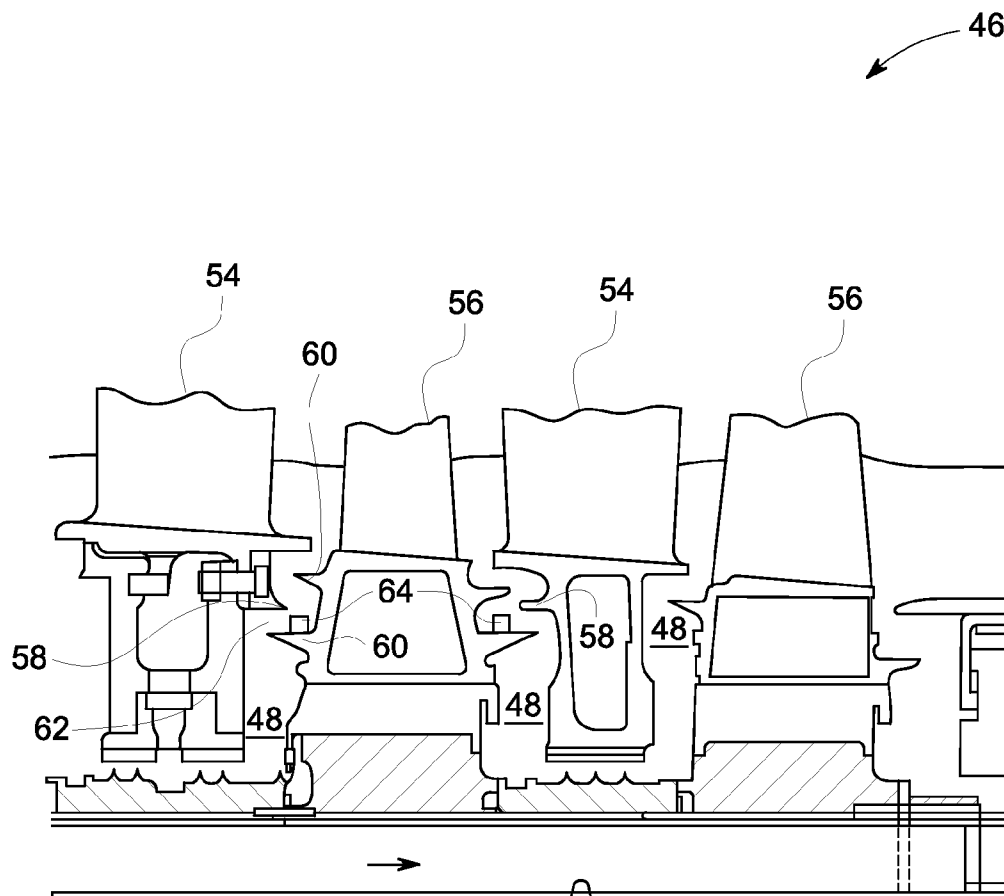




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(19) **United States**(12) **Patent Application Publication****Devi et al.**(10) **Pub. No.: US 2012/0163955 A1**(43) **Pub. Date: Jun. 28, 2012**(54) **SYSTEM AND METHOD TO ELIMINATE A
HARD RUB AND OPTIMIZE A PURGE FLOW
IN A GAS TURBINE**(52) **U.S. Cl. 415/1; 415/173.1**(75) **Inventors:** **Ravindra Gopaldas Devi,**
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(US)(21) **Appl. No.: 12/977,144**(22) **Filed: Dec. 23, 2010****Publication Classification**(51) **Int. Cl.**
F01D 11/08 (2006.01)(57) **ABSTRACT**

A system and method to eliminate hard rub and optimize a purge flow in a gas turbine is provided. The gas turbine includes a stator configured to guide a flow of an incoming gas. The gas turbine also includes a rotor configured to expand the incoming gas and extract kinetic energy from the incoming gas. The gas turbine further includes a purge flow bled from a compressor and configured to reduce a temperature of a wheel space by limiting ingestion of the incoming gas. The gas turbine also includes an angel wing disposed between the rotor and the stator and configured to act as a sealing surface between the rotor and the stator. The gas turbine further includes a fan blade disposed on a surface of the angel wing at an axial position and configured to generate a recirculation zone of the purge flow, wherein the recirculation zone is reduces a volume of successive purge flows entering the wheel space.



