the hooks (72) and the front face of the rotor disk (36) is retained against radial outward movement by the rotor seal (34). 20 25 30
5. Rotor assembly according to claim 1, characterized in that a plurality of individual seal plates (80) are supported on the rear face of the disk (10) to block the flow of cooling air admitted into the dead air cavity between the blade neck sections (16) through the front face of the disk (10), said plates (80) being retained by said second retaining ring (86). 35 40
6. Rotor assembly according to claim 1, wherein each blade (10) has a platform (20) radially outwardly of said neck section (16) and, said rotor assembly further characterized by including an interplatform seal (52) comprising a relatively flat rectangular plate member curved at either end fitting underneath adjacent blade platforms (20) to seal between adjacent platforms (20), nubs (54, 56) formed on the forward and rearward underside surface of said platform (20) for receiving and retaining said plate member, and a finger (53) on the blade (10) defining a gap for permitting said plate member to slide along the platform (20). 45 50 55

Patentansprüche

1. Rotorbaugruppe für ein Gasturbinentriebwerk, mit einer Scheibe (36), wobei die Scheibe (36) einen Randteil und sich radial nach außen erstreckende Scheibennasen (99) in dem Randteil hat, die zwischen sich Scheibenschlitze bilden, wobei die Scheibennasen (99) jeweils eine vordere Stirnfläche und eine hintere Stirnfläche haben, mit mehreren Laufschaufeln (10), wobei jede Laufschaufel (10) einen Fußabschnitt (14) und einen Halsabschnitt (16) radial außerhalb von dem Fußabschnitt (14) hat, wobei der Fußabschnitt (14) jeder Laufschaufel (10) in einem entsprechenden der Scheibenschlitze aufgenommen ist, wobei ein toter Randhohlraum radial außerhalb jeder Scheibennase (99) zwischen den Halsabschnitten von benachbarten Laufschaufeln (10) gebildet ist, wobei die Rotorbaugruppe weiter eine Einrichtung aufweist zum Absorbieren von übermäßigen Schwingungsbewegungen, die durch die Drehung der Turbine hervorgerufen werden, wobei die Einrichtung einen Dämpfer (26) aufweist, der aus einem gewichteten Element gebildet ist, das einen radialen inneren Endteil und einen radialen äußeren Endteil in seiner zusammengebauten Position und gegenüber den Seitenrändern (28, 30) hat, eine Rotordichtung (34) an der Scheibe (36), die sich radial benachbart zu den Halsabschnitten (16) der Laufschaufeln (10) erstreckt, wobei der radiale innere Endteil des gewichteten Elements in einem Raum eingeschlossen ist, der auf einer Seite durch einen sich radial erstreckenden ringförmigen Teil (44) der Rotordichtung (34) begrenzt wird, dadurch gekennzeichnet, daß die andere Seite des Zwischenraums durch die vordere Stirnseite der Scheibennase (99) begrenzt ist und jeder Laufschaufelfußabschnitt (14) einen Teil (48) hat, der sich axial über die vordere Stirnfläche der Scheibennasen (99) hinaus zu der Rotordichtung (36) und unter einen Teil des radialen inneren Endteils des gewichteten Elements radial einwärts desselben erstreckt, wobei die sich axial erstreckenden Fußteile (48) der beiden benachbarten Laufschaufeln (10) mit dem ringförmigen Teil (44) der Rotordichtung (34) und der vorderen Seite der Scheibennase (99) zwischen den beiden benachbarten Laufschaufeln (10) eine Tasche zum Aufnehmen und Positionieren des inneren Endteils des gewichteten Elements bilden, wobei die Seitenränder (28, 30) an dem radialen äußeren Endteil des Elements in gegenüberliegenden Taschen (24) aufgenommen sind, die in den Laufschaufelhalsabschnitten (16) gebildet sind.



