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GAS TURBINE ENGINE CONFIGURATION FOR CONTAINMENT TESTING

Abstract

A spool of a gas turbine engine includes an outer shaft assembly positioned at and configured to rotate about an engine central longitudinal axis. The outer shaft assembly is secured to one or more rotating components of the gas turbine engine. The outer shaft assembly includes a first shaft portion, and a second shaft portion. The first shaft portion axially overlaps the first shaft portion at a shaft joint. A centering feature dis positioned at the shaft joint and is configured to radially center the second shaft portion relative to the first shaft portion. A tie shaft is concentric with and located radially inboard of the outer shaft assembly. The tie shaft is configured to apply an axially compressive load on the outer shaft assembly.

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Background/Summary

BACKGROUND

[0001] Exemplary embodiments of the present disclosure pertain to the art of gas turbine engines.

[0002] Gas turbine engines often are dual-spool configurations in which rotating components are mounted to concentric shafts that extend along an engine central longitudinal axis. The rotating components are configured to be enclosed and contained in a nacelle.

[0003] The gas turbine engine is required to meet requirements for containment performance of the nacelle in conditions such as separation or decoupling of one or more of the concentric shafts. Due to these requirements, not only must the engine be configured to meet the requirements, but must also be configured such that required testing may be feasibly performed.

BRIEF DESCRIPTION

[0004] In one exemplary embodiment, a spool of a gas turbine engine includes an outer shaft assembly positioned at and configured to rotate about an engine central longitudinal axis. The outer shaft assembly is secured to one or more rotating components of the gas turbine engine. The outer shaft assembly includes a first shaft portion, and a second shaft portion. The first shaft portion axially overlaps the first shaft portion at a shaft joint. A centering feature dis positioned at the shaft joint and is configured to radially center the second shaft portion relative to the first shaft portion. A tie shaft is concentric with and located radially inboard of the outer shaft assembly. The tie shaft is configured to apply an axially compressive load on the outer shaft assembly.

[0005] Additionally or alternatively, in this or other embodiments a nut is applied to the tie shaft to apply the compressive load.

[0006] Additionally or alternatively, in this or other embodiments the centering feature includes an outer diameter lip of the first shaft portion that axially overlaps the second shaft portion.

[0007] Additionally or alternatively, in this or other embodiments the centering feature includes an inner diameter lip of the first shaft portion that axially overlaps the second shaft portion.

[0008] Additionally or alternatively, in this or other embodiments the spool is a high pressure spool of a two-spool gas turbine engine.

[0009] Additionally or alternatively, in this or other embodiments the spool includes an impeller and a turbine. The impeller is positioned at the first shaft portion and the turbine is positioned at the second shaft portion.

[0010] Additionally or alternatively, in this or other embodiments the tie shaft is continuous and unbroken along an axial length of the outer shaft assembly.

[0011] In another exemplary embodiment, a gas turbine engine includes a combustor, and at least one spool. The at least one spool includes a turbine configured to be driven by products of the combustor and a compressor operably connected to and driven by rotation of the turbine. The spool further includes an outer shaft assembly including a first shaft portion connected to the compressor and a second shaft portion connected to the turbine. The first shaft portion axially overlaps the first shaft portion at a shaft joint. A centering feature is positioned at the shaft joint and is configured to radially center the second shaft portion relative to the first shaft portion.

[0012] Additionally or alternatively, in this or other embodiments a tie shaft is concentric with and located radially inboard of the outer shaft assembly. The tie shaft is configured to apply an axially compressive load on the outer shaft assembly.

[0013] Additionally or alternatively, in this or other embodiments a nut is applied to the tie shaft to apply the compressive load.

[0014] Additionally or alternatively, in this or other embodiments application of the nut to the tie shaft applies a tensile load to the tie shaft.

[0015] Additionally or alternatively, in this or other embodiments the tie shaft is continuous and unbroken along an axial length of the outer shaft assembly.

[0016] Additionally or alternatively, in this or other embodiments the centering feature includes an outer diameter lip of the first shaft portion that axially overlaps the second shaft portion.