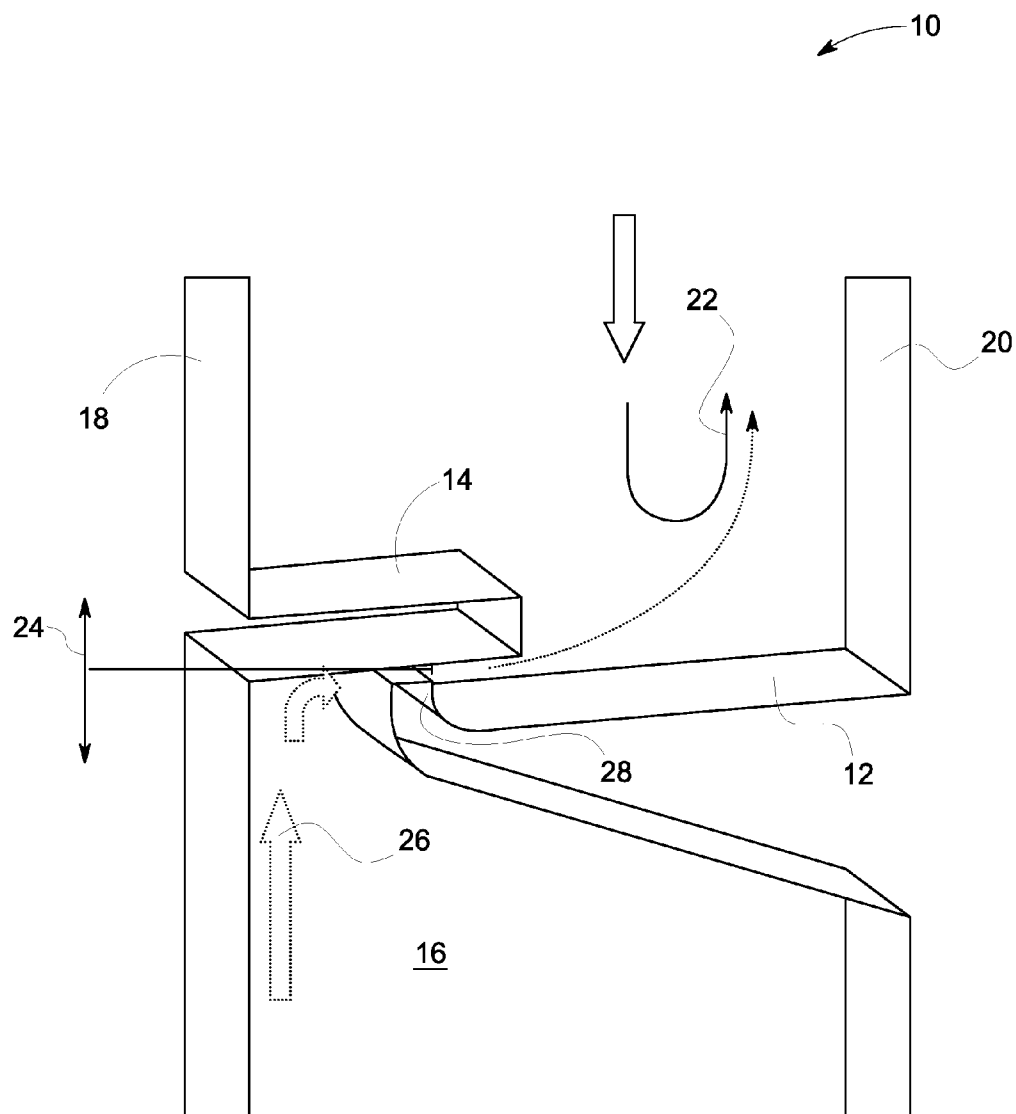


FIG. 1
(PRIOR ART)

