US 20120034101A1

(19) **United States**

(12) **Patent Application Publication**

(10) **Pub. No.: US 2012/0034101 A1**

(43) **Pub. Date: Feb. 9, 2012**

James et al.

(54) **TURBINE BLADE SQUEALER TIP**

(76) Inventors: **Allister W. James**, Chuluota, FL (US); **Anand A. Kulkarni**, Oviedo, FL (US)

(21) Appl. No.: **12/852,679**

(22) Filed: **Aug. 9, 2010**

Publication Classification

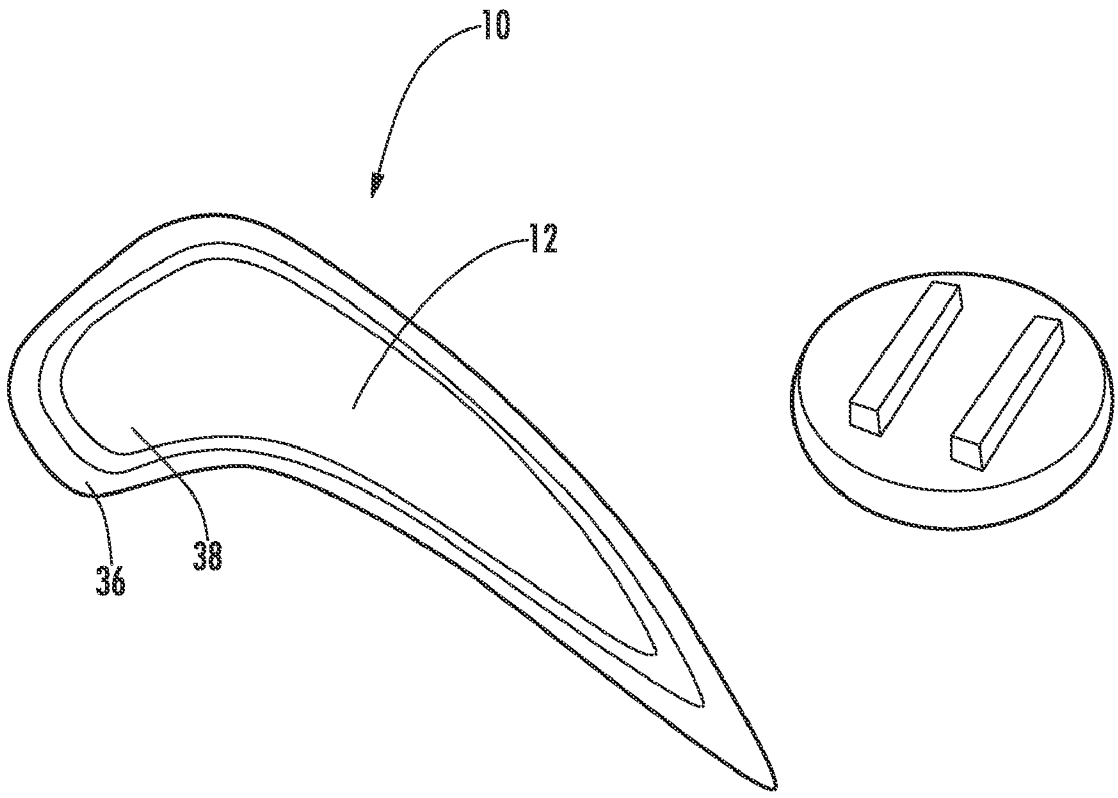
(51) **Int. Cl.**

F01D 5/18	(2006.01)
F01D 5/30	(2006.01)
F01D 5/14	(2006.01)

(52) **U.S. Cl.** .... **416/96 R**; 416/241 R; 416/219 R

(57) **ABSTRACT**

A turbine blade having a squealer tip coupled to a radially outer end of the turbine blade that is usable in a gas turbine engine is disclosed. The squealer tip may require less cooling air and may therefore be more efficient than conventional configurations. The squealer tip may be formed from one or more materials such as oxide dispersion strengthened alloys and FeCrAl alloys. The squealer tip may be formed from a plurality of segmented tips extending radially outward and spaced apart from each other. For example, the squealer tip may be formed from two rails extending radially outward and spaced apart from each other. The two rails may be formed from outer and inner rails that each form a continuous ring. The squealer tip may be attached to the tip with a transient liquid phase bond or an additive manufacturing process, such as, a selective laser melting process.



