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(54) **ROTOR KEYHOLE FILLET FOR A GAS TURBINE ENGINE**

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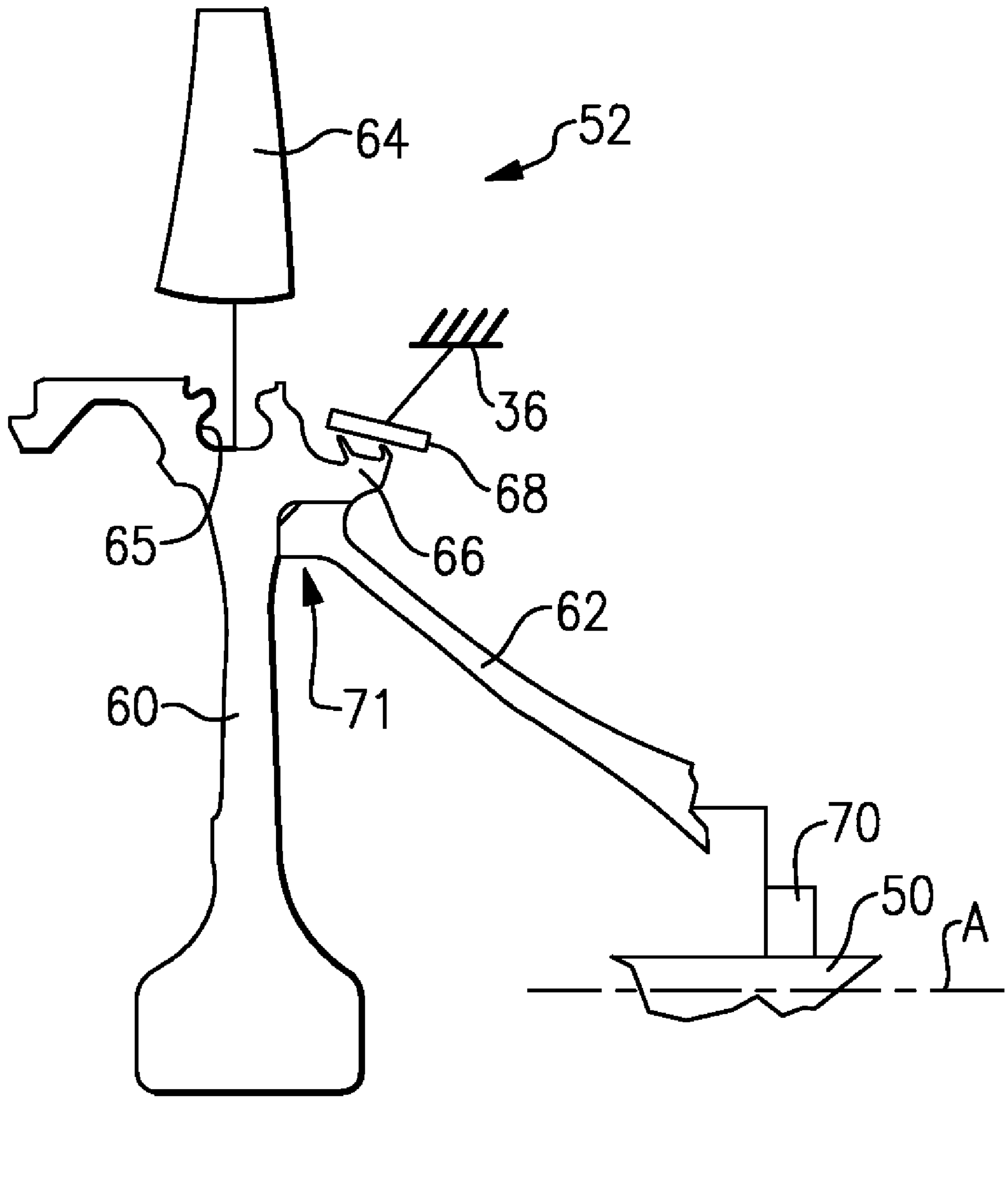
(57) **ABSTRACT**

A rotor for a gas turbine engine includes an annular structure having a blade slot. A hub engagement feature is provided on the annular structure. The hub engagement feature includes first and second surfaces transverse to one another and joined by a fillet that is recessed with respect to the first and second surfaces. A method of manufacturing a rotor includes the steps of machining an annular hub engagement feature into a rotor. The hub engagement feature includes first and second surfaces transverse to one another and is joined by a fillet that is recessed with respect to the first and second surfaces. The method includes the step of peening the fillet, and grinding the first and second surfaces.



