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Bearing scavenge pump incorporated into turbine disk cover plate

Abstract

A bearing scavenge pump incorporated into a disk cover plate including a rotor disk having a rear surface and an axis; the disk cover plate attached to the rotor disk, the disk cover plate including fins extending into a gap formed between a rear surface of the rotor disk and the disk cover plate, the disk cover plate including anti-vortex features located axially distal from the fins relative to the axis; an inverted bearing located in a bearing compartment proximate the disk cover plate and disk; and a liquid fuel lubricant contacting the inverted bearing.

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Background/Summary

BACKGROUND
(1) The present disclosure is directed to expendable gas turbine engines with improved air-cooled fuel lubricated bearings.
(2) Attritable or expendable propulsion systems have a short lifespan relative to typical flight applications. The attritable engine is utilized for a limited lifespan and disposed. The attritable gas turbine engine may not even be operated through a full operational cycle. The attritable gas turbine engine may only perform start-up, and operational load before being decommissioned.
(3) Since the operational modes of the attritable gas turbine engine may be significantly less than the conventional gas turbine engine, the attritable engine does not need to meet the same durability or safety requirements as the conventional gas turbine engine. Conventional gas turbine engine designs deployed for attritable engines can be more costly and more complex than needed.
(4) What is needed is a less complex and less costly turbine engine design for the attritable engine.
SUMMARY

(5) In accordance with the present disclosure, there is provided a bearing scavenge pump incorporated into a disk cover plate comprising a rotor disk having a rear surface and an axis; a cover plate attached to the rotor disk, the cover plate including anti-vortex features extending into a gap formed between a rear surface of the rotor disk and the cover plate; an inverted bearing located in a bearing compartment proximate the cover plate and disk; and a liquid lubricant contacting the inverted bearing.
(6) A further embodiment of any of the foregoing embodiments may additionally and/or alternatively include the cover plate includes fins located at least one of on a lower portion of the cover plate, inside a chamber formed between the rotor disk and cover plate upstream of the lower portion, or both.
(7) A further embodiment of any of the foregoing embodiments may additionally and/or alternatively include the fins are configured to pump air radially outwardly relative to the axis toward an exhaust nozzle section.
(8) A further embodiment of any of the foregoing embodiments may additionally and/or alternatively include the anti-vortex features include radial holes and/or vanes within the coverplate oriented radially distal from the fins relative to the axis.
(9) A further embodiment of any of the foregoing embodiments may additionally and/or alternatively include the anti-vortex features are configured as tubing/passages that are configured to prevent swirling by cooling air.
(10) A further embodiment of any of the foregoing embodiments may additionally and/or alternatively include the inverted bearing includes a static inner race and dynamic outer race and sump configured to spin.
(11) A further embodiment of any of the foregoing embodiments may additionally and/or alternatively include the liquid lubricant is introduced into a cooling air, entrained in the cooling air and provided to lubricate the inverted bearing and where at least a portion of the cooling air is scavenged with the liquid lubricant.
(12) In accordance with the present disclosure, there is provided an attritable gas turbine engine turbine section with bearing scavenge pump incorporated into a disk cover plate comprising turbine rotors including a rotor disk, and a plurality of circumferentially spaced turbine blades, the rotor disk having a rear surface and an axis; a cover plate attached to the rotor disk, the cover plate including anti-vortex features extending into a gap formed between a rear surface of the rotor disk and the cover plate; an inverted bearing is located in a bearing compartment proximate the cover plate and disk; and a fuel tank providing a liquid fuel lubricant contacting the inverted bearing.
(13) A further embodiment of any of the foregoing embodiments may additionally and/or alternatively include the cover plate includes fins located at least one of on a lower portion of the cover plate, inside a chamber formed between the rotor disk and cover plate upstream of the lower portion, or both.
(14) A further embodiment of any of the foregoing embodiments may additionally and/or alternatively include the fins are configured to pump air radially outwardly relative to the axis toward an exhaust nozzle section.
(15) A further embodiment of any of the foregoing embodiments may additionally and/or alternatively include the anti-vortex features include holes and/or vanes oriented radially distal from the fins relative to the axis.
(16) A further embodiment of any of the foregoing embodiments may additionally and/or alternatively include the anti-vortex features are configured as tubing/passages that are configured to prevent swirling by cooling air.
(17) A further embodiment of any of the foregoing embodiments may additionally and/or alternatively include the inverted bearing includes a static inner race and dynamic outer race and sump configured to spin.
(18) In accordance with the present disclosure, there is provided a process for lubricating an