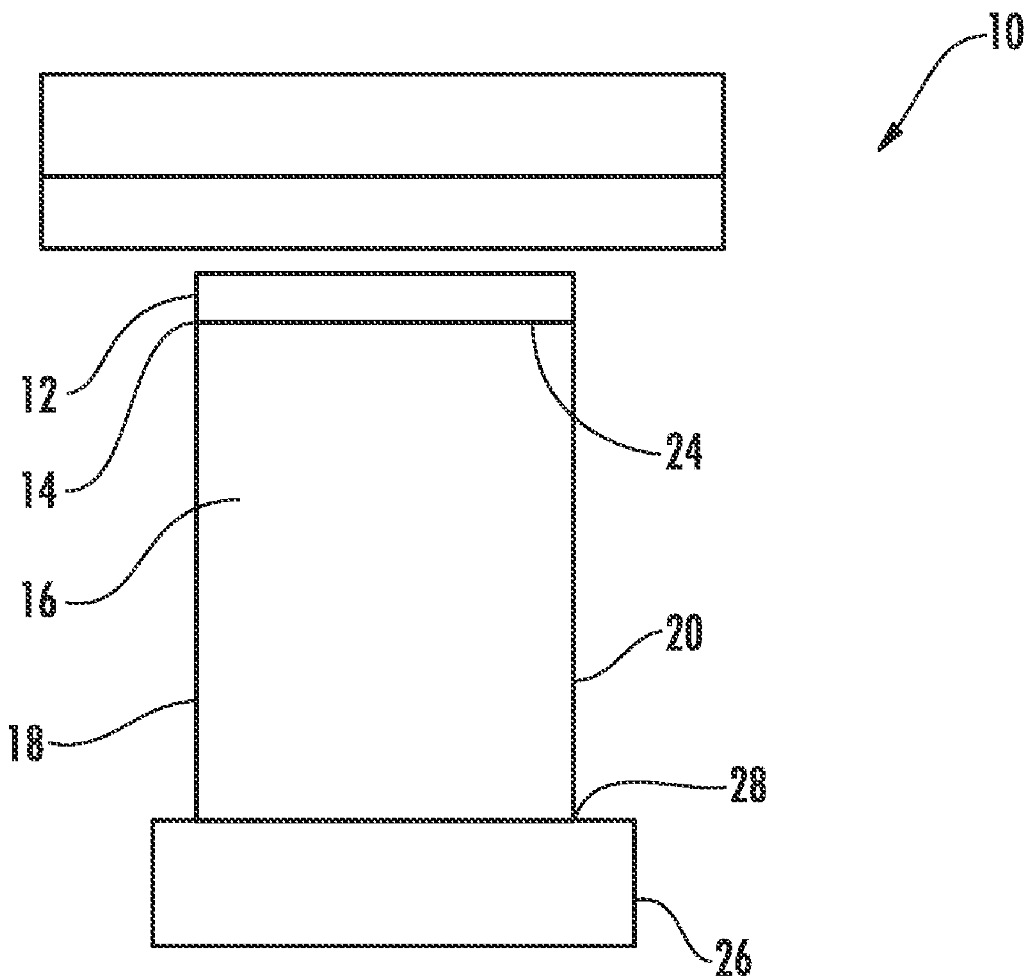


FIG. 1

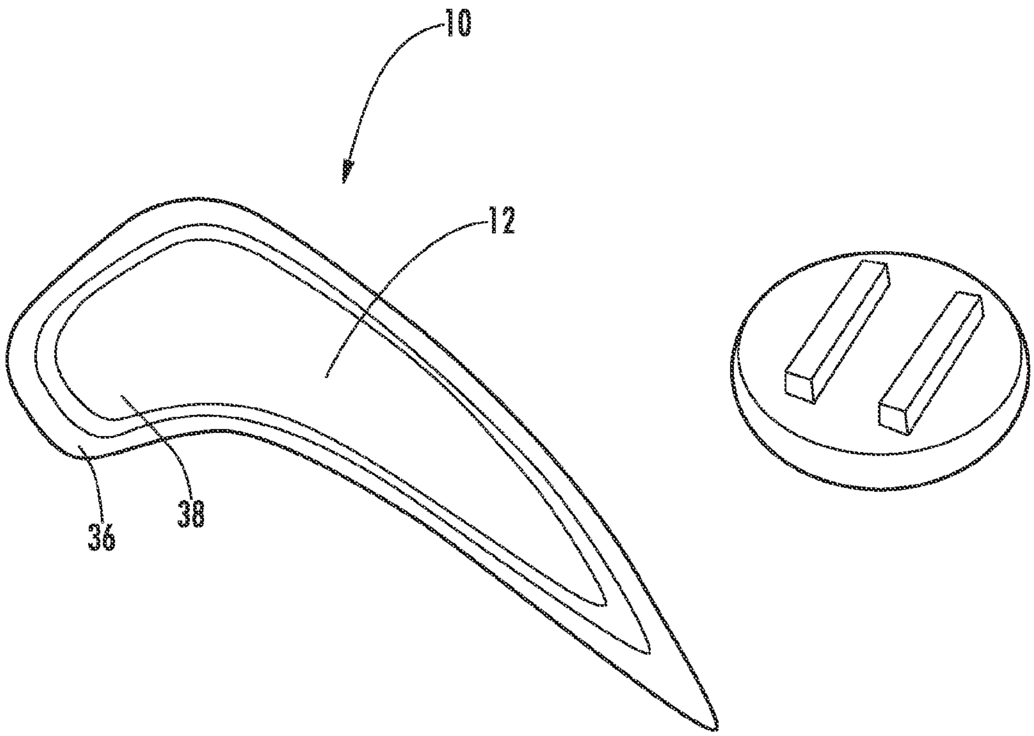


FIG. 2

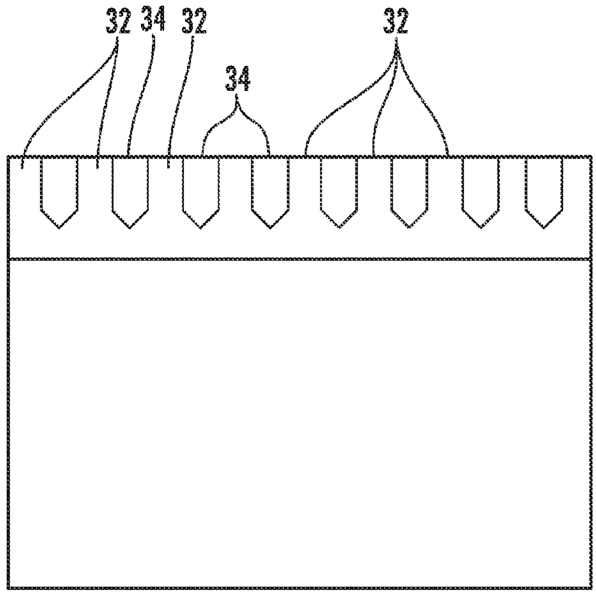


FIG. 3

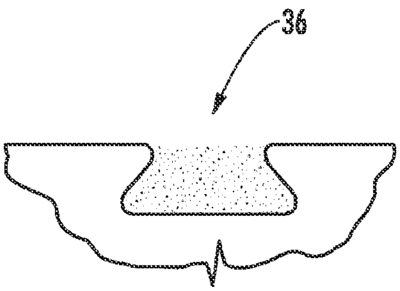


FIG. 4

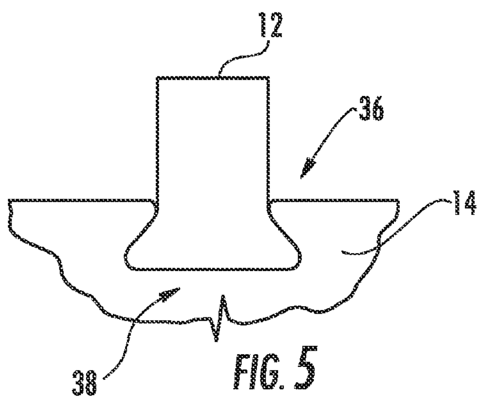


FIG. 5

TURBINE BLADE SQUEALER TIP

FIELD OF THE INVENTION

[0001] This invention is directed generally to turbine blades, and more particularly to tip sealing systems for turbine blades.