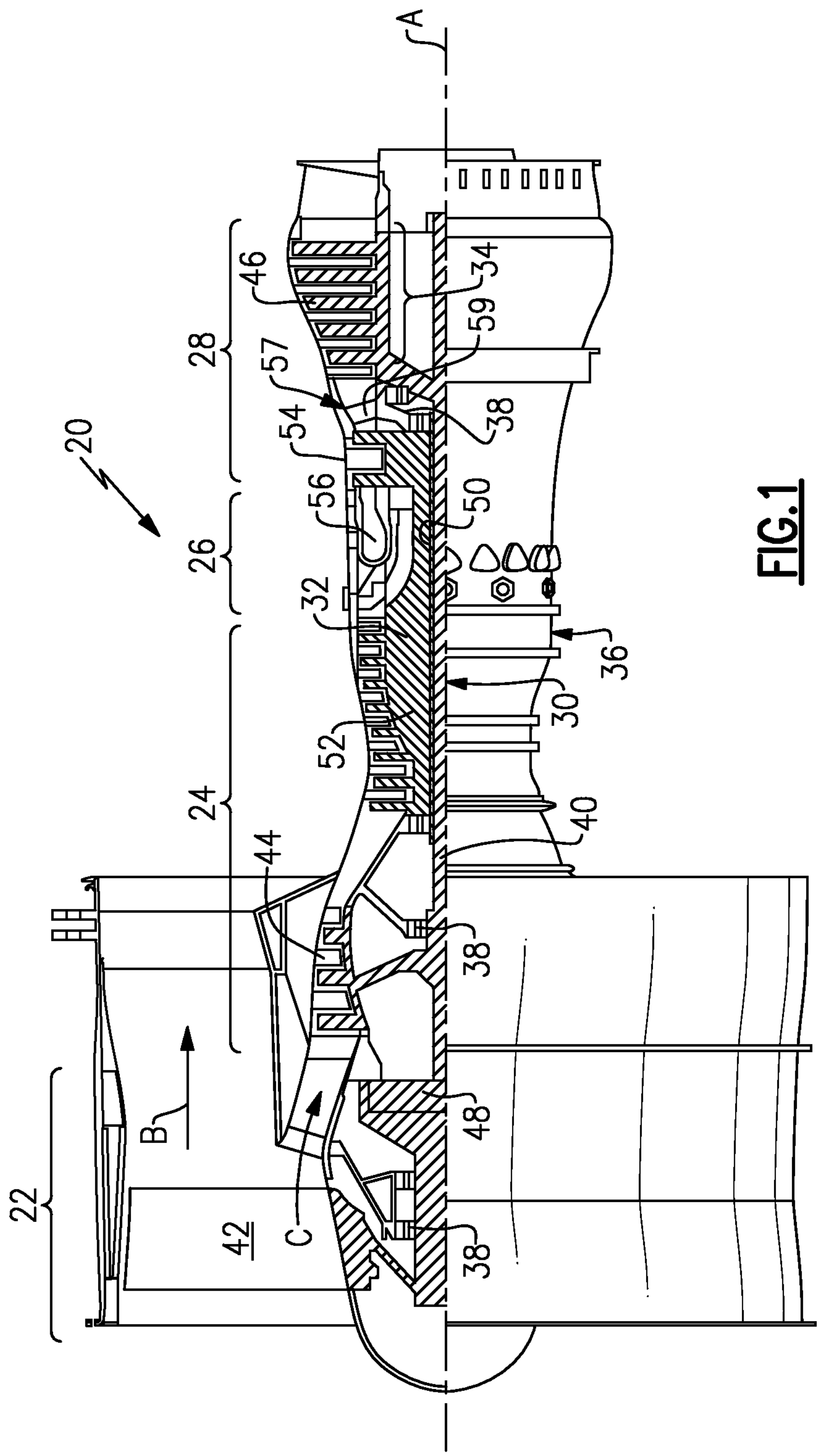


FIG.1

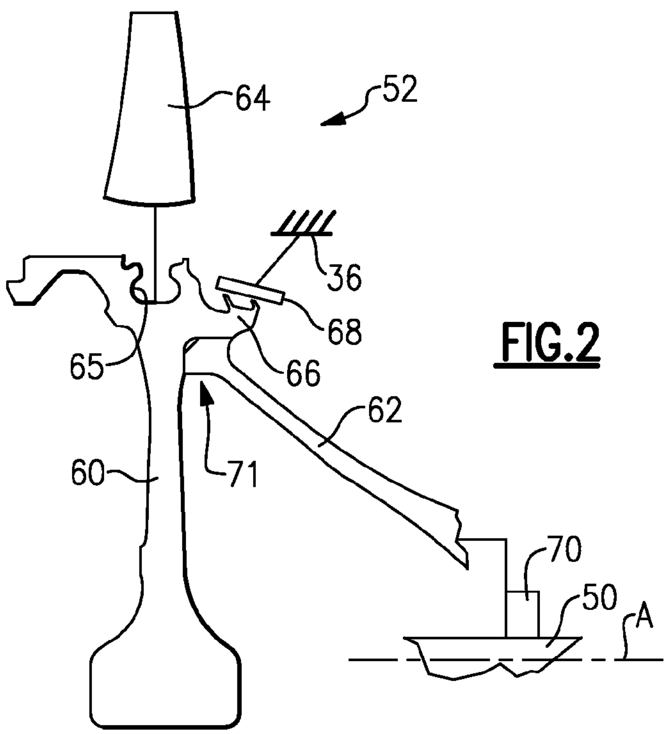


FIG.2

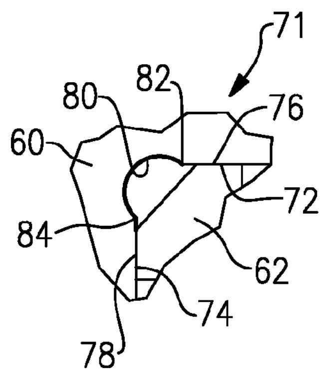


FIG.3

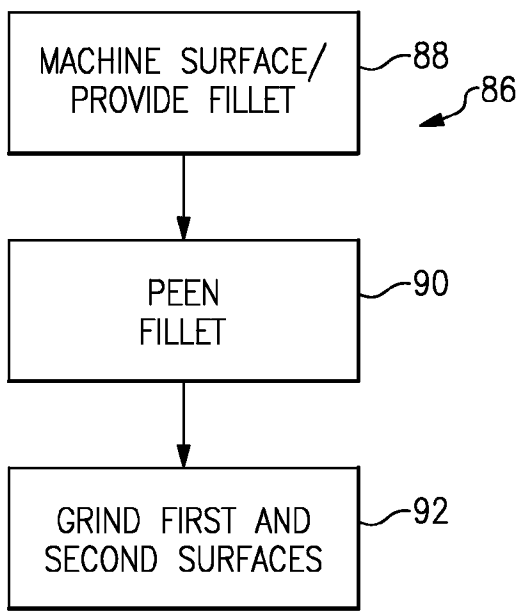


FIG.4

ROTOR KEYHOLE FILLET FOR A GAS TURBINE ENGINE

BACKGROUND

[0001] This disclosure relates to a rotor for a gas turbine engine. More particularly, the disclosure relates to fillet geometry for the rotor.

[0002] A typical gas turbine engine includes multiple of compressor stages upstream from a combustor section. A turbine section is arranged downstream from the combustor. In one example configuration, at least one end of a compressor rotor is secured to a shaft by a hub. The hub engages a hub engagement feature on the rotor to secure the rotor relative to the shaft. Typically, a nut is received on the correspondingly threaded portion of the shaft and applies a clamping load to the rotor via the hub.

[0003] The hub engagement feature on the rotor is provided by first and second annular surfaces that are at a right angle to one another. A fillet joins the first and second surfaces, which are arranged tangentially relative to the fillet.

SUMMARY

[0004] In one exemplary embodiment, a rotor for a gas turbine engine includes an annular structure having a blade slot. A hub engagement feature is provided on the annular structure. The hub engagement feature includes first and second surfaces transverse to one another and joined by a fillet that is recessed with respect to the first and second surfaces.

