

## Description

The present invention concerns an assembly of abradable seal system according to the precharacterizing portion of the claim.

This invention relates to the field of gas turbine engines abradable seals. This invention relates to the reduction of detrimental initial interactions in an abradable seal system.

Gas turbine engines find wide application as sources of power, particularly in the aircraft industry. Such engines consist of a compressor section which compresses air to moderate pressure, moderate temperature conditions. A combustor section combines fuel with the compressed air and a turbine section extracts useful power from the products of combustion. The turbine section feeds power back to the compressor section and optionally to external loads. In a common form of gas turbine engine, the turbine section also powers a fan section which provides added thrust.

The efficiency of the engine can be increased by insuring that air flows only where it is desired to have it flow and that leakage, for example around blade tips and vane ends is minimized. The sealing task is made more difficult because the turbine engine components expand and contract with temperature and clearances change with varied load conditions. Currently abradable seals are widely used. An abradable seal consists of a brittle, frangible material, usually a weakly bonded particulate composite, which (in theory) breaks cleanly away rather than flowing or smearing when it interacts with the moving blade tip or vane end. The abradable seal system comprises an abradable structure (usually stationary) in combination with a moving component which interacts with the abradable to cut a groove therein. The moving component, during normal operation, operates in the groove thus achieving a good measure of sealing.

The task of finding the proper abradable and abrasive combination for operation at elevated temperatures is a demanding one especially when reasonable fabrication costs are also required.

The US-A 3,413,136, 3,879,831, 3,844,011, and 3,147,087 describe typical abradable seal systems which are designed for interaction with a variety of moving components. The abrasive portion is added to insure that wear occurs on the abradable component rather than on the moving blade tip or knife-edge seal. The optimum combination of abradable and abrasive has not yet been found. There are still substantial problems which occur when the abradable and abrasive do not interact properly, but instead the abradable interaction occurs in a smearing or a ductile fashion causing adherence and buildup of deposits on the abrading surface. Once this type of behavior starts it will persist because the deposit on the abrading surface is wettable by and attractive to the

abradable seal constituents. Any wetting of the rotating member by the seal material will have subsequent detrimental effects-even to the extent of causing sufficient imbalance to cause vibration and eventual fatigue cracking.

The EP-A- 0 187 612 describes an abradable system containing an abradable material and on the surface of that material is applied a thin layer comprising a polymerized ceramic matrix containing a rounded particulate filler.

It is an object of the invention to provide an abradable and abrasive system along with a transient intermediate coating which provides for minimal interaction, with minimal material transfer from the seal to the rotating member especially during the initial contact between the abrasive surface and the abradable seal.

The abradable and abrasive system of the present invention is defined in the characterizing portion of the claim.

It has been noted that most of abrasive - abradable interaction occurs during the initial few seconds or minutes of engine operation. It is during this brief initial period that the great volume of abradable material is abraded and during this period of time the interaction between the abrasive and abradable sets the tone for succeeding engine operation and seal behavior.

According to the present invention a conventional abradable seal can have its interaction with an abrasive surface substantially modified through the interposition of a transient coating on the surface of the moving component prior to initial engine operation.

According to one form of the prior art an abrasive material can be plasma sprayed on blade tips and knife-edge seals. This material consists of an oxidation and corrosion resistant matrix containing abrasive material selected from the group consisting of carbides, nitrides, and oxides. This abrasive will interact with an abradable seal of a conventional type, for example that shown in US-A-3,413,136, 3,879,831, 3,844,011, and 3,147,087. According to past experience with this type of technology such combinations have not been entirely satisfactory because adverse interactions have occurred.

According to the invention these interactions are substantially reduced by depositing on the surface of the abrasive a colloidal suspension of a ceramic material which is not wettable by the abradable material during high temperature interactions; thus minimizing transfer and adherence of abradable material to rotating component. Typical materials include  $Al_2O_3$ ,  $MgO$ ,  $ZrO_2$ ,  $Si_3N_4$  and  $BN$ . The adverse provision of such material greatly reduces the interaction during the first moments of engine operation. If adverse interactions can be avoided during initial engine operation, abradable seal system which would otherwise be un-

satisfactory can be satisfactory for the substantially less demanding interactions which occur during routine engine use.

The interaction reduction apparently results from reductions in frictional heating (the fine particles provide some lubricity) in combination with the nonwetting nature of the materials.

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

The Figure is a cross-section through a portion of a gas turbine engine illustrating typical seal structures.

The present invention relates to seals using in gas turbine engines, particularly those of the axial flow type. Such engines include alternate rows of stationary vanes and moving blades with the blades being attached at the periphery of shaft mounted rotating disks.

The Figure illustrates a cross-section of a portion of a modern gas turbine engine. Components important to understanding the present invention include a plurality of rotatable disks 1 upon whose outer periphery are mounted a plurality of blades 2. The blades rotate within the inner case 3 and are closely spaced thereto. Minimum leakage between the blades and the inner case is achieved by the provision of a seal 4 (the outer air seal), mounted on the inner case.

Mounted within and upon the inner case 3 are a plurality of vanes 5 on whose inner, free ends 6 is mounted another seal 7 (the inner air seal) which is closely spaced to knife edges 8 mounted on extensions of the disks 1. The knife edge 8 and inner air seal 7 cooperate to reduce leakage and improve efficiency. In an alternate engine scheme, the disks do not have integral projections, but are separated by spacers upon which knife edges may be mounted.