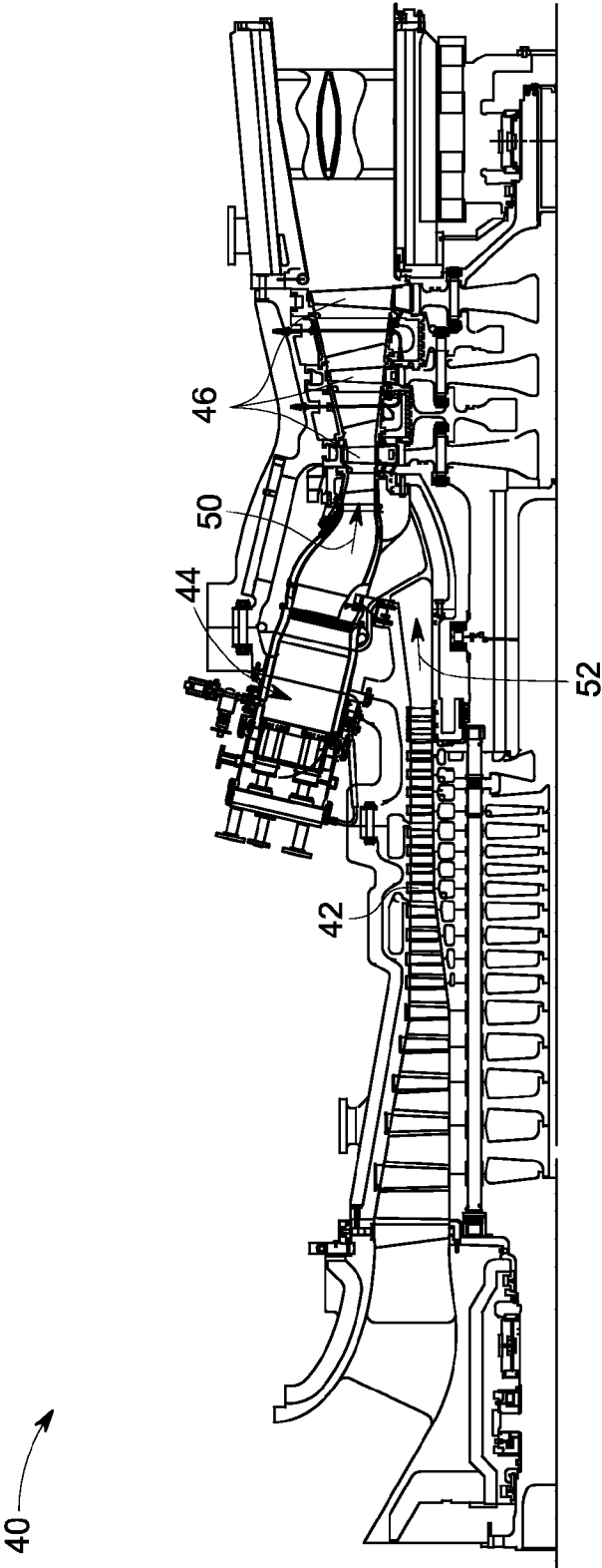


FIG. 2

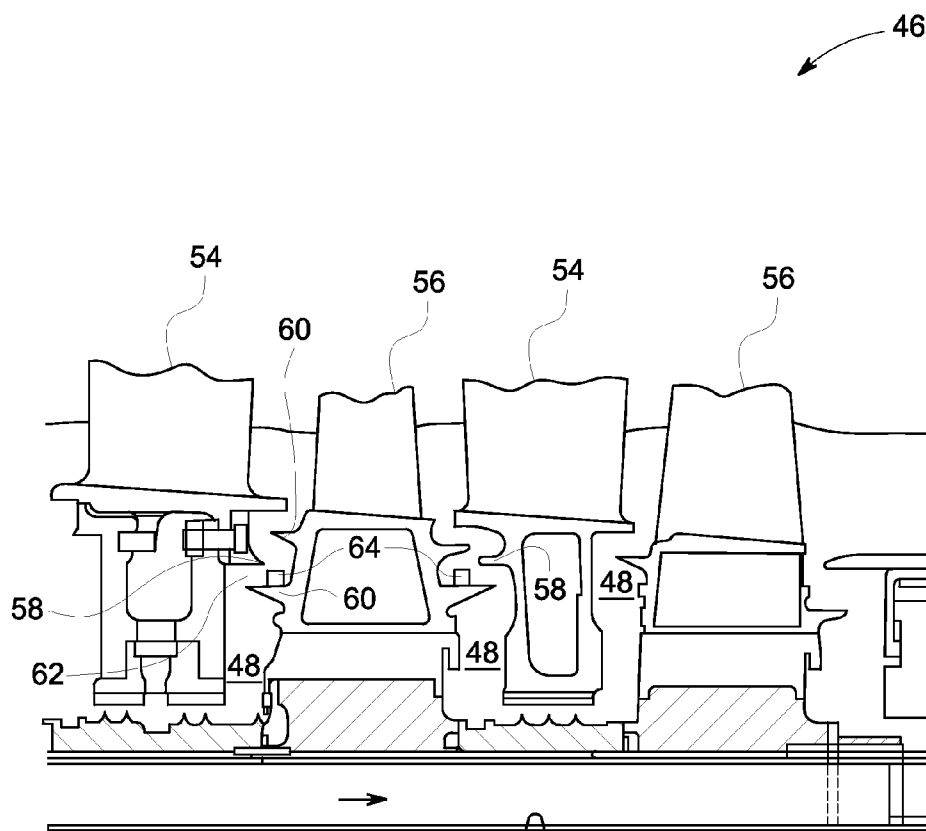


FIG. 3

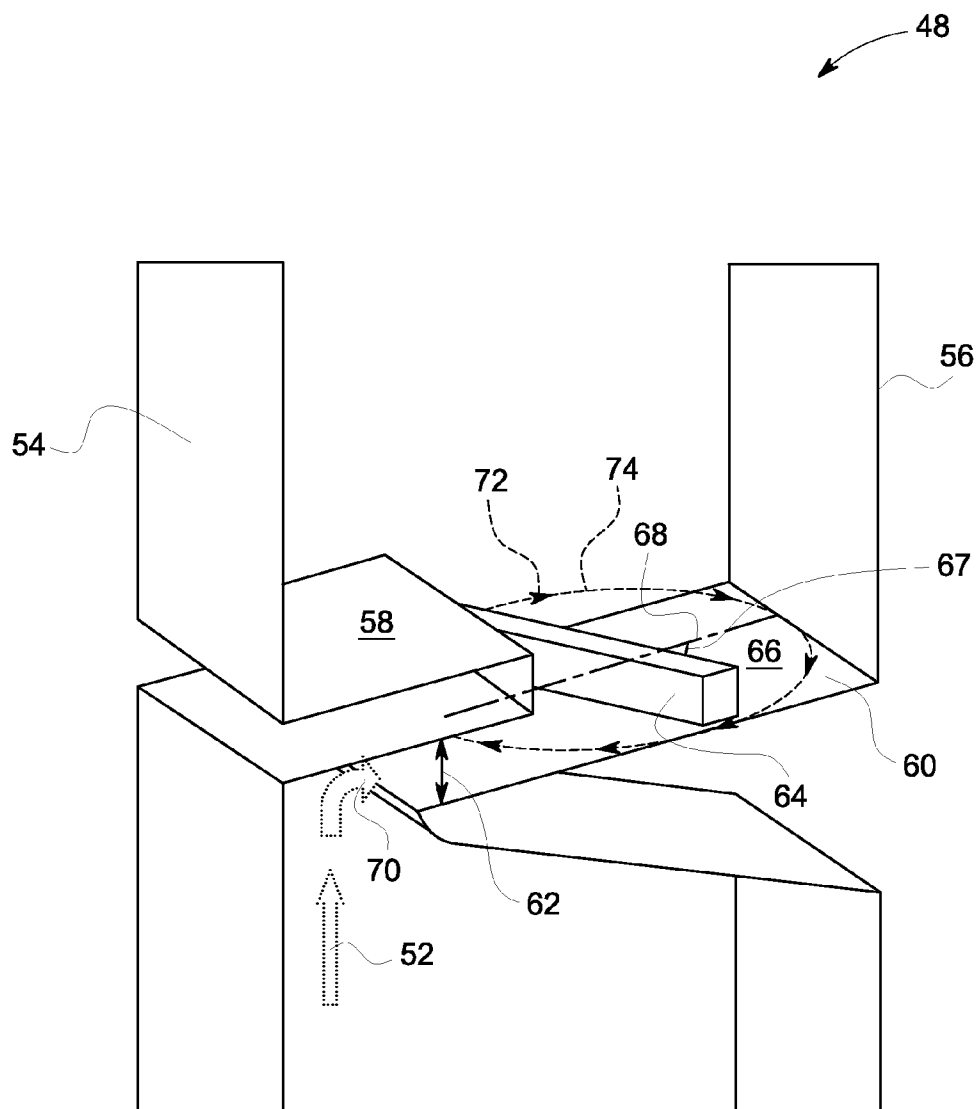


FIG. 4

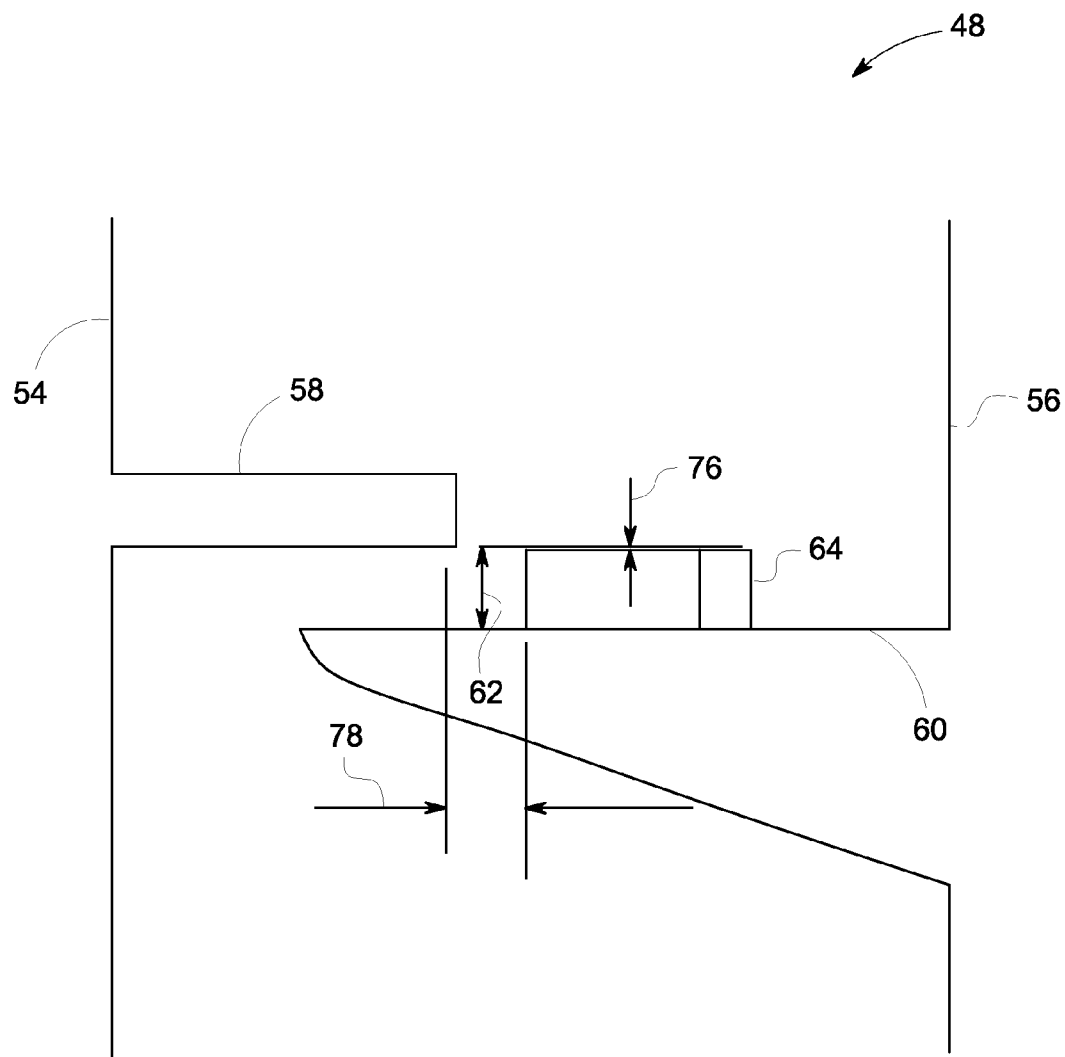


FIG. 5

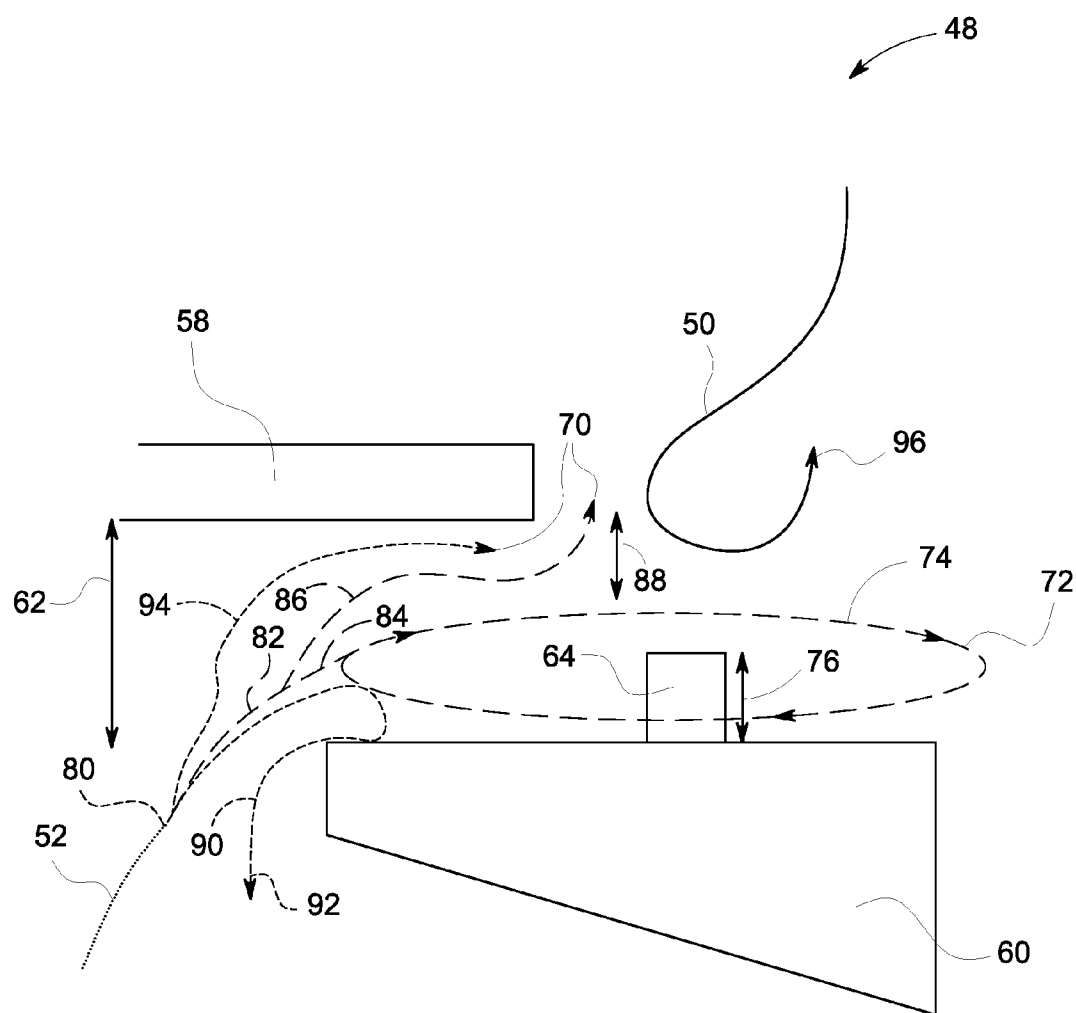


FIG. 6

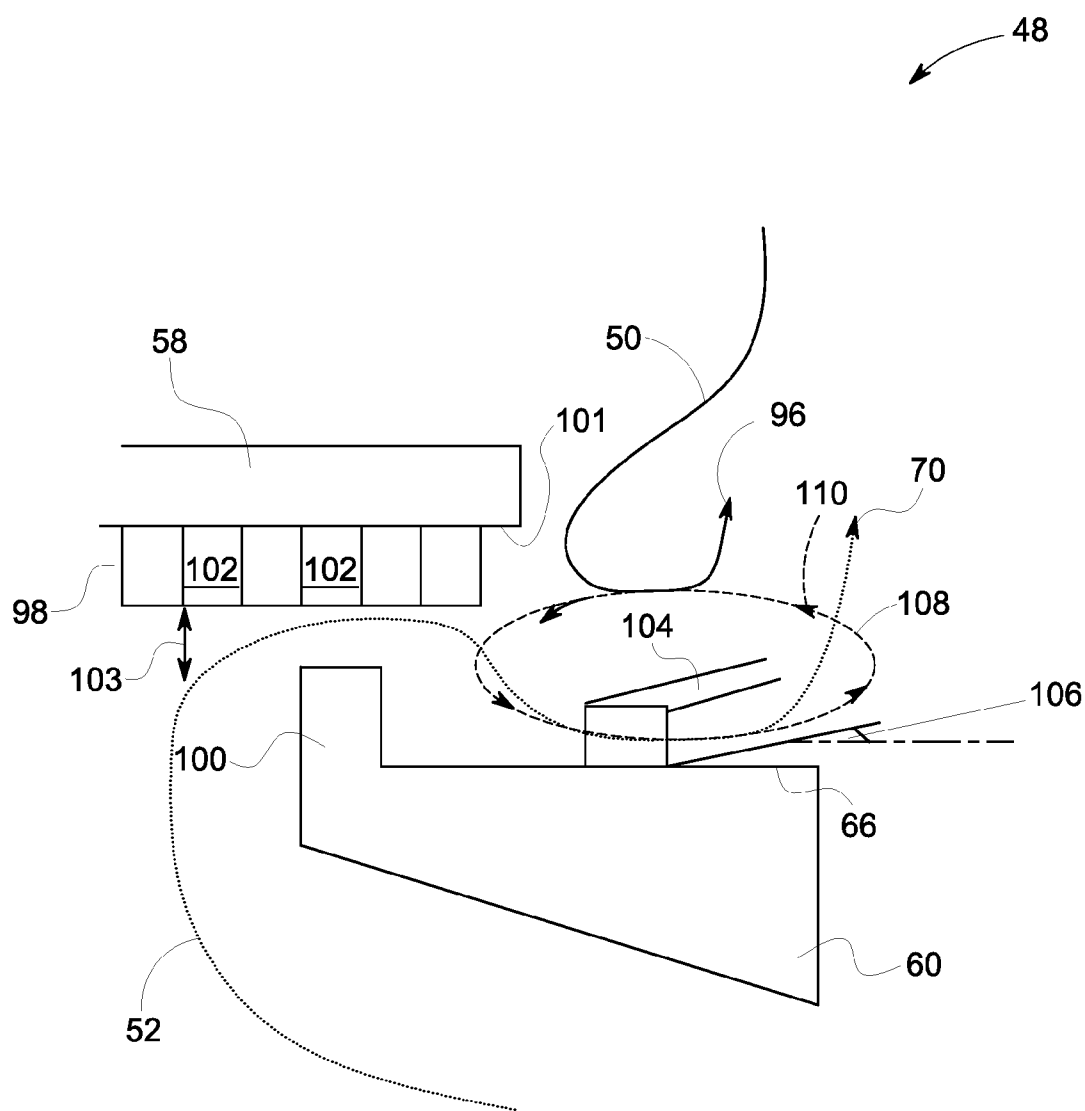


FIG. 7