2. Rotorbaugruppe nach Anspruch 1, dadurch gekennzeichnet, daß das gewichtete Element eine vordere Stirnfläche und eine hintere Stirnfläche aufweist, wobei zentral angeordnete, sich axial erstreckende Teile (27) an dem Element diesem Gewicht in einem bestimmten Ausmaß und an einer bestimmten Stelle hinzufügen, um die Energie zu absorbieren, die durch die umlaufende Rotorbaugruppe hervorgerufen wird.

3. Rotorbaugruppe nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß die Taschen (24) in die Laufschaufeln (10) eingegossen sind.

4. Rotorbaugruppe nach Anspruch 1, dadurch gekennzeichnet, daß die Laufschaufeln (10) in den Rotorscheibenschlitz durch einen ersten Haltering (76) axial gehalten sind, der durch erste Haken (72) abgestützt ist, die an der vorderen Stirnfläche der Scheibennasen (99) gebildet sind, und durch einen zweiten Haltering (86), der durch zweite Haken (82) abgestützt ist, die an der hinteren Stirnfläche der Scheibennasen (99) gebildet sind, und daß die ersten Haken (72), die an der vorderen Stirnfläche der Rotorscheibe (36) gebildet sind, radial nach außen gerichtet sind, und daß der erste Haltering (76), der in Nuten (74) aufgenommen ist, die zwischen den Haken (72) und der vorderen Stirnseite der Rotorscheibe (36) gebildet sind, gegen eine radiale Auswärtsbewegung durch die Rotordichtung (34) festgehalten ist.

5. Rotorbaugruppe nach Anspruch 1, dadurch gekennzeichnet, daß mehrere einzelne Dichtplatten (80) an der hinteren Stirnfläche der Scheibe (10) abgestützt sind, um die Strömung von Kühlluft zu blockieren, die in den toten Lufthohlraum zwischen den Laufschaufelhalsabschnitten (16) über die vordere Stirnfläche der Scheibe (10) eingelassen wird, wobei die Platten (80) durch den zweiten Haltering (86) festgehalten werden.

6. Rotorbaugruppe nach Anspruch 1, wobei jede Laufschaufel (10) eine Plattform (20) radial außerhalb des Halsabschnitts (16) hat und wobei die Rotorbaugruppe weiter dadurch gekennzeichnet ist, daß sie eine Zwischenplattformdichtung (52) aufweist, die aus einem relativ ebenen, rechteckigen Plattenteil besteht, das an beiden Enden gekrümmt ist und unter benachbarte Laufschaufelplattformen (20) paßt, um zwischen benachbarten Plattformen (20) abzudichten, wobei Noppen (54, 56), die an der vorderen und hinteren Unterfläche der Plattform (20) zum Aufnehmen und Festhalten

des Plattenteils gebildet sind, und ein Finger (53) an der Laufschaufel (10) einen Spalt bilden, um ein Verschieben des Plattenteils längs der Plattform (20) zu erlauben.