The seals for which the present invention is particularly suited are located on the inner case 3 adjacent the free ends of the blades 2 (the outer air seal), and on the free ends 6 of the vanes 5 (the inner air seal). The seals of the present invention are preferably mounted on stationary substrates arranged to engage moving components.

The invention comprises the improved use of conventional seal materials which have been tried in the prior art with erratic results. The invention brings success these previously less than successful combinations through the interposition of an initial intermediate coating which greatly reduces adverse and detrimental interactions between the abrasive and abradable during initial engine run. The abradable seal may be for example selected from the teachings of US-A-3,413,136, 3,879,831, 3,844,011, and 3,147,087.

Alumina is a well known ceramic used at high temperatures and has a characteristic of being generally nonreactive or nonwetting with metal alloys of

the type which are used in the abradable structures and the abrasive surfaces. By insuring that such a nonwetting, nonreactive material is present during the initial rub between the abrasive and the abradable the initial interaction will be a nonwetting interaction and the problems which often occur during initial engine run will be minimized. The invention includes functionally equivalent nonwetttable ceramics which are stable to at least 1650°C (3000°F) including  $\text{Al}_2\text{O}_3$ ,  $\text{MgO}$ ,  $\text{ZrO}_2$ ,  $\text{Si}_3\text{N}_4$  and  $\text{BN}$ . Particle sizes are preferably less than 10  $\mu\text{m}$  (microns) and the coating thickness should exceed 25.4  $\mu\text{m}$  (1 mil).

The abrasive surface which interacts with this abradable seal material can be provided by coplasma spraying an abrasive substance selected from the group consisting of carbides and oxides and more specifically  $\text{WC}$ ,  $\text{Cr}_2\text{C}_3$ ,  $\text{Si}_3\text{N}_4$ ,  $\text{Al}_2\text{O}_3$ ,  $\text{SiC}$ , and mixtures thereof with a binder material.

The binder, if employed, is selected to be essentially nonreactive, i.e. nonwetttable by, with the abrasive. In the case of tungsten carbide, a powder mixture comprising 88 weight percent of tungsten carbide and 12 weight percent of a cobalt binder has been utilized while in the case of the chromium carbide abrasive layer, a powder containing 75 weight percent of  $\text{Cr}_3\text{C}_2$  and 25 weight percent of an alloy comprised of 80% nickel and 20% chrome has been utilized. It will often be found desirable to employ an initial bond coat to ensure that the abrasive material adheres to the substrate; such a bond coat may, for example, comprise the same of similar alloys to that employed as the matrix material or binder material in connection with the abrasive material. Other bond coats may be employed including alloys of the  $\text{MCrAl}$  type, where M is a material selected from the group consisting of iron, nickel, cobalt and mixtures thereof; Cr is chromium in an amount of from 5% to 25% by weight; and Al is aluminum in an amount from 5% to 20% by weight. Reactive metals such as Y, La, Sc, Hf and the like may be added in amounts on the order of 0.1% to 2%.

It is the abradable material which primarily adversely interacts with the abrasive coating and it is this reaction at high temperatures between the abrasive and the abradable which is prevented by the transient zirconia coating of the present invention. The present invention coating can be applied most advantageously as a colloidal suspension either an aqueous or organic, i.e. cellulose nitrate based, or conceptually could be applied by a very light plasma spray coating. We have used liquid applications with success.

## Claims

1. An initial assembly of abradable seal system of a gas-turbine engine, comprising a layer of abrad-

satisfactory can be satisfactory for the substantially less demanding interactions which occur during routine engine use.

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## Claims

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able material (4) on a stationary component (3) and a relatively moving component (2) having an abrasive coating on the free end thereof and interacting therewith, characterized in that, in order to improve the efficiency, a thin temporary layer of colloidal ceramic particles nonwetable by the abradable material (4) is applied onto the abrasive coating to minimize negative interaction between the layer of the abradable material (4) and the moving component (2) at the initial period of the run of the engine.

### Patentansprüche

1. Anfangsaufbau eines abschleifbaren Dichtungssystems eines Gasturbinentriebwerks, mit einer Schicht abschleifbaren Materials (4) auf einem stationären Bauteil (3) und mit einem relativbewegten Bauteil (2), das einen Schleifüberzug auf seinem freien Ende hat, der mit dem stationären Bauteil in Wechselwirkung tritt, dadurch gekennzeichnet, daß zum Verbessern des Wirkungsgrads eine dünne, vorübergehende Schicht von kolloidalen Keramikpartikeln, die durch das abschleifbare Material (4) nicht benetzbar ist, auf den Schleifüberzug aufgebracht wird, um eine negative Wechselwirkung zwischen der Schicht des abschleifbaren Materials (4) und dem bewegten Bauteil (2) in der Anfangsperiode des Laufes des Triebwerks zu minimieren.

### Revendications

1. Assemblage initial d'un système de joint d'étanchéification apte à l'abrasion d'un moteur équipé d'une turbine à gaz, comprenant une couche d'une matière (4) apte à l'abrasion sur un composant stationnaire (3) et un composant (2) à mobilité relative possédant un revêtement abrasif sur son extrémité libre et interagissant avec elle, caractérisé en ce que, afin d'améliorer l'efficacité, on applique une mince couche provisoire de particule de céramique colloïdale non imprégnable par la matière (4) apte à l'abrasion sur le revêtement abrasif pour minimiser l'interaction négative entre la couche de matière (4) apte à l'abrasion et le composant mobile (2) lors de la période initiale de mise en service du moteur.

