



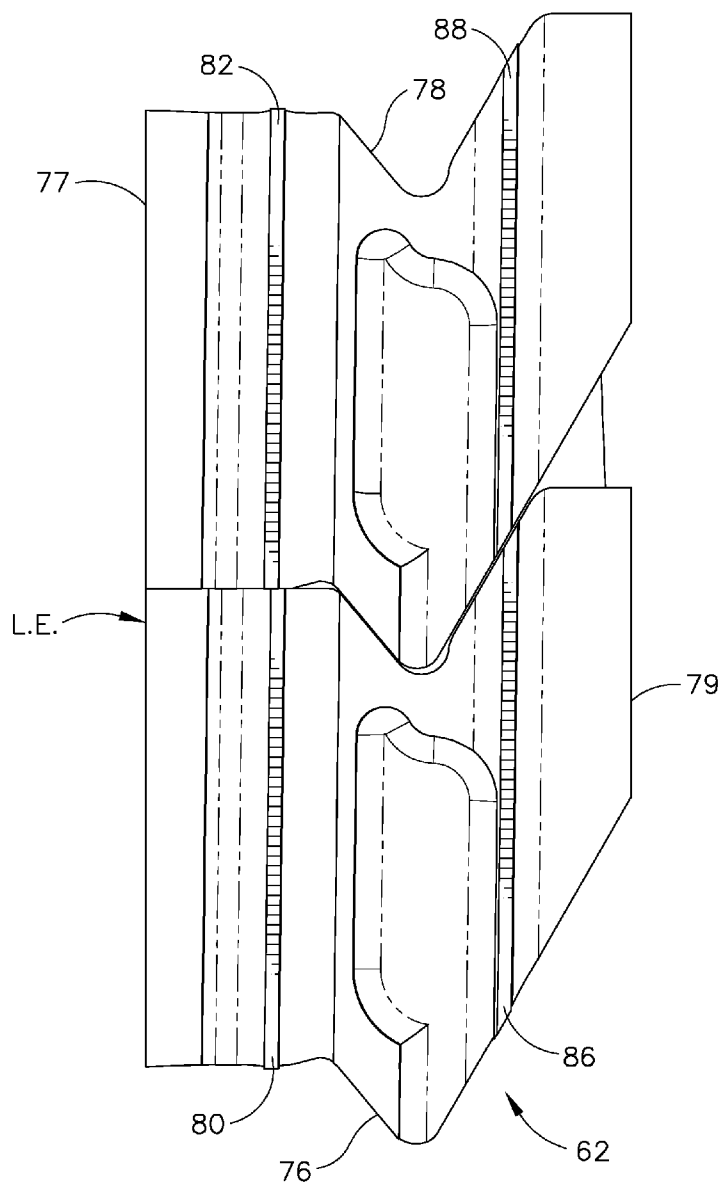
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Erdmann et al.(10) **Pub. No.: US 2009/0097979 A1**(43) **Pub. Date: Apr. 16, 2009**(54) **ROTOR BLADE**(22) Filed: **Jul. 31, 2007**(76) Inventors: **Omer Duane Erdmann,**
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CINCINNATI, OH 45215 (US)(21) Appl. No.: **11/831,078**(57) **ABSTRACT**

A rotor blade may include a tip shroud having at least one seal tooth disposed at an angle that may be relative to the engine centerline when in an assembled condition, the leading edge of the tip shroud and/or the trailing edge of the tip shroud.