[0005] In a further embodiment of any of the above, the first and second surfaces are normal to one another.

[0006] In a further embodiment of any of the above, the fillet includes a peened surface.

[0007] In a further embodiment of any of the above, the annular structure is constructed from a nickel alloy.

[0008] In a further embodiment of any of the above, the first and second surfaces are provided by ground surfaces.

[0009] In a further embodiment of any of the above, the first and second surfaces are non-tangential to the fillet.

[0010] In another exemplary embodiment, a rotor assembly for a gas turbine engine includes a shaft. The rotor assembly includes a rotor that supports a blade and includes a hub engagement feature. The hub engagement feature includes first and second rotor surfaces transverse to one another and is joined by a fillet that is recessed with respect to the first and second rotor surfaces. A hub is supported on the shaft and engages the hub engagement feature.

[0011] In a further embodiment of any of the above, the rotor assembly includes a nut secured to the shaft and applies a clamping load to the hub engagement feature via the hub.

[0012] In a further embodiment of any of the above, the hub includes first and second hub surfaces respectively engaging the first and second rotor surfaces under the clamping load. The first and second hub surfaces are spaced from the fillet.

[0013] In a further embodiment of any of the above, the first and second rotor surfaces are normal to one another.

[0014] In a further embodiment of any of the above, the fillet includes a peened surface.

[0015] In a further embodiment of any of the above, the rotor is constructed from a nickel alloy.

[0016] In a further embodiment of any of the above, the first and second rotor surfaces are provided by ground surfaces.

[0017] In a further embodiment of any of the above, the first and second rotor surfaces are non-tangential to the fillet.

[0018] In another exemplary embodiment, a method of manufacturing a rotor includes the steps of machining an annular hub engagement feature into a rotor. The hub engagement feature includes first and second surfaces transverse to one another and is joined by a fillet that is recessed with respect to the first and second surfaces. The method includes the step of peening the fillet, and grinding the first and second surfaces.

[0019] In a further embodiment of any of the above, the grinding step is performed after the peening step.

[0020] In a further embodiment of any of the above, the first and second surfaces are non-tangential to the fillet.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] The disclosure can be further understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

[0022] FIG. **1** is a schematic cross-sectional view of an example gas turbine engine.

[0023] FIG. **2** is a schematic view of an example rotor and hub supported by a shaft.

[0024] FIG. **3** is an enlarged cross-sectional view of a portion of the rotor and hub.

[0025] FIG. **4** is a flow chart depicting an example method of manufacturing a rotor.

DETAILED DESCRIPTION

[0026] FIG. **1** schematically illustrates an example gas turbine engine **20** that includes a fan section **22**, a compressor section **24**, a combustor section **26** and a turbine section **28**. Alternative engines might include an augmenter section (not shown) among other systems or features. The fan section **22** drives air along a bypass flow path B while the compressor section **24** draws air in along a core flow path C where air is compressed and communicated to a combustor section **26**. In the combustor section **26**, air is mixed with fuel and ignited to generate a high pressure exhaust gas stream that expands through the turbine section **28** where energy is extracted and utilized to drive the fan section **22** and the compressor section **24**.

[0027] Although the disclosed non-limiting embodiment depicts a turbofan gas turbine engine, it should be understood that the concepts described herein are not limited to use with turbofans as the teachings may be applied to other types of turbine engines; for example a turbine engine including a three-spool architecture in which three spools concentrically rotate about a common axis and where a low spool enables a low pressure turbine to drive a fan via a gearbox, an intermediate spool that enables an intermediate pressure turbine to drive a first compressor of the compressor section, and a high spool that enables a high pressure turbine to drive a high pressure compressor of the compressor section.

[0028] The example engine **20** generally includes a low speed spool **30** and a high speed spool **32** mounted for rotation about an engine central longitudinal axis A relative to an engine static structure **36** via several bearing systems **38**. It should be understood that various bearing systems **38** at various locations may alternatively or additionally be provided.