attritable gas turbine engine turbine section with bearing scavenge pump incorporated into a disk cover plate comprising providing turbine rotors including a rotor disk, and a plurality of circumferentially spaced turbine blades, the rotor disk having a rear surface and an axis; attaching a cover plate to the rotor disk, the cover plate including anti-vortex features extending into a gap formed between a rear surface of the rotor disk and the cover plate; locating an inverted bearing in a bearing compartment proximate the cover plate and disk; and contacting the inverted bearing with a liquid lubricant.
(19) A further embodiment of any of the foregoing embodiments may additionally and/or alternatively include the process further comprising supplying a cooling air to a rear surface of the rotor disk between an axially downstream side of the cover plate and an axially upstream face of the rotor disk.
(20) A further embodiment of any of the foregoing embodiments may additionally and/or alternatively include the process further comprising carrying the liquid fuel lubricant with the cooling air to the inverted bearing impelled by a pumping action induced by rotation of the rotor disk and cover plate.
(21) A further embodiment of any of the foregoing embodiments may additionally and/or alternatively include the process further comprising forming the gap between the cover plate and a contour of the rotor disk; and creating a boundary layer effect that pumps a cooling air from a central location to a radially outward location near an exhaust nozzle section responsive to rotation of the cover plate and the rotor disk.
(22) A further embodiment of any of the foregoing embodiments may additionally and/or alternatively include the process further comprising configuring the anti-vortex features as tubing/passages; and preventing swirling by cooling air.
(23) A further embodiment of any of the foregoing embodiments may additionally and/or alternatively include the inverted bearing includes a static inner race and dynamic outer race sump configured to spin.
(24) A further embodiment of any of the foregoing embodiments may additionally and/or alternatively include the cover plate includes fins located at least one of on a lower portion of the cover plate, inside a chamber formed between the rotor disk and cover plate upstream of the lower portion, or both; wherein the anti-vortex features include holes and/or vanes oriented radially distal from fins relative to the axis.
(25) Other details of the bearing scavenge pump incorporated into high pressure turbine disk coverplate are set forth in the following detailed description and the accompanying drawings wherein like reference numerals depict like elements.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) FIG. **1** is a cross sectional view schematic representation of an exemplary attritable gas turbine engine.
(2) FIG. **2** is a cross sectional view schematic representation of an exemplary scavenge pump in a disk coverplate.
(3) FIG. **3** is a schematic representation of details of an exemplary scavenge pump in a disk coverplate.
DETAILED DESCRIPTION
(4) Referring now to FIG. **1**, there is illustrated an exemplary attritable gas turbine engine, specifically a turbojet engine **10**. The gas turbine engine **10** includes an inlet section **12** upstream of a compressor section **14** where air **16** is drawn in and compressed. Fuel **18** is injected into a combustion section **20** downstream of the compressor section **14**. The air **16** is mixed with fuel **18**

and burned in the combustion section **20**. The combusted fuel **18** and air **16** are combined into a highly energized combustion product **22** that expands through a turbine section **24** (HPT). The products of combustion move downstream over turbine rotors **26**, driving the turbine rotors **26** to rotate creating rotary power. The products of combustion **22** move downstream, exit the turbine section **24** and flow into the exhaust nozzle section **28** where engine thrust is developed for propulsion.

(5) Referring also to FIG. **2** and FIG. **3**, the turbine rotors **26** can include a rotor disk **30**, and a plurality of circumferentially spaced removable turbine blades **32**. Since the rotor disk **30** and turbine blades **32** are subject to extreme temperatures, cooling air **34** is typically delivered to bearings **36** and the rotor disk **30** and blade **32** for cooling through various cooling passages **38**. The rotor disk **30** rotates about an axis A.

(6) To seal the cooling passages **38**, a cover plate **40** can be attached to the rotor disk **30**. The cover plate **40** can form a gap **42** by following the contour of the rotor disk **30** to create a boundary layer effect that pumps cooling air **34** from a central location **44** to a radially outward location **46** near the exhaust nozzle section **28** when the cover plate **40** and rotor disk **30** rotate. The cover plate **40** can be formed with one or more internal fins **48**, each of which increases the pumping effectiveness.

(7) The cooling air **34** can be supplied to a rear surface **50** between an axially downstream side **52** of the cover plate **40** and an axially upstream face **54** of the rotor disk **30**. In order to improve air pumping effectiveness, the fin(s) **48** can be incorporated into the cover plate **40**. The fin(s) **48** can be located on the lower portion **56** of the cover plate **40** or inside a chamber **58** formed between the rotor disk **30** and cover plate **40** upstream of the lower portion **56** or both. Fin(s) **48** can extend along the entirety of the lower portion **56** and/or the chamber **58**. The fin(s) **48** can extend the length of the cooling passage from the lower portion **56** to a mid portion **60**. In exemplary embodiments, the fin(s) **48** need not extend along the entirety of these portions or be continuous. The fin geometry shown in FIG. **2** and FIG. **3** is only one potential non-limiting embodiment.