[0017] Additionally or alternatively, in this or other embodiments the centering feature includes an inner diameter lip of the first shaft portion that axially overlaps the second shaft portion.
[0018] Additionally or alternatively, in this or other embodiments the spool is a high pressure spool of a two-spool gas turbine engine.
[0019] Additionally or alternatively, in this or other embodiments the compressor is an impeller.
[0020] In yet another exemplary embodiment, a spool of a gas turbine engine includes an outer shaft assembly located at and configured to rotate about an engine central longitudinal axis. The outer shaft assembly is secured to one or more rotating components of the gas turbine engine. The outer shaft assembly includes a first shaft portion and a second shaft portion. The first shaft portion axially overlaps the first shaft portion at a shaft joint. A centering feature is positioned at the shaft joint and is configured to radially center the second shaft portion relative to the first shaft portion. A tie shaft is concentric with and is located radially inboard of the outer shaft assembly. The tie shaft is configured to apply an axially compressive load on the outer shaft assembly. A method of testing the spool includes configuring the tie shaft to accept a pyrotechnic charge, detonating the pyrotechnic charge thus separating the tie shaft, releasing the compressive load on the outer shaft assembly via detonating the pyrotechnic charge, and uncoupling the first shaft portion from the second shaft portion via the release of the compressive load.
[0021] Additionally or alternatively, in this or other embodiments the spool is rotated at a preselected speed prior to detonating the pyrotechnic charge.
[0022] Additionally or alternatively, in this or other embodiments the pyrotechnic charge is placed at a same axial location as the shaft joint.
[0023] Additionally or alternatively, in this or other embodiments the pyrotechnic charge is placed at a radially inner surface of the tie shaft.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0024] The following descriptions should not be considered limiting in any way. With reference to the accompanying drawings, like elements are numbered alike:
[0025] FIG. **1** is a partial cross-sectional view of an embodiment of a gas turbine engine;
[0026] FIG. **2** is a partial cross-sectional view of an embodiment of a shaft joint of a gas turbine engine;
[0027] FIG. **3** is a partial cross-sectional view of another embodiment of a shaft joint of a gas turbine engine; and
[0028] FIG. **4** is a partial cross-sectional view of yet another embodiment of a shaft joint of a gas turbine engine;
DETAILED DESCRIPTION
[0029] A detailed description of one or more embodiments of the disclosed apparatus and method are presented herein by way of exemplification and not limitation with reference to the Figures.
[0030] FIG. **1** schematically illustrates a gas turbine engine **10**. The gas turbine engine **10** is disclosed herein as a two-spool turbofan that generally incorporates a fan section **12**, a compressor section **14**, a combustor section **16** and a turbine section **18**. Alternative engines might include other systems or features. The fan section **12** drives air along a bypass flow path B in a bypass duct, while the compressor section **14** drives air along a core flow path C for compression and communication into the combustor section **16** then expansion through the turbine section **18**. Although depicted as a two-spool turbofan gas turbine engine in the disclosed non-limiting embodiment, it should be understood that the concepts described herein are not limited to use with two-spool turbofans as the teachings may be applied to other types of turbine engines including three-spool architectures.

[0031] The exemplary engine **10** generally includes a low speed spool **20** and a high speed spool **22** mounted for rotation about an engine central longitudinal axis A relative to an engine static structure **26**.

[0032] The low speed spool **20** generally includes an inner shaft **30** that interconnects a fan **32**, and a low pressure turbine **36**. The high speed spool **22** includes an outer shaft **40** that interconnects an impeller **42** and high pressure turbine **44**. A combustor **46** is arranged in exemplary gas turbine **10** between the impeller **42** and the high pressure turbine **44**. An engine static structure **36** is arranged generally between the high pressure turbine **44** and the low pressure turbine **36**. The inner shaft **30** and the outer shaft **40** are concentric and rotate about the engine central longitudinal axis A which is collinear with their longitudinal axes.

[0033] The core airflow is compressed by the impeller **42**, mixed and burned with fuel in the combustor **46**, then expanded over the high pressure turbine **44** and low pressure turbine **36**. The turbines **36**, **44** rotationally drive the respective low speed spool **20** and high speed spool **22** in response to the expansion. It will be appreciated that each of the positions of the fan section **12**, compressor section **14**, combustor section **16**, and turbine section **18**, may be varied.