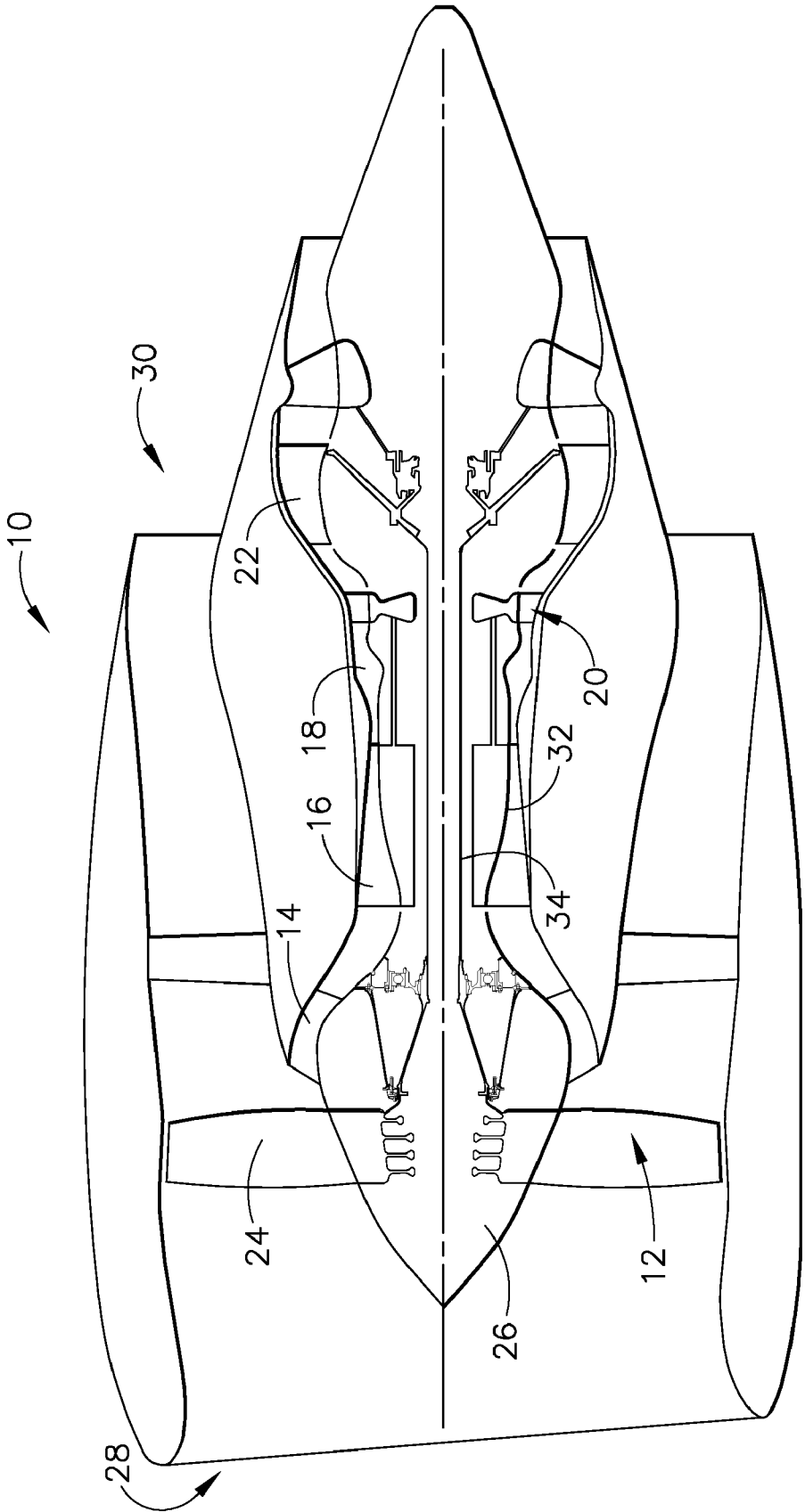


FIG. 1

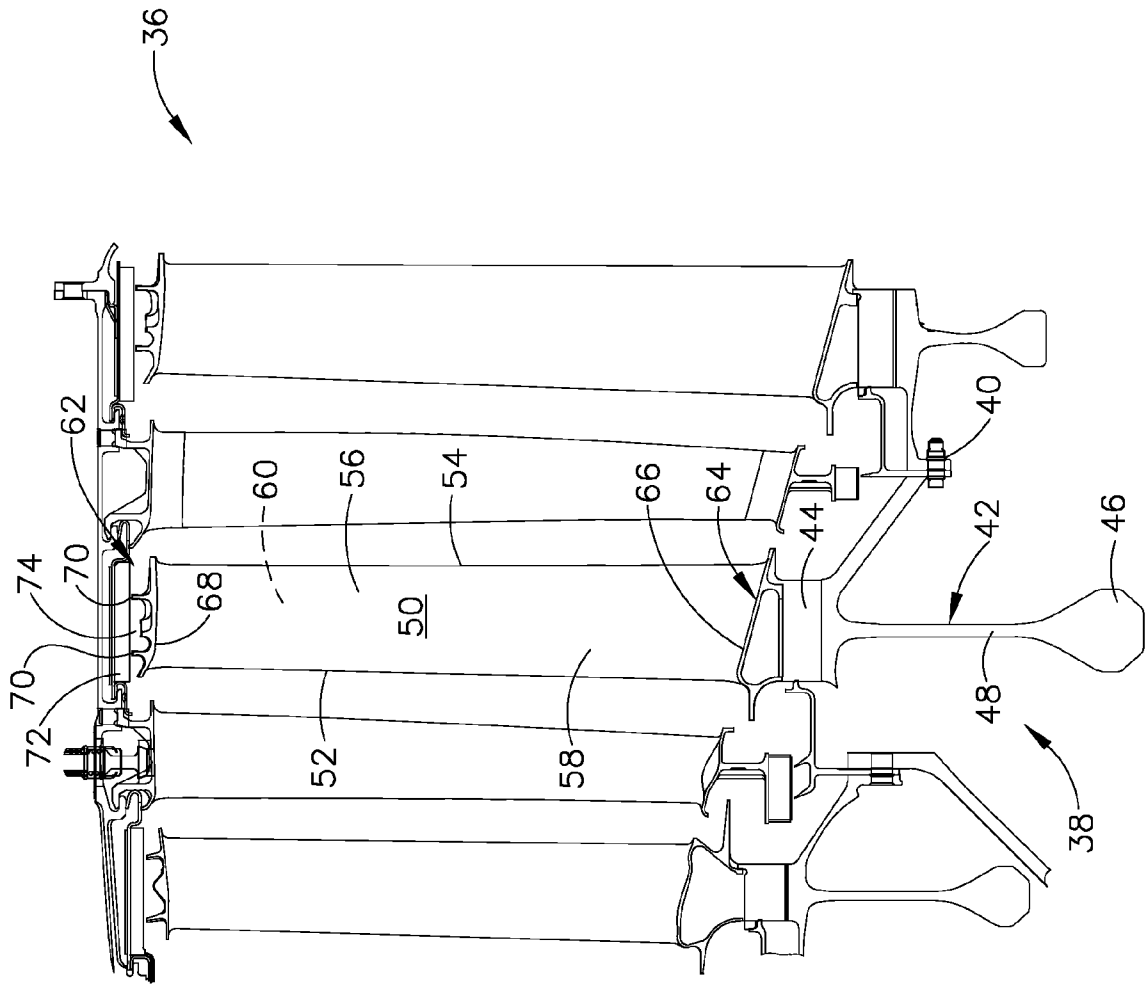


FIG. 2

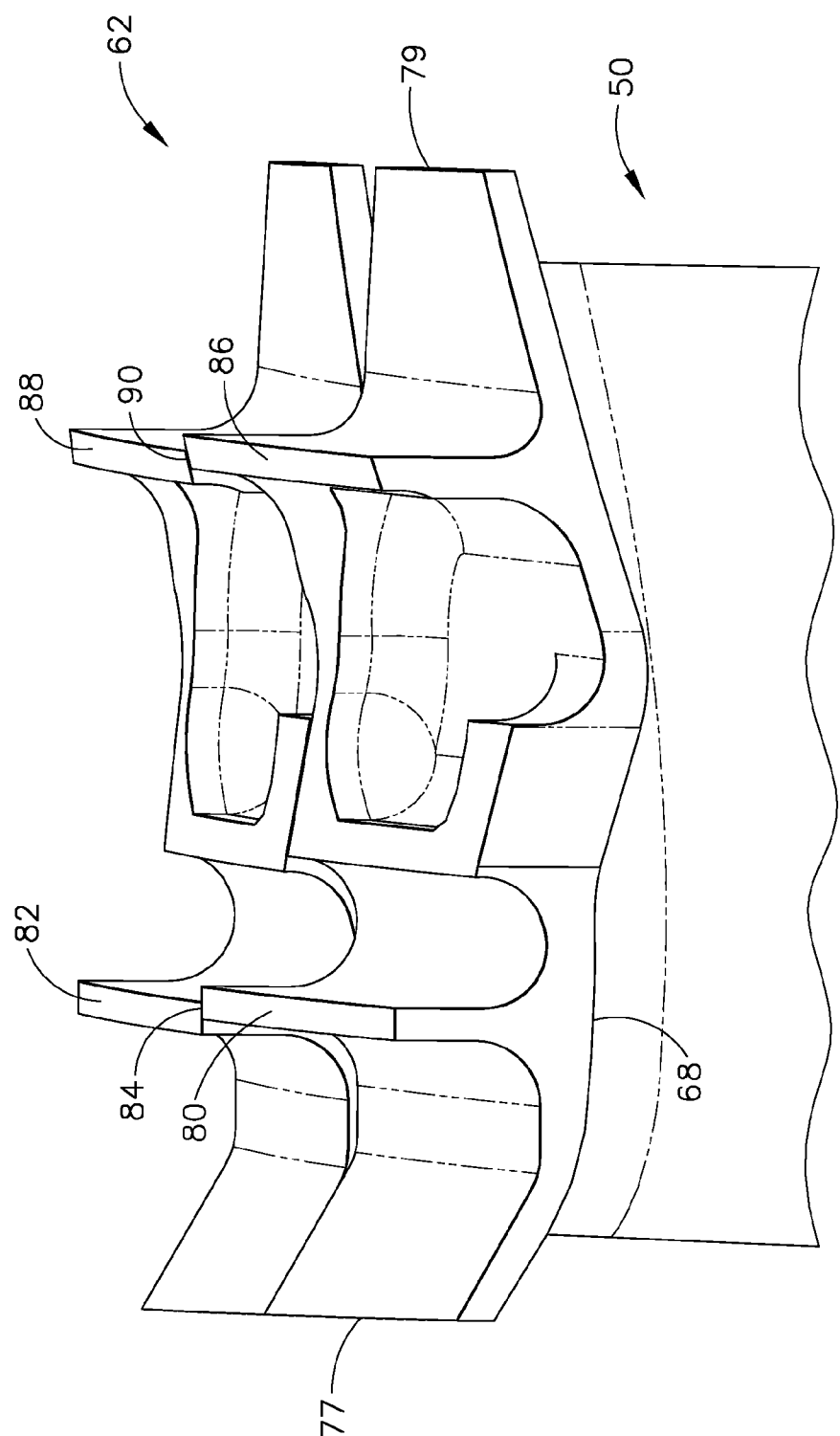


FIG. 3

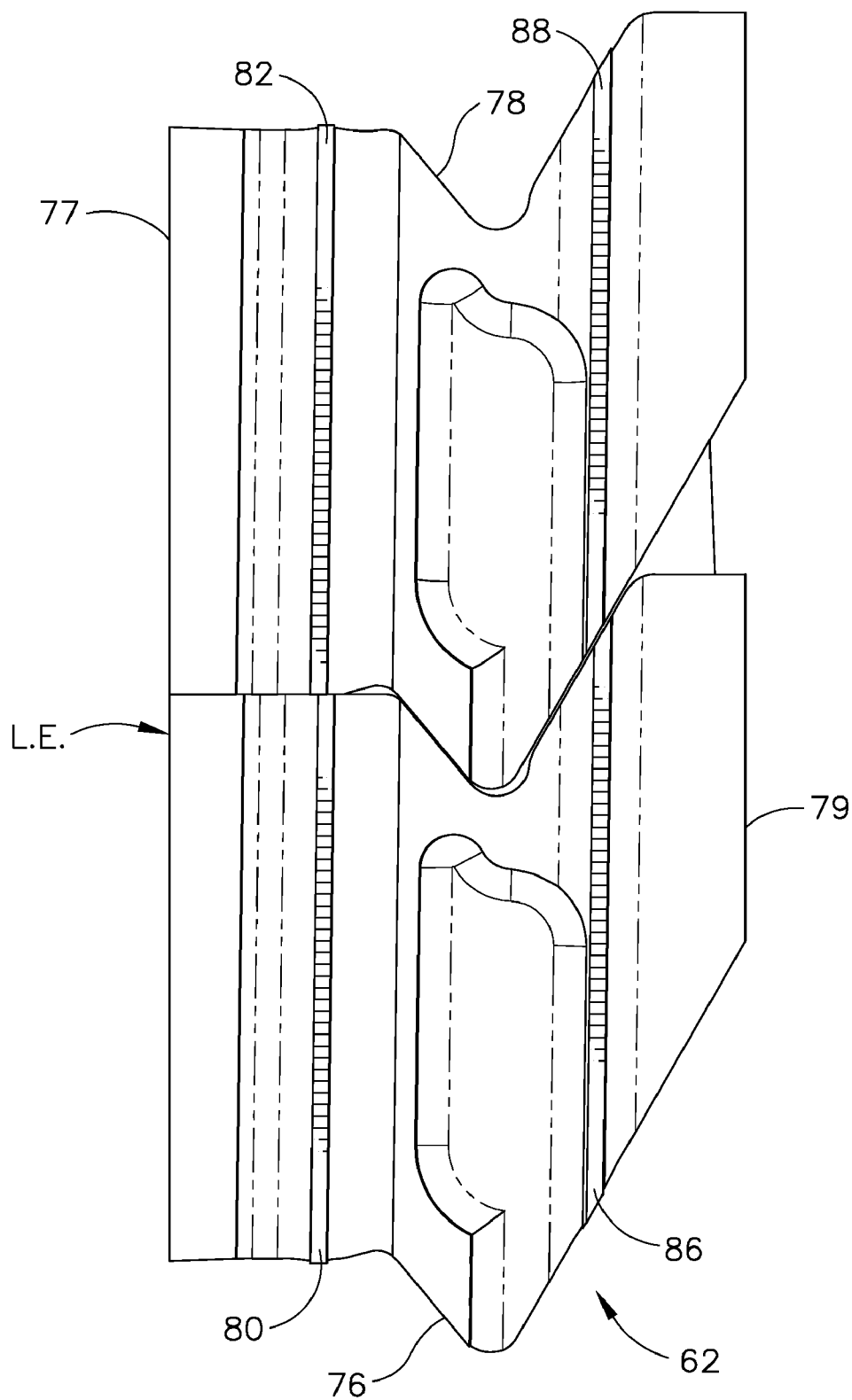


FIG. 4

ROTOR BLADE

BACKGROUND OF THE INVENTION

[0001] The exemplary embodiments relate generally to gas turbine engine components and more specifically to rotor blades having tip shrouds.

[0002] Gas turbine engines typically include a compressor, a combustor, and at least one turbine. The compressor may compress air, which may be mixed with fuel and channeled to the combustor. The mixture may then be ignited for generating hot combustion gases, and the combustion gases may be channeled to the turbine. The turbine may extract energy from the combustion gases for powering the compressor, as well as producing useful work to propel an aircraft in flight or to power a load, such as an electrical generator.

[0003] The turbine may include a rotor assembly and a stator assembly. The rotor assembly may include a plurality of rotor blades extending radially outward from a disk. Each rotor blade may include an airfoil, which may extend between a platform and a tip. Each rotor blade may also include a root that may extend below the platform and be received in a corresponding slot in the disk. Alternatively, the disk may be a blisk or bladed disk, which may alleviate the need for a root and the airfoil may extend directly from the disk. A combustion gas flowpath through the rotor assembly may be bound radially inward by the rotor blade platforms, and radially outward by a plurality of tip shrouds, wherein each tip shroud may include at least one seal tooth.