[0029] The low speed spool **30** generally includes an inner shaft **40** that connects a fan **42** and a low pressure (or first) compressor section **44** to a low pressure (or first) turbine section **46**. The inner shaft **40** drives the fan **42** through a speed change device, such as a geared architecture **48**, to drive the fan **42** at a lower speed than the low speed spool **30**. The high-speed spool **32** includes an outer shaft **50** that interconnects a high pressure (or second) compressor section **52** and a high pressure (or second) turbine section **54**. The inner shaft **40** and the outer shaft **50** are concentric and rotate via the bearing systems **38** about the engine central longitudinal axis A.

[0030] A combustor **56** is arranged between the high pressure compressor **52** and the high pressure turbine **54**. In one example, the high pressure turbine **54** includes at least two stages to provide a double stage high pressure turbine **54**. In another example, the high pressure turbine **54** includes only a single stage. As used herein, a "high pressure" compressor or turbine experiences a higher pressure than a corresponding "low pressure" compressor or turbine.

[0031] The core airflow C is compressed by the low pressure compressor **44** then the high pressure compressor **52**, mixed and burned with fuel in the combustor **56**, then expanded over the high pressure turbine **54** and low pressure turbine **46**. The mid-turbine frame **57** includes airfoils **59** which are in the core airflow path. The turbines **46**, **54** rotationally drive the respective low speed spool **30** and high speed spool **32** in response to the expansion.

[0032] The engine **20** in one example is a high-bypass geared aircraft engine. In a further example, the engine **20** bypass ratio is greater than about six (6), with an example embodiment being greater than ten (10), the geared architecture **48** is an epicyclic gear train, such as a star gear system or other gear system, with a gear reduction ratio of greater than about 2.3 and the low pressure turbine **46** has a pressure ratio that is greater than about 5. In one disclosed embodiment, the engine **20** bypass ratio is greater than about ten (10:1), the fan diameter is significantly larger than that of the low pressure compressor **44**, and the low pressure turbine **46** has a pressure ratio that is greater than about 5:1. Low pressure turbine **46** pressure ratio is pressure measured prior to inlet of low pressure turbine **46** as related to the pressure at the outlet of the low pressure turbine **46** prior to an exhaust nozzle. It should be understood, however, that the above parameters are only exemplary of one embodiment of a geared architecture engine and that the present invention is applicable to other gas turbine engines including direct drive turbofans.

[0033] A significant amount of thrust is provided by the bypass flow B due to the high bypass ratio. The fan section **22** of the engine **20** is designed for a particular flight condition—typically cruise at about 0.8 Mach and about 35,000 feet. The flight condition of 0.8 Mach and 35,000 ft, with the engine at its best fuel consumption—also known as "bucket cruise Thrust Specific Fuel Consumption ('TSFC')"—is the industry standard parameter of lbm of fuel being burned per hour divided by lbf of thrust the engine produces at that minimum point. "Fan pressure ratio" is the pressure ratio across the fan blade alone, without a Fan Exit Guide Vane ("FEGV") system. The low fan pressure ratio as disclosed herein according to one non-limiting embodiment is less than about 1.45. "Low corrected fan tip speed" is the actual fan tip speed in ft/sec divided by an industry standard temperature correction of [(Tambient deg R)/518.7)^0.5]. The "Low corrected fan tip speed" as disclosed herein according to one non-limiting embodiment is less than about 1150 ft/second.

[0034] Referring to FIG. **2**, the high pressure compressor **52** includes a rotor **60** supported relative to the outer shaft **50**. In an example, the rotor **60** is the last stage disk of the high pressure compressor **52**. The hub **62** supports the rotor **60** relative to the outer shaft **52**. The hub **62** is secured to the outer shaft **50** by a nut **70**, which applies a clamping force to a hub engagement feature **71** (discussed below) on the rotor **62**.

[0035] The rotor **60**, which is constructed from a nickel alloy, includes one or more slots **65** that support multiple circumferentially spaced blades **64**. It should be understood, however, that the blades **64** may be integrated with the rotor **60**.

[0036] A first air seal **66** is supported by the rotor **60**, in the example, which cooperates with a second air seal **68** supported by the engine static structure **36**. The first air seal **66** may integral with or separate from the rotor **62**.