BACKGROUND

[0002] Typically, gas turbine engines include a compressor for compressing air, a combustor for mixing the compressed air with fuel and igniting the mixture, and a turbine blade assembly for producing power. Combustors often operate at high temperatures that may exceed 2,500 degrees Fahrenheit. Typical turbine combustor configurations expose turbine blade assemblies to these high temperatures. As a result, turbine blades must be made of materials capable of withstanding such high temperatures. In addition, turbine blades often contain cooling systems for prolonging the life of the blades and reducing the likelihood of failure as a result of excessive temperatures.

[0003] Typically, turbine blades are formed from a root portion at one end and an elongated portion forming an airfoil that extends outwardly from a platform coupled to the root portion at an opposite end of the turbine blade. The blade is ordinarily composed of a tip opposite the root section, a leading edge, and a trailing edge. The tip of a turbine blade often has a tip seals to reduce the gap between ring segments and blades in the gas path of the turbine. The tip seals are often referred to as squealer tips and are frequently incorporated onto the tips of blades to help reduce pressure losses between turbine stages. These features are designed to minimize the gap between the blade tip and the ring segment. The material at the tip is exposed to the hot gas path because there is not a ceramic thermal barrier coating on the squealer tips. Squealer tips are integrally cast with the turbine blade. Turbine engines are being run at higher and higher temperatures in an effort to create increasing amounts of power from the engines. These higher temperatures are creating increased thermal stress levels on the turbine airfoils.

[0004] The inner aspects of most turbine blades typically contain an intricate maze of cooling channels forming a cooling system. The cooling channels often include multiple flow paths that are designed to maintain all aspects of the turbine blade at a relatively uniform temperature. However, centrifugal forces and air flow at boundary layers often prevent some areas of the turbine blade from being adequately cooled, which results in the formation of localized hot spots. Localized hot spots, depending on their location, can reduce the useful life of a turbine blade and can damage a turbine blade to an extent necessitating replacement of the blade.

SUMMARY OF THE INVENTION

[0005] A turbine blade having a squealer tip coupled to a radially outer end of the turbine blade that is usable in a gas turbine engine is disclosed. The squealer tip may be configured such that the squealer tip requires less cooling fluids than conventional squealer tips, therefore increasing the efficiency of the turbine engine in which the squealer tip is used. In at least one embodiment, the squealer tip may use about 1.5 percent less cooling fluids than conventional turbine blades. In addition, the squealer tip may also be configured to be used in turbine engines that are designed to operate at higher operating temperatures than conventional turbine engines. The squealer tip may be formed from a material that is different than the material forming the turbine blade.

[0006] The turbine blade may be formed from a generally elongated blade having a leading edge, a trailing edge, a tip wall at a first end, a root coupled to the blade at an end generally opposite the first end for supporting the blade and for coupling the blade to a disc, and at least one cavity forming a cooling system in the blade. The squealer tip may be coupled to the tip at the first end. The squealer tip may be formed from a material selected from the group consisting of oxide dispersion strengthened alloys and FeCrAl alloys. The oxide dispersion strengthened alloys may include, but are not limited to, PM2000 and ODM 751, and the FeCrAl alloy may include, but are not limited to, APMT.

[0007] The squealer tip may be formed from a plurality of segmented tips extending radially outward and spaced apart from each other to relieve thermal stress at the tip. To relieve thermal stress in the squealer tip, the squealer tip may be formed from two rails extending radially outward and spaced apart from each other. The two rails may be formed from outer and inner rails that each form a continuous ring.

[0008] The squealer tip may be attached to the tip using a joining method such as transient liquid phase bonding. Alternatively, the squealer tip may be attached to the tip with an additive manufacturing process. The additive manufacturing process may be a selective laser melting process or a direct metal laser sintering process.

[0009] An advantage of this invention is that the squealer tip may enable turbine blade tips to be exposed to higher temperatures without an increased risk of failure.

[0010] Another advantage of this invention is that the squealer tip may be made with materials that would reduce cooling requirements at the tip and improve blade clearance while increasing the operating efficiency of the turbine engine by about ½ percent.