[0004] Typically, the at least one seal tooth may cooperate with a radially adjacent honeycomb to seal the flowpath. The at least one seal tooth may have at least one portion that is larger in cross section than the rest of the seal tooth. During forward motion of the blade relative to the honeycomb, this larger portion may engage with the honeycomb prior to the remainder of the seal tooth, and cut a wear track into the honeycomb. This may require the seal tooth to be non-axisymmetric.

[0005] Rotor blades can be made from a variety of materials. Some of these materials may allow the non-axisymmetric seal tooth to be cast into the final shape with little if any necessary machining. Other lower weight, lower cost or longer life materials, however, do not have the capability to be cast to a final shape and need to be machined. Machining of non-axisymmetric features with these materials can be time consuming and cause wasted material leading to longer production cycles.

BRIEF DESCRIPTION OF THE INVENTION

[0006] One exemplary embodiment may be directed to a rotor blade having a tip shroud having at least one seal tooth disposed at an angle relative to an engine centerline when in an assembled condition. In another exemplary embodiment, the seal tooth may be disposed at an angle relative to the leading and/or trailing edge.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. 1 is a cross-sectional schematic view of an exemplary gas turbine engine.

[0008] FIG. 2 is a partial cut-away cross-sectional view of an exemplary turbine assembly that may be used with a gas turbine engine, such as the gas turbine engine shown in FIG. 1.

[0009] FIG. 3 is a perspective view of a portion of an exemplary rotor blade that may be used with a gas turbine engine, such as the gas turbine engine shown in FIG. 1.

[0010] FIG. 4 is a top plan view of the rotor blade shown in FIG. 3.

DETAILED DESCRIPTION OF THE INVENTION

[0011] FIG. 1 is a schematic illustration of an exemplary gas turbine engine 10 including a fan assembly 12, a booster 14, a high pressure compressor 16, and a combustor 18. The engine 10 also includes a high pressure turbine 20, and a low pressure turbine 22. The fan assembly 12 includes an array of fan blades 24 extending radially outward from a rotor disk 26. The engine 10 has an intake side 28 and an exhaust side 30. The engine 10 may be any gas turbine engine. For example, the engine 10 may be, but is not limited to being, a GE90 gas turbine engine available from General Electric Company, Cincinnati, Ohio. The fan assembly 12, booster 14, and turbine 22 may be coupled by a first rotor shaft 32, and the compressor 16 and turbine 20 may be coupled by a second rotor shaft 34.

[0012] In operation, air flows through the fan assembly 12 and compressed air is supplied to the high pressure compressor 16 through the booster 14. The highly compressed air is delivered to the combustor 18, where it is mixed with a fuel and ignited to generate combustion gases. The combustion gases are channeled from the combustor 18 to drive the turbines 20 and 22. The turbine 22 drives the fan assembly 12 and booster 14 by way of shaft 32. The turbine 20 drives the compressor 16 by way of shaft 34.

[0013] FIG. 2 is a partial cut-away cross-sectional view of an exemplary rotating assembly that may be used with a gas turbine engine, such as, but not limited to, the gas turbine engine 10 (shown in FIG. 1). In the exemplary embodiment, the rotor assembly 36 may be a turbine, such as, but not limited to, the low pressure turbine 20 (shown in FIG. 1). However, the exemplary embodiments described and/or illustrated herein may be used with any rotor assembly. Rotor assembly 36 includes a plurality of rotors 38 joined together by couplings 40 about an axial centerline axis (not shown). Each rotor 38 includes a rotor disk 42 including an annular radially outer rim 44, a radially inner hub 46, and an integral web 48 extending radially therebetween. Each rotor 38 also includes a plurality of blades 50 extending radially outwardly from the outer rim 44. One or more blades 50, of one or more rotors 40, may be integrally joined with respective rims 44. Moreover, one or more blades 50 of one or more rotors 40 may be removably joined to the respective rim 44 in a known manner using blade dovetails (not shown) which mount in complementary slots (not shown) in the respective rim 44.