(8) As the rotor disk **30** and cover plate **40** are driven to rotate by the products of combustion **22**, the fin(s) **48** impel the air radially outwardly toward the exhaust nozzle section **28** due to a pressure differential.

(9) Anti-vortex features **62** can be employed with the cover plate **40**. The anti-vortex features **62** can include radial holes and/or vanes oriented radially distal from the internal fin(s) **48** relative to the axis A. The anti-vortex features **62** can be employed with the cover plate **40** at a location proximate the upstream face **54** of the rotor disk **30** downstream from the fin(s) **48**. The anti-vortex features **62** can be configured as tubing/passages that are configured to prevent swirling by the cooling air **34**. Preventing swirling enables the pumping action of the cooling air **34** between the rotor disk **30** and cover plate **40**.

(10) An inverted bearing **64** located in a bearing compartment **65** proximate the cover plate **40** and rotor disk **30** is incorporated into the design disclosed. The inverted bearing **64** has a static inner race **66** and rotating outer race **67**. The inverted bearing **64** includes a dynamic outer diameter sump **68** that is configured to spin. The inverted bearing is configured opposite a typical rotor bearing. The inverted bearing **64** allows for lubrication from a liquid lubricant **70** sourced from a tank **72**. In an exemplary embodiment, the tank **72** can be a fuel tank **72**. The liquid lubricant **70** can be liquid fuel lubricant **70**. The liquid lubricant **70** can be entrained in the cooling air **34** and provided to the inverted bearing **64** to lubricate contacting rotating elements **74**. The excess liquid lubricant **70** can be carried with the cooling air **34** and pumped away from the inverted bearing **64** after providing lubrication, impelled by the pumping action induced by the rotation of the rotor disk **30** and cover plate **40**. By utilizing the liquid lubricant **70** there is no need for more complex lubricant oil components making the gas turbine engine **10** simpler and less costly. The liquid lubricant **70** provides sufficient lubrication for the limited duration anticipated by the attritable gas turbine engine **10**.

(11) A technical advantage of the disclosed bearing scavenge pump incorporated into the high-pressure turbine disk cover plate includes a design that permits the air that cools the bearing to be fed from a lower pressure source.
(12) Another technical advantage of the disclosed bearing scavenge pump incorporated into the high-pressure turbine disk cover plate includes a design that permits the air that cools the bearing to be fed from a cooler source.
(13) Another technical advantage of the disclosed bearing scavenge pump incorporated into the high-pressure turbine disk cover plate includes a design that provides operating conditions that are beneficial to bearing health and life.
(14) Another technical advantage of the disclosed bearing scavenge pump incorporated into the high-pressure turbine disk cover plate includes radial holes and/or vanes under the cover plate act as a centrifugal pump, pressurizing the flow of cooling air exiting the bearing compartment as it flows outward in the radius between the disk and cover plate to the exhaust nozzle section.
(15) Another technical advantage of the disclosed bearing scavenge pump incorporated into the high-pressure turbine disk cover plate includes the elimination of a buffer cooler on the cooling air system.
(16) Another technical advantage of the disclosed bearing scavenge pump incorporated into the high-pressure turbine disk cover plate includes a design that simplifies routing of the secondary air flow.
(17) There has been provided a bearing scavenge pump incorporated into high-pressure turbine disk cover plate. While the bearing scavenge pump incorporated into high pressure turbine disk coverplate has been described in the context of specific embodiments thereof, other unforeseen alternatives, modifications, and variations may become apparent to those skilled in the art having read the foregoing description. Accordingly, it is intended to embrace those alternatives, modifications, and variations which fall within the broad scope of the appended claims.