[0011] Yet another advantage of this invention is that the squealer tip may be formed from segmented tips to alleviate thermal stress in the squealer tip.

[0012] These and other embodiments are described in more detail below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The accompanying drawings, which are incorporated in and form a part of the specification, illustrate embodiments of the presently disclosed invention and, together with the description, disclose the principles of the invention.

[0014] FIG. **1** is a perspective view of a turbine blade having features according to the instant invention.

[0015] FIG. **2** is top view of the turbine blade.

[0016] FIG. **3** is a detailed, side view of a squealer tip.

[0017] FIG. **4** is a partial side of a squealer tip being formed in a mechanical attachment system.

[0018] FIG. **5** is a partial side view of a squealer tip attached to a tip of the turbine blade.

DETAILED DESCRIPTION OF THE INVENTION

[0019] As shown in FIGS. **1-5**, this invention is directed to a turbine blade **10** having a squealer tip **12** for use in turbine engines. The squealer tip **12** may be configured such that the squealer tip **12** requires less cooling fluids than conventional squealer tips, thereby increasing the efficiency of the turbine engine in which the squealer tip **12** is used. In at least one embodiment, the squealer tip **12** may use about 1.5 percent less cooling fluids than conventional turbine blades. In addition, the squealer tip **12** may also be configured to be used in turbine engines that are designed to operate at higher operating temperatures than conventional turbine engines without an increased risk of failure.

[0020] The squealer tip **12** may be attached to a radially outward tip **14** of a turbine blade **10**. The turbine blade **10** may be formed from a generally elongated airfoil **16** having a leading edge **18**, a trailing edge **20**, the tip **14** at a first end **24**, a root **26** coupled to the blade **10** at an end **28** generally opposite the first end **24** for supporting the blade **10** and for coupling the blade **10** to a disc, and one or more cavities forming a cooling system in the blade **10**. The cooling system may have any appropriate configuration within internal aspects of the elongated blade **16**.

[0021] The squealer tip **12** may be coupled to the tip **14** at the first end **24**. The squealer tip **12** may be formed from a material having high temperature oxidation and corrosion properties. The squealer tip **12** may be formed from materials that are different from the turbine blade **10**. The material may be, but is not limited to, an oxide dispersion strengthened alloy, such as, but not limited to, PM2000 and ODM 751. The material may also be an advanced dispersion strengthened powder metallurgy FeCrAl alloy, such as, but not limited to Kanthal APMT. These materials are capable of withstanding temperatures in excess of 1200 degrees Celsius in an uncoated condition.

[0022] The squealer tip **12** may be configured such that the squealer tip **12** is formed from a plurality of segmented tips **32** extending radially outward and spaced apart from each other, as shown FIG. **3**. The tips **32** may include channels **34** between each adjacent tip **32**. The segments tips **32** may be aligned with each other or otherwise positioned. The channels **34** may extend any appropriate depth into the squealer tip **12** but not completely through the squealer tip **12** and into the tip **14** of the turbine blade **10**. The channels **34** may be square, rectangular, or have any other appropriate cross-sectional configuration.

[0023] In one embodiment, as shown in FIG. **2**, the squealer tip **12** may be formed from two rails **36**, **38** extending radially outward and spaced apart from each other. The rails **36**, **38** may be formed from inner and outer rails **36**, **38** that each form a continuous ring.

[0024] The squealer tip **12** may be formed using powder manufacturing systems that enable easy buildup of different structures on the tip **14** of the turbine blade **10**. The squealer tip **12** may be manufactured using an additive manufacturing technique such as selective laser melting (SLM), direct metal laser sintering (DMLS) or via the attachment of a preform by techniques such as transient liquid phase (TLP) bonding. Such a system enables multiple rails, such as rails **36**, **38**, to be formed, which may have increased efficiencies. In particular, these manufacturing systems enable the formation of the inner and outer rails **36**, **38** that follow the exterior shape of the turbine blades **10**.