[0034] Referring now to FIG. **2**, the gas turbine engine **10** has a requirement to be tested for containment performance in the event of decoupling or separation of the high speed spool **22**. As previously stated, the high speed spool **22** includes the impeller **42** and high pressure turbine **44**, disposed along outer shaft **40**, which is concentric with a tie shaft **48** disposed radially inboard of the outer shaft **40**. The impeller **42** and the high pressure turbine **44** are axially retained along the tie shaft **48** via a nut **50** located at the high pressure turbine **44**, which when tightened puts a compressive load on the outer shaft **40** between the impeller **42** and the high pressure turbine **44**. Meanwhile, tightening of the nut **50** puts a tensile load on the tie shaft **48**.

[0035] The outer shaft **40** is a two-piece construction, and has a first shaft portion **52** extending axially rearwardly from the impeller **42** toward the high pressure turbine **44**, and has a second shaft portion **54** extending axially forwardly from the high pressure turbine **44** toward the impeller **42**. The first shaft portion **52** is joined to the second shaft portion **54** at a shaft joint **56**, which in some embodiments is located at a midpoint between the impeller **42** and the high pressure turbine **44**. One or more centering features are included at the shaft joint **56**. In the embodiment of FIG. **2**, the centering features include an outer diameter lip **58** of the first shaft portion **52** that axially overlaps a radially outer surface **60** of the second shaft portion **54**. This centers the second shaft portion **54** and the high pressure turbine **44** relative to the first shaft portion **52** and the impeller **42**, while also providing sufficient resistance to bending and vibratory loads at the shaft joint **56**.

[0036] While the outer diameter lip **58** is utilized in the embodiment of FIG. **2**, in other embodiments the centering feature may take other forms. In FIG. **3**, for example, the centering features include an inner diameter lip **62** at the first shaft portion **52** that axially overlaps a radially inner surface **64** of the second shaft portion **54**. Further, while the outer diameter lip **58** and the inner diameter lip **62** are illustrated herein as portions of the first shaft portion **52**, one skilled in the art will readily appreciate that the outer diameter lip **58** and the inner diameter lip **62** may similarly be portions of the second shaft portion **54** that axially overlap the first shaft portion **52**. In other embodiments, such as shown in FIG. **4**, the first shaft portion **52** may include a conical first end surface **66** that mates to a complimentary conical second end surface **68** of the second shaft portion **54**. The conical first end surface **66** and the conical second end surface **68** may include a face spline or curvic coupling to connect the first shaft portion **52** and the second shaft portion **54**, while still allowing for decoupling.

[0037] Referring again to FIG. **2**, the configurations of the outer shaft **40** disclosed herein reduce axial resistance to tension, and reduces resistance to bending and vibratory loads, while still providing for centering of the first shaft portion **52** relative to the second shaft portion **54**. Additionally, for testing purposes, the tie shaft **48** includes modifications, such as an inner surface pocket **70**, to accept a pyrotechnic charge **72**, which is only present for testing of decoupling.

[0038] To execute such as test, the pyrotechnic charge **72** is placed at the inner surface pocket **70**, which in some embodiments is located at a same axial location of the shaft joint **56**. In some embodiments, the test may be performed with a static outer shaft **40**, while in other embodiments the gas turbine engine **10** is operated so that the outer shaft **40** rotates about the engine central longitudinal axis A at a preselected rotational speed. Activation or detonation of the pyrotechnic charge separates the tie shaft **48** and removes the compressive load from the outer shaft **40**, resulting in decoupling of the shaft joint **46**.
[0039] The term “about” is intended to include the degree of error associated with measurement of the particular quantity based upon the equipment available at the time of filing the application. For example, “about” can include a range of ±8% or 5%, or 2% of a given value.
[0040] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the present disclosure. As used herein, the singular forms “a”, “an” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms “comprises” and/or “comprising,” when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, element components, and/or groups thereof.
[0041] While the present disclosure has been described with reference to an exemplary embodiment or embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the present disclosure. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the present disclosure without departing from the essential scope thereof. Therefore, it is intended that the present disclosure not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this present disclosure, but that the present disclosure will include all embodiments falling within the scope of the claims.