Claims

1. A bearing scavenge pump incorporated into a disk cover plate comprising: a rotor disk having a rear surface and an axis; the disk cover plate attached to the rotor disk, the disk cover plate including anti-vortex features extending into a gap formed between the rear surface of the rotor disk and the disk cover plate; an inverted bearing located in a bearing compartment proximate and upstream of the disk cover plate and the rotor disk, wherein the inverted bearing includes a static inner race and dynamic outer race configured to spin and a sump configured to spin; and a liquid fuel lubricant contacting the inverted bearing, wherein the liquid fuel lubricant is introduced into a cooling air upstream of the inverted bearing, entrained in the cooling air and provided to lubricate the inverted bearing and where at least a portion of the cooling air is scavenged with the liquid fuel lubricant; wherein an excess liquid fuel lubricant is carried with the cooling air and pumped away from the inverted bearing after providing lubrication, impelled by a pumping action induced by rotation of the rotor disk and cover plate downstream of the inverted bearing.
2. The bearing scavenge pump incorporated into the disk cover plate according to claim 1, wherein the disk cover plate includes fins located at least one of on a lower portion of the disk cover plate, inside a chamber formed between the rotor disk and the disk cover plate upstream of the lower portion, or both.
3. The bearing scavenge pump incorporated into the disk cover plate according to claim 2, wherein the fins are configured to cause the cooling air to be pumped radially outward relative to the axis toward an exhaust nozzle section.
4. The bearing scavenge pump incorporated into the disk cover plate according to claim 1, wherein the anti-vortex features are configured as tubing/passages that are configured to prevent swirling by the cooling air.

5. An attritable gas turbine engine turbine section with a bearing scavenge pump incorporated into a disk cover plate comprising: turbine rotors including a rotor disk, and a plurality of circumferentially spaced turbine blades, the rotor disk having a rear surface and an axis; the disk cover plate attached to the rotor disk, the disk cover plate including anti-vortex features extending into a gap formed between the rear surface of the rotor disk and the disk cover plate; an inverted bearing located in a bearing compartment proximate and upstream of the disk cover plate and the rotor disk, wherein the inverted bearing includes a static inner race and dynamic outer race configured to spin and sump configured to spin; and a fuel tank configured to provide a liquid fuel lubricant to the inverted bearing, wherein the liquid fuel lubricant is introduced into a cooling air upstream of the inverted bearing, where at least a portion of the cooling air is scavenged with the liquid fuel lubricant; wherein an excess liquid fuel lubricant is carried with the cooling air and pumped away from the inverted bearing after providing lubrication, impelled by a pumping action induced by rotation of the rotor disk and cover plate downstream of the inverted bearing.
6. The attritable gas turbine engine turbine section with the bearing scavenge pump incorporated into the disk cover plate according to claim 5, wherein the disk cover plate includes fins located at least one of on a lower portion of the cover plate, inside a chamber formed between the rotor disk and the disk cover plate upstream of the lower portion, or both.
7. The attritable gas turbine engine turbine section with the bearing scavenge pump incorporated into the disk cover plate according to claim 6, wherein the fins are configured to cause air to be pumped radially outwardly relative to the axis toward an exhaust nozzle section.
8. The attritable gas turbine engine turbine section with the bearing scavenge pump incorporated into the disk cover plate according to claim 5, wherein the anti-vortex features are configured as tubing/passages that are configured to prevent swirling by cooling air.
9. A process for lubricating an attritable gas turbine engine turbine section with a bearing scavenge pump incorporated into a disk cover plate comprising: providing turbine rotors including a rotor disk, and a plurality of circumferentially spaced turbine blades, the rotor disk having a rear surface and an axis; attaching the disk cover plate to the rotor disk, the disk cover plate including anti-vortex features extending into a gap formed between the rear surface of the rotor disk and the disk cover plate; locating an inverted bearing in a bearing compartment proximate and upstream of the disk cover plate and the rotor disk, wherein the inverted bearing includes a static inner race and dynamic outer race configured to spin and sump configured to spin; and contacting the inverted bearing with a liquid fuel lubricant; introducing the liquid fuel lubricant into a cooling air upstream of the inverted bearing, entrained in the cooling air and provided to lubricate the inverted bearing; scavenging at least a portion of the cooling air with the liquid fuel lubricant; carrying the liquid fuel lubricant with the cooling air; and pumping the liquid fuel lubricant away from the inverted bearing after providing lubrication, impelled by a pumping action induced by rotation of the rotor disk and cover plate downstream of the inverted bearing.
10. The process of claim 9, further comprising: supplying the cooling air to the rear surface of the rotor disk between an axially downstream side of the disk cover plate and an axially upstream face of the rotor disk.
11. The process of claim 9, further comprising: forming the gap between the disk cover plate and a contour of the rotor disk; and creating a boundary layer effect that pumps the cooling air from a central location to a radially outward location near an exhaust nozzle section responsive to rotation of the disk cover plate and the rotor disk.
12. The process of claim 9, further comprising: configuring the anti-vortex features as tubing/passages; and preventing swirling by cooling air.
13. The process of claim 9, wherein the disk cover plate includes fins located at least one of on a lower portion of the disk cover plate, inside a chamber formed between the rotor disk and disk cover plate upstream of the lower portion, or both.