[0014] Rotor blades 50 each include a leading edge 52, a trailing edge 54, and an airfoil 56 extending therebetween. Each airfoil 56 includes a suction side 58 and a circumferentially opposite pressure side 60. Suction and pressure sides 58 and 60, respectively, extend between axially spaced apart leading and trailing edges 52 and 54, respectively, and extend in radial span between a rotor blade tip shroud 62 and a rotor blade platform 64. A blade chord is measured between rotor blade leading and trailing edges 52 and 54, respectively. The radially outer surfaces 66 of the platforms 64 define a radially inner flowpath surface of rotor assembly 36 and the radially inner surfaces 68 of the blade tip shrouds 62 define a radially outer flowpath surface of rotor assembly 36.

[0015] FIG. 3 is a perspective view of a portion of an exemplary rotor blade that may be used with a gas turbine engine, such as the gas turbine engine shown in FIG. 1. FIG. 4 is a top plan view of the rotor blade shown in FIG. 3. In one exemplary embodiment, the rotor blades 50 may include one or more seal teeth 70, which may be adjacent to and interact with a stator shroud 72. The one or more seal teeth 70 may be disposed within a cavity 74 defined by stator shroud 72 and rotor blade tip shroud 62. The seal teeth 70 may cooperate with a radially adjacent honeycomb on the stator shroud 72 to seal the flowpath. The honeycomb may be disposed on the radially lower surface of the stator shroud 72. Although each blade tip shroud 62 is illustrated in FIGS. 2-4 as including two seal teeth 70 that each extend across an entire circumferential width of shroud 62 (shown in FIG. 3), it should be noted that each tip shroud 62 may include any number of seal teeth 70 that may each extend across any portion of the circumferential width of shroud 62. Moreover, each tip shroud 62 may also include a pair of opposite interlock surfaces 76 and 78 that facilitate interlocking shrouds 62 of adjacent rotor blades 50 within a rotor 40. Each tip shroud 62 may include a leading edge 77 and a trailing edge 79.

[0016] As shown in FIGS. 3 and 4, the tip shroud 62 may include one or more seal teeth, such as seal tooth 80. The seal tooth 80 may be disposed at an angle such that a seal tooth 82 of an adjacent blade is offset from the seal tooth 80, thus creating a 'saw tooth' pattern at the blade-to-blade interface 84. The angle may be any angle so long as the seal tooth is not perpendicular to the engine centerline when in an assembled condition. The seal tooth may also be disposed at an angle relative to the leading edge 77 and/or trailing edge 79 of the tip shroud 80. The offset allows the seal tooth 80 to have an 'effective' enlarged portion at the interface 84 so that the seal tooth 80 may appropriately cut into the honeycomb without having additional material. The offset may also allow the seal tooth 80 to be axisymmetric, which may be beneficial for manufacturing. The angle of the seal teeth 80 and 82 can be any appropriate angle such that one seal tooth is offset as to the adjacent seal tooth. In one exemplary embodiment, the seal tooth 80 and the seal tooth 82 may overlap at the interface 84. In one exemplary embodiment, the tip shroud 62 may have an additional seal tooth 86. Similar to seal tooth 80, seal tooth 86 may be disposed at an angle such that a seal tooth 88 of an adjacent blade is offset from the seal tooth 86, thus creating the saw tooth pattern at the blade-to-blade interface 90. The angle of seal teeth 86 and 88 may be any appropriate angle such that one seal tooth is offset as to the adjacent seal tooth. In one exemplary embodiment, seal teeth 80 and 82 may have the same angle as seal teeth 86 and 88, thus being parallel to each other. In another exemplary embodiment, seal teeth 80 and 82 may have an angle different from the angle of seal teeth 86 and 88.

[0017] The rotor blades and/or tip shrouds may be made of any material known in the art. In one exemplary embodiment, the blades and/or tip shrouds may be made from a nickel or cobalt-based superalloy. In another exemplary embodiment, the blades and/or tip shrouds may be made from a titanium alloy, such as, but not limited to titanium aluminide. In addition, the blade, tip shroud and/or seal teeth may be coated with any coating known in the art. In one exemplary embodiment, the blade and/or tip shroud may be coated with an environmental coating. The seal teeth may be coated with an abrasive coating, such as, but not limited to, aluminum oxide.