Claims

1. A spool of a gas turbine engine, comprising: an outer shaft assembly disposed at and configured to rotate about an engine central longitudinal axis, the outer shaft assembly secured to two or more rotating components of the gas turbine engine, the outer shaft assembly including: a first shaft portion including a first shaft body; a second shaft portion, the first shaft portion axially overlapping the first second shaft portion at a shaft joint; wherein the first shaft portion includes a centering feature disposed at the shaft joint configured to radially center the second shaft portion relative to the first shaft portion; and a tie shaft concentric with and radially inboard of the outer shaft assembly, the tie shaft configured to apply an axially compressive load on the outer shaft assembly; and a separation device configured to separate the tie shaft; wherein separating the tie shaft releases the axially compressive load thus allowing the uncoupling of the first shaft portion from the second shaft portion; wherein the centering feature radially protrudes from the first shaft body.
2. The spool of claim 1, further comprising a nut applied to the tie shaft to apply the compressive load.
3. The spool of claim 1, wherein the centering feature includes an outer diameter lip of the first shaft portion that axially overlaps the second shaft portion.
4. The spool of claim 1, wherein the centering feature includes an inner diameter lip of the first shaft portion that axially overlaps the second shaft portion.
5. The spool of claim 1, wherein the spool is a high pressure spool of a two-spool gas turbine engine.
6. The spool of claim 5, wherein the spool includes: an impeller; and a turbine; wherein the first shaft portion extends axially rearwardly from the impeller and the second shaft portion extends

axially forwardly from the turbine.
7. The spool of claim 1, wherein the tie shaft is continuous and unbroken along an axial length of the outer shaft assembly.
8. A gas turbine engine, comprising: a combustor; and at least one spool, the at least one spool including: a turbine configured to be driven by products of the combustor; a compressor operably connected to and driven by rotation of the turbine; an outer shaft assembly including: a first shaft portion connected to the compressor, the first shaft portion including a first shaft body; a second shaft portion connected to the turbine, the first shaft portion axially overlapping the second shaft portion at a shaft joint; wherein the first shaft portion includes a centering feature disposed at the shaft joint configured to radially center the second shaft portion relative to the first shaft portion; a tie shaft concentric with and radially inboard of the outer shaft assembly, the tie shaft configured to apply an axially compressive load on the outer shaft assembly; and a separation device configured to separate the tie shaft; wherein separating the tie shaft releases the axially compressive load thus allowing the uncoupling of the first shaft portion from the second shaft portion; wherein the centering feature radially protrudes from the first shaft body.
9. (canceled)
10. The gas turbine engine of claim 8, further comprising a nut applied to the tie shaft to apply the compressive load.
11. The gas turbine engine of claim 10, wherein application of the nut to the tie shaft applies a tensile load to the tie shaft.
12. The gas turbine engine of claim 8, wherein the tie shaft is continuous and unbroken along an axial length of the outer shaft assembly.
13. The gas turbine engine of claim 8, wherein the centering feature includes an outer diameter lip of the first shaft portion that axially overlaps the second shaft portion.
14. The gas turbine engine of claim 8, wherein the centering feature includes an inner diameter lip of the first shaft portion that axially overlaps the second shaft portion.
15. The gas turbine engine of claim 8, wherein the spool is a high pressure spool of a two-spool gas turbine engine.
16. The gas turbine engine of claim 8 wherein the compressor is an impeller.
17. A method of testing a spool of a gas turbine engine, the spool including: an outer shaft assembly disposed at and configured to rotate about an engine central longitudinal axis, the outer shaft assembly secured to one or more rotating components of the gas turbine engine, the outer shaft assembly including: a first shaft portion; a second shaft portion, the first shaft portion axially overlapping the first shaft portion at a shaft joint; and a centering feature disposed at the shaft joint configured to radially center the second shaft portion relative to the first shaft portion; and a tie shaft concentric with and radially inboard of the outer shaft assembly, the tie shaft configured to apply an axially compressive load on the outer shaft assembly, the method including: configuring the tie shaft to accept a pyrotechnic charge; detonating the pyrotechnic charge thus separating the tie shaft; releasing the compressive load on the outer shaft assembly via detonating the pyrotechnic charge; and uncoupling the first shaft portion from the second shaft portion via the release of the compressive load.
18. The method of claim 17, further comprising rotating the spool at a preselected speed prior to detonating the pyrotechnic charge.
19. The method of claim 17, further comprising placing the pyrotechnic charge at a same axial location as the shaft joint.
20. The method of claim 17, further comprising placing the pyrotechnic charge at a radially inner surface of the tie shaft.