Revendications

1. Ensemble de rotor pour un turbomoteur comportant un disque (36), ce disque (36) ayant une portion de bord et des nervures du disque (99), s'étendant radialement vers l'extérieur, dans cette portion de bord, en définissant entre elles des rainures du disque, ces nervures (99) du disque ayant chacune une face avant et une face arrière, une pluralité d'aubes (10), chaque aube (10) ayant une section de racine (14) et une section de col (16) située vers l'extérieur, dans le sens radial, par rapport à la section de racine (14), la section de racine (14) de chaque aube (10) étant logée dans une rainure correspondante du disque, une cavité morte de bord étant formée, à l'extérieur, dans le sens radial, de chaque nervure (99) du disque, entre les sections de col d'aubes adjacentes (10); cet ensemble de rotor comportant en outre des moyens pour absorber des mouvements vibratoires excessifs provoqués par la rotation de la turbine, ces moyens comportant un amortisseur (26) formé d'un élément pesant ayant une partie extrême interne, dans le sens radial, et une partie extrême externe, dans le sens radial, dans sa position assemblée, et des bords latéraux opposés (28,30), un joint d'étanchéité rotorique (34) adjacent au disque (36) et s'étendant radialement à proximité immédiate des sections de col (16) des aubes (10), la partie extrême interne, dans le sens radial, de l'élément pesant étant piégée dans un espace délimité, d'un côté, par une portion annulaire (44), s'étendant radialement, du joint d'étanchéité rotorique (34), caractérisé en ce que l'autre côté de l'espace est délimité par la face avant de la nervure (99) du disque et chaque section de racine (14) d'une aube comporte une portion (48) s'étendant axialement au-delà de la face avant des nervures (99) du disque, en direction du joint d'étanchéité rotorique (34) et sous une portion de la partie extrême interne, dans le sens radial, de l'élément pesant, vers l'intérieur dans le sens radial, les portions (48), s'étendant axialement, des racines de deux aubes adjacentes (10) définissant, avec la portion annulaire (44) du joint d'étanchéité rotorique (34) et la face avant de la nervure (99) du disque se trouvant entre les deux aubes adjacentes (10), une poche destinée à recevoir et à maintenir en position la partie extrême interne de l'élément pesant,



les bords latéraux (28,30), sur la partie extrême externe, dans le sens radial, de l'élément pesant, étant logés dans des poches opposées (24) formées dans les sections de col (16) des aubes.

2. Ensemble de rotor suivant la revendication 1 caractérisé en ce que l'élément pesant comporte une face avant et une face arrière et des portions (27) sur cet élément, qui sont disposées centralement et s'étendent axialement, pour ajouter un poids à l'élément, d'une valeur donnée et en un emplacement donné, afin d'absorber l'énergie induite par l'ensemble du rotor en rotation.
3. Ensemble de rotor suivant l'une quelconque des revendications 1 ou 2 caractérisé en ce que les poches (24) sont moulées dans les aubes (10).
4. Ensemble de rotor suivant la revendication 1 caractérisé en ce que les aubes (10) sont retenues axialement dans les rainures du disque du rotor, par un premier anneau de retenue (76) supporté par des premiers crochets (72) formés sur la face avant des nervures (99) du disque, et par un second anneau de retenue (86) supporté par des seconds crochets (22) formés sur la face arrière des nervures (99) du disque, et en ce que les premiers crochets (72) formés sur la face avant du disque du rotor (36) sont dirigés vers l'extérieur, dans le sens radial, et le premier anneau de retenue (67) qui est logé dans des gorges (74) définies entre les crochets (72) et la face avant du disque du rotor (36), est retenu, par le joint d'étanchéité rotorique (34), à l'encontre de tout mouvement radial vers l'extérieur.
5. Ensemble de rotor suivant la revendication 1 caractérisé en ce qu'une pluralité de plaques d'étanchéité individuelles (80) sont supportées sur la face arrière du disque (10) afin de bloquer l'écoulement d'air de refroidissement admis dans la cavité morte d'air, entre les sections de col (16) des aubes, à travers la face avant du disque (10), ces plaques (80) étant maintenues par le second anneau de retenue (86).
6. Ensemble de rotor suivant la revendication 1 dans lequel chaque aube (10) comporte une plate-forme (20) située vers l'extérieur, dans le sens radial, par rapport à la section de col (16), caractérisé en ce qu'il comporte en outre un joint d'étanchéité (52) entre les plates-formes, comprenant une plaque rectangulaire re-

lativement plane, incurvée à ses deux extrémités, s'emboîtant en dessous des plates-formes (20) d'aubes adjacentes, afin d'assurer une étanchéité entre les plates-formes adjacentes (20), des bossages (54,56) formés à l'avant et à l'arrière de la surface inférieure de la plate-forme (20), afin de recevoir et de retenir la plaque, et un doigt (53) prévu sur l'aube (10) pour définir un intervalle afin de permettre à la plaque de glisser le long de la plate-forme.

5

10

15

20

25

30

35

40

45

50

55