[0018] The blades and/or tip shrouds may be formed to their final shape or they may be formed and then machined to their final shape. In the event that the outer surface of the tip shroud needs to be machined, the use of an angled seal tooth may facilitate an axisymmetric form for ease of machining, while allowing a feature to 'cut' the honeycomb. Typically, the tip shrouds may be machined on an arcuate path with the axis of rotation being the engine centerline. When the outer surface of the tip shroud is generally cylindrical (i.e. substantially parallel to the engine centerline in cross-section) then the axis of rotation of the arcuate path to create the outer surface may be the engine centerline rotated sufficiently to achieve the offset between adjacent seal teeth. If the outer surface is generally conical, the axis of rotation may need to be offset as well as angled relative to engine centerline. This may be required to ensure that the thickness at the edges of the tip shroud do not become undesirably thin or thick.

[0019] While this application has described various specific exemplary embodiments, those skilled in the art will recognize that those exemplary embodiments can be practiced with modification within the spirit and scope of the claims.

What is claimed is:

1. A rotor blade comprising:
 - a tip shroud extending from said airfoil, said tip shroud having at least one seal tooth disposed at an angle relative to an engine centerline when in an assembled condition.
2. The rotor blade of claim 1 wherein said at least one seal tooth is axisymmetric.
3. The rotor blade of claim 1 wherein said at least one seal tooth is not perpendicular to said engine centerline.
4. The rotor blade of claim 1 wherein said tip shroud further comprises:
 - a leading edge;
 - a trailing edge opposite said leading edge;
 - a first interlocking surface; and
 - a second interlocking surface.
5. The rotor blade of claim 4 wherein said tip shroud further comprises:
 - a second seal tooth disposed at an angle relative to an engine centerline when in an assembled condition.
6. The rotor blade of claim 1 wherein said tip shroud further comprises:
 - a second seal tooth disposed at an angle relative to an engine centerline when in an assembled condition.
7. The rotor blade of claim 1 wherein said rotor blade is formed of titanium aluminide.
8. A rotor blade comprising:
 - a tip shroud extending from said airfoil, said tip shroud having a leading edge, a trailing edge and at least one seal tooth, said at least one seal tooth disposed at an angle relative to the leading and/or trailing edge such that said at least one seal tooth is not parallel to said leading and/or trailing edge.
9. The rotor blade of claim 8 wherein said at least one seal tooth is axisymmetric.
10. The rotor blade of claim 8 wherein said at least one seal tooth is not perpendicular to said engine centerline.
11. The rotor blade of claim 8 wherein said tip shroud further comprises:
 - a first interlocking surface; and
 - a second interlocking surface.

12. The rotor blade of claim **11** wherein said tip shroud further comprises:

a second seal tooth disposed at an angle relative to said leading and/or trailing edge such that said a second seal tooth is not parallel to said leading and/or trailing edge.

13. The rotor blade of claim **8** wherein said tip shroud further comprises:

a second seal tooth disposed at an angle relative to said leading and/or trailing edge such that said a second seal tooth is not parallel to said leading and/or trailing edge.

14. The rotor blade of claim **8** wherein said rotor blade is formed of titanium aluminide.

15. A rotor assembly comprising:

a rotor;

a first rotor blade extending radially from said rotor having a first seal tooth;

a second rotor blade extending radially from said rotor having a second seal tooth, said first and second seal teeth arranged so that said seal teeth are offset with respect to each other.

16. The rotor assembly of claim **15** wherein said first and second seal teeth are axisymmetric.

17. The rotor assembly of claim **16** wherein said first rotor blade is adjacent to said second rotor blade.

18. The rotor assembly of claim **17** wherein said first seal tooth and said second seal tooth overlap, creating a saw tooth pattern.

19. The rotor assembly of claim **18** further comprising: said first rotor blade having a third seal tooth that is axisymmetric and parallel to said first seal tooth; and said second rotor blade having a fourth seal tooth that is axisymmetric and parallel to said second seal tooth.

20. The rotor assembly of claim **19** wherein said rotor blades are formed of titanium aluminide.

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