TURBINE BLADE WEAR PROTECTION SYSTEM WITH MULTILAYER SHIM

BACKGROUND OF THE INVENTION

This invention relates to turbine engines, and, more particularly, to the reduction of frictionally induced wear damage within the rotors of the compressor and fan stages.

When two pieces of material rub or slide against each other in a repetitive manner, the resulting frictional forces can cause damage to the materials through the generation of heat or through a variety of fatigue processes generally termed fretting. Some materials systems, such as titanium contacting titanium, are particularly susceptible to such damage. When two pieces of titanium are rubbed against each other with an applied normal force, the pieces can exhibit a type of surface damage called galling after as little as as a hundred cycles. The galling increases with the number of cycles and can eventually lead to failure of either or both pieces by fatigue.

The use of titanium parts that can potentially rub against each other occurs in several aerospace applications. Titanium alloys are used in aircraft and aircraft engines because of their good strength, low density and favorable environmental properties at low and moderate temperatures. If a particular design requires titanium pieces to rub against each other, the type of fatigue damage just outlined may occur.

In one type of aircraft engine design, a titanium compressor disk, also referred to as a rotor, or fan disk has an array of dovetail slots in its outer periphery. The dovetail base of a titanium compressor blade or fan blade fits into each dovetail slot of the disk. When the disk is at rest, the dovetail of the blade is retained within the slot. When the engine is operating, centrifugal force induces the blade to move radially outward. The sides of the blade dovetail slide against the sloping sides of the dovetail slot of the disk, producing relative motion between the blade and the rotor disk.

This sliding movement occurs between the disk and blade titanium pieces during transient operating conditions such as engine startup, power-up (takeoff), power-down and shutdown. With repeated cycles of operation, the sliding movement can affect surface topography and lead to a reduction in fatigue capability of the mating titanium pieces. During such operating conditions, normal and sliding forces exerted on the rotor in the vicinity of the dovetail slot can lead to galling, followed by the initiation and propagation of fatigue cracks in the disk. It is difficult to predict crack initiation or extent of damage as the number of engine cycles increase. Engine operators, such as the airlines, must therefore inspect the insides of the rotor dovetail slots frequently, which is a highly laborious process.

Various techniques have been tried to avoid or reduce the damage produced by the frictional movement between the titanium blade dovetail and the dovetail slot of the titanium rotor disk. At the present time, the most widely accepted technique is to coat the contacting regions of the titanium pieces with a metallic alloy to protect the titanium parts from galling. The sliding contact between the two coated contacting regions is lubricated with a solid dry film lubricant containing primarily molybdenum disulfide, to further reduce friction.

While this approach can be effective in reducing the incidence of fretting or fatigue damage in rotor/blade pieces, the service life of the coating has been shown to vary considerably. Furthermore, the process for applying the metallic alloy to the disk and the blade pieces has been shown to be capable of reducing the fatigue capability of the coated pieces. There exists a continuing need for an improved approach to reducing such damage and assure component integrity. Such an approach would desirably avoid a major redesign of the rotor and blades, which have been optimized over a period of years, while increasing the life of the titanium components and the time between required inspections. The present invention fulfills this need, and further provides related advantages.

A new approach to reduce the incidence of fretting in high temperature components described in European Patent Application 89106921.3 utilizes two independent, but superposed foils having material contact surfaces with a low coefficient of friction, but surfaces which mate with the dovetail and dovetail slot having high coefficients of friction. The foils allow sliding movement along the material contact surfaces having the low coefficient of friction, but prevent sliding between the foil and the mating parts due to the high coefficient of friction. Experience with this type of design has shown that each of the thin foils gradually work their way out of the dovetail slot region, leaving the blade dovetail and rotor dovetail slot in contact, resulting in fretting. In an attempt to reduce this movement, in one embodiment, the foils have formed flanges. The flanges necessarily are small because of the small gap between the blade dovetail and rotor dovetail slot, and although providing some improvement, are not expected to eliminate the problem of gradual movement of the foil.

SUMMARY OF THE INVENTION

The present invention provides an approach to reducing fatigue-induced damage from fretting to titanium blades and titanium rotors of the compressor or fan of a gas turbine induced by sliding contact of the blade dovetail and the rotor dovetail slot. The wear life of the titanium parts is increased, as compared with prior approaches, and the life is also more consistent. Neither the rotor nor the blades require special coatings to reduce wear, and therefore are not subject to special coating processes which can adversely affect base material properties. When the wear life of the shim of the present invention is reached, the engine may be readily refurbished and prepared for further service. During the refurbishment, it is not necessary to perform a major disassembly of the engine. The expensive rotor is not scrapped or reworked in the refurbishment.

In accordance with the invention, a rotor and blade assembly comprises a titanium rotor having a dovetail slot in the circumference thereof, the dovetail slot including sidewalls and a bottom. A titanium blade having a dovetail is sized to fit into the dovetail slot and contact the rotor along a pair of contacting regions on the sidewalls of the dovetail slot, one contacting region on each side of the dovetail slot, there remaining a non-contacting region between the dovetail slot bottom and the blade dovetail bottom. A reinforced shim is disposed in this non-contacting region between the blade dovetail bottom and the rotor dovetail slot bottom, the reinforced shim including means for inhibiting fretting wear of the titanium blade dovetail and the titanium