[0025] As shown in FIGS. **4** and **5**, the squealer tip **12** may be attached to the tip **14** via a mechanical attachment system **36**. The mechanical attachment system **36** may be any cavity having a ledge under which the squealer tip **12** may be attached. As shown in FIG. **4**, a powder may be placed in a cavity and sintered therein to build the squealer tip **12**. As shown in FIG. **5**, the squealer tip **12** may extend radially outward from the tip **14**. The mechanical attachment system **36** may be a dovetail attachment system **38**, as shown in FIG. **5**.

[0026] The foregoing is provided for purposes of illustrating, explaining, and describing embodiments of this invention. Modifications and adaptations to these embodiments will be apparent to those skilled in the art and may be made without departing from the scope or spirit of this invention.

I claim:

1. A turbine blade, comprising:

a generally elongated airfoil having a leading edge, a trailing edge, a tip at a first end, a root coupled to the airfoil at an end generally opposite the first end for supporting the airfoil and for coupling the blade to a disc, and at least one cavity forming a cooling system in the blade; and

a squealer tip coupled to the tip at the first end, wherein the squealer tip is formed from a material selected from the group consisting of oxide dispersion strengthened alloys and FeCrAl alloys.

2. The turbine blade of claim **1**, wherein the oxide dispersion strengthened alloys comprise PM2000 and ODM 751.

3. The turbine blade of claim **1**, wherein the FeCrAl alloys comprise APMT.

4. The turbine blade of claim **1**, wherein the squealer tip is comprised of a plurality of segmented tips extending radially outward and spaced apart from each other.

5. The turbine blade of claim **1**, wherein the squealer tip is comprised of two rails extending radially outward and spaced apart from each other.

6. The turbine blade of claim **5**, wherein the two rails are formed from outer and inner rails that each form a continuous ring.

7. The turbine blade of claim **1**, wherein the squealer tip is attached to the tip with a transient liquid phase bond.

8. The turbine blade of claim **1**, wherein the squealer tip is attached to the tip with an additive manufacturing process.

9. The turbine blade of claim **8**, wherein the additive manufacturing process is a selective laser melting process.

10. The turbine blade of claim **8**, wherein the additive manufacturing process is a direct metal laser sintering.

11. The turbine blade of claim **1**, wherein the squealer tip is attached to the tip with a mechanical attachment system.

12. The turbine blade of claim **11**, wherein the mechanical attachment system is a dovetail attachment system.

13. A turbine blade, comprising:

a generally elongated blade having a leading edge, a trailing edge, a tip at a first end, a root coupled to the airfoil at an end generally opposite the first end for supporting the airfoil and for coupling the blade to a disc, and at least one cavity forming a cooling system in the blade; and

a squealer tip coupled to the tip at the first end, wherein the squealer tip is formed from two rails extending radially outward and spaced apart from each other.

14. The turbine blade of claim **13**, wherein the two rails are formed from outer and inner rails that each form a continuous ring.

15. The turbine blade of claim **13**, wherein the squealer tip is formed from a material selected from the group consisting of oxide dispersion strengthened alloys PM2000 and ODM 751 and FeCrAl alloys of APMT.

16. The turbine blade of claim **13**, wherein the squealer tip is attached to the tip with a transient liquid phase bond.

17. The turbine blade of claim **13**, wherein the squealer tip is attached to the tip with an additive manufacturing process selected from the group consisting of a selective laser melting process and a direct metal laser sintering.

18. The turbine blade of claim **13**, wherein the squealer tip is attached to the tip with a mechanical attachment system.

19. A turbine blade, comprising:

a generally elongated blade having a leading edge, a trailing edge, a tip at a first end, a root coupled to the blade at an end generally opposite the first end for supporting the blade and for coupling the blade to a disc, and at least one cavity forming a cooling system in the blade; and

a squealer tip coupled to the tip at the first end, wherein the squealer tip is formed from a material selected from the group consisting of oxide dispersion strengthened alloys and FeCrAl alloys;

wherein the squealer tip is attached to the tip with a transient liquid phase bond.

20. The turbine blade of claim **19**, wherein the oxide dispersion strengthened alloys comprise PM2000 and ODM 751, and the FeCrAl alloy comprises APMT.

21. The turbine blade of claim **19**, wherein the squealer tip is comprised of a plurality of segmented tips extending radially outward and spaced apart from each other.

* * * * *