[0037] The hub engagement feature **71** is shown in more detail in FIG. **3**. First and second rotor surfaces **72**, **74** are provided on the rotor **60** normal (that is, perpendicular) to one another. The hub **62** includes first and second hub surfaces **76**, **78** that also are normal with respect to one another. The first and second hub surfaces **76**, **78** respectively engage the first and second rotor surfaces **72**, **74** of the hub engagement feature **71**. A fillet **80** joins the first and second rotor surfaces **72**, **74** to one another. The fillet **80** is recessed with respect to the first and second rotor surfaces **72**, **74** such that the first and second rotor surfaces **72**, **74** are not tangential to the fillet **80**. The first and second rotor surfaces **72**, **74** meet the fillet **80** at first and second intersections **82**, **84**, respectively, providing a keyhole-shaped fillet geometry. Said another way, the first and second rotor surfaces **72**, **74** are proud of, or extend above, the fillet **80**. The first and second rotor surfaces **72**, **74** extend toward the fillet **80** beyond the first and second hub surfaces **76**, **78**.

[0038] Referring to FIG. **4**, a method **86** of manufacturing the rotor **60** is described. The annular hub engagement feature **71** is machined into the rotor **60**, as indicated at block **88**. The hub engagement feature **71** includes the first and second rotor surfaces **72**, **74**, which are transverse to one another, for example, at a right angle. The fillet **80** may be machined at the same time as the first and second rotor surfaces **72**, **74**, subsequently to the first and second rotor surfaces **72**, **74**, or prior to forming the first and second rotor surfaces **72**, **74**. The fillet **80** is peened to relieve the stresses in this typically high stressed area, as indicated at block **90**. The peening operation may occur before or after machining of the first and second rotor surfaces **72**, **74**. The first and second rotor surfaces **72**, **74** may receive a finish grinding, as indicated at block **92**, to provide a dimensionally precise surface with desired surface finish for receiving the hub **62**.

[0039] Although an example embodiment has been disclosed, a worker of ordinary skill in this art would recognize that certain modifications would come within the scope of the claims. For that reason, the following claims should be studied to determine their true scope and content.

What is claimed is:

1. A rotor for a gas turbine engine comprising:

an annular structure having a blade slot; and

a hub engagement feature provided on the annular structure, the hub engagement feature including first and second surfaces transverse to one another and joined by a fillet that is recessed with respect to the first and second surfaces.

2. The rotor according to claim **1**, wherein the first and second surfaces are normal to one another.

3. The rotor according to claim **1**, wherein the fillet includes a peened surface.

4. The rotor according to claim **3**, wherein the annular structure is constructed from a nickel alloy.

5. The rotor according to claim **3**, wherein the first and second surfaces are provided by ground surfaces.

6. The rotor according to claim **1**, wherein the first and second surfaces are non-tangential to the fillet.

7. A rotor assembly for a gas turbine engine comprising:

a shaft;

a rotor supporting a blade and including a hub engagement feature, the hub engagement feature including first and second rotor surfaces transverse to one another and joined by a fillet that is recessed with respect to the first and second rotor surfaces; and

a hub supported on the shaft and engaging the hub engagement feature.

8. The rotor assembly according to claim **7**, comprising a nut secured to the shaft and applying a clamping load to the hub engagement feature via the hub.

9. The rotor assembly according to claim **8**, wherein the hub includes first and second hub surfaces respectively engaging the first and second rotor surfaces under the clamping load, the first and second hub surfaces spaced from the fillet.

10. The rotor assembly according to claim **9**, wherein the first and second rotor surfaces are normal to one another.

11. The rotor assembly according to claim **7**, wherein the fillet includes a peened surface.

12. The rotor assembly according to claim **11**, wherein the rotor is constructed from a nickel alloy.

13. The rotor assembly according to claim **11**, wherein the first and second rotor surfaces are provided by ground surfaces.

14. The rotor assembly according to claim **7**, wherein the first and second rotor surfaces are non-tangential to the fillet.

15. A method of manufacturing a rotor comprising the steps of:

machining an annular hub engagement feature into a rotor, the hub engagement feature including first and second surfaces transverse to one another and joined by a fillet that is recessed with respect to the first and second surfaces;

peening the fillet; and

grinding the first and second surfaces.

16. The method according to claim **15**, wherein the grinding step is performed after the peening step.

17. The method according to claim **15**, wherein the first and second surfaces are non-tangential to the fillet.

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