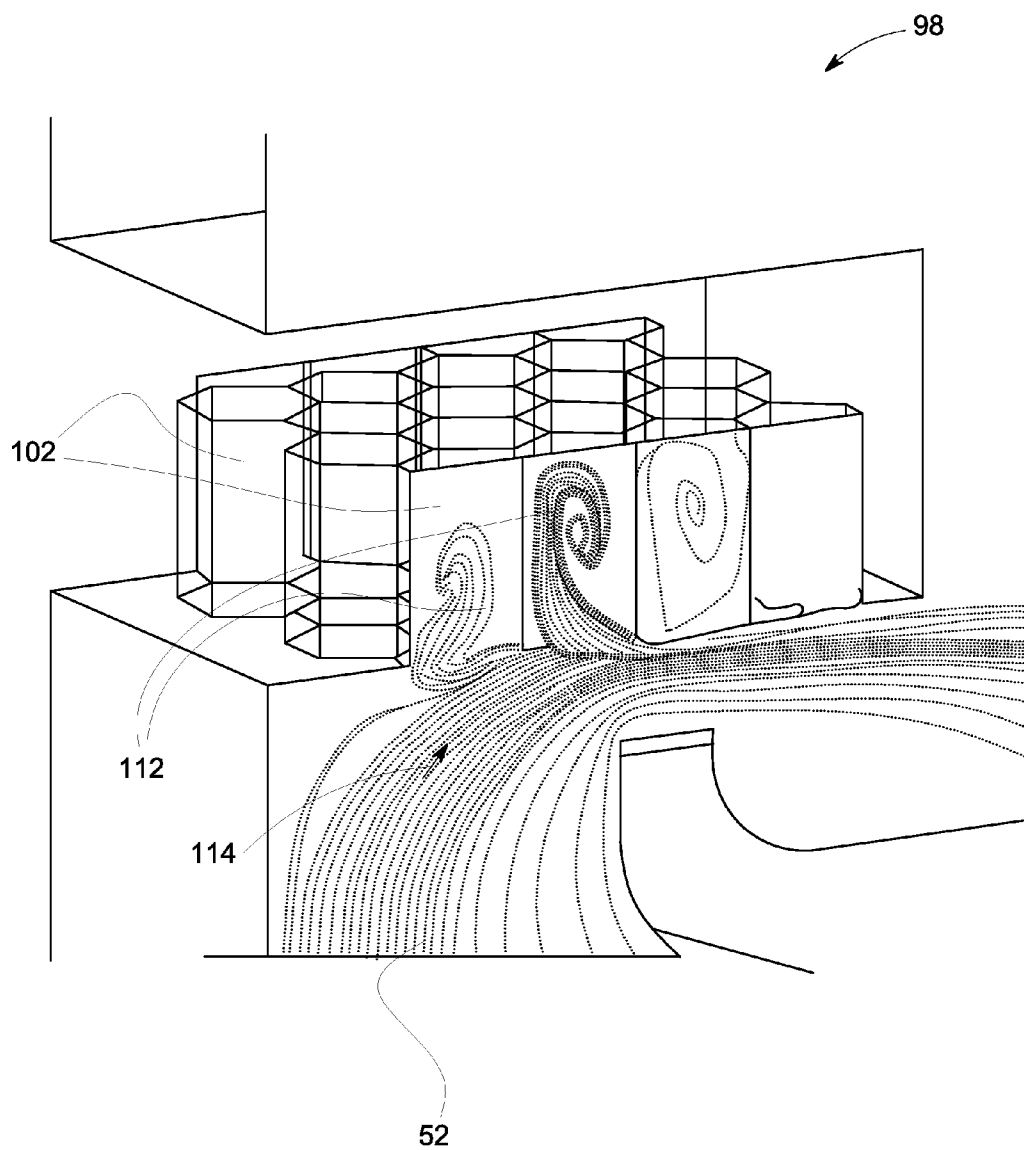


FIG. 8

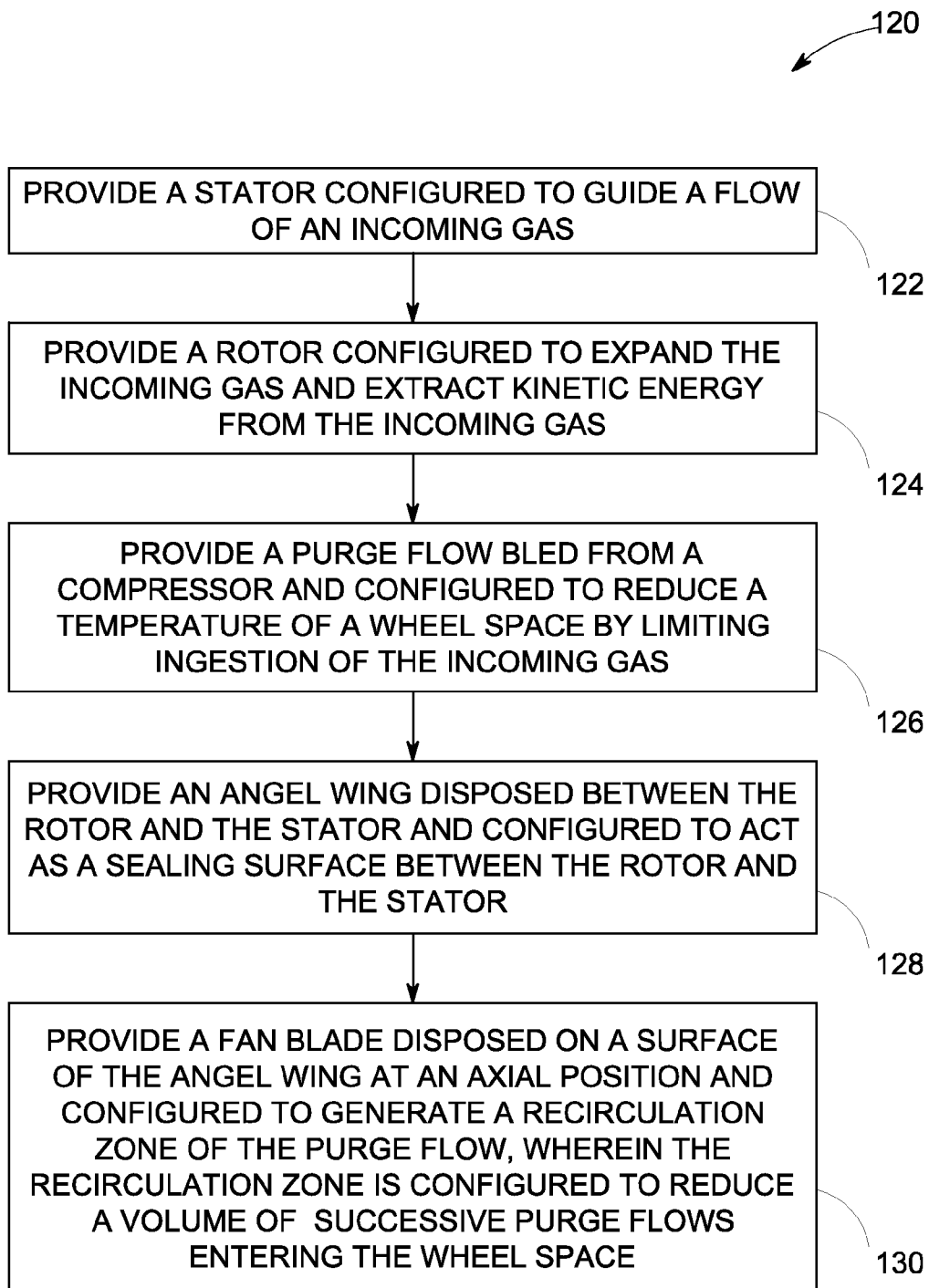


FIG. 9

SYSTEM AND METHOD TO ELIMINATE A HARD RUB AND OPTIMIZE A PURGE FLOW IN A GAS TURBINE

BACKGROUND

[0001] The invention relates generally to a gas turbine and more particularly, to a system and a method to reduce wheel space purge flow without risking a hard rub in a gas turbine.

[0002] Generally, a gas turbine typically comprises a compressor, a combustor and a turbine. The turbine further includes multiple wheel spaces wherein each of the multiple wheel spaces includes a rotor and a stator. The stator includes vanes or nozzles that guide the flow of an incoming gas to the rotor. The rotor, in an example, includes blades or buckets that extract work from the incoming gas received from the stator. During operation of the turbine, an undesired ingestion of the incoming gas into the wheel space can result in overheating of the metal components. In some embodiments, a purge flow is directed into the wheel space via a clearance area to prevent the incoming gas ingestion and associated overheating. Typically, an adequate purge flow needs to be maintained to sustain an acceptable temperature in the wheel space. However, maintaining the adequate purge flow in the wheel space, during the operation of the gas turbine, results in complexities, costs and maintenance.

[0003] In some embodiments, in order to maintain the adequate purge flow, an angel wing and a discourager are disposed on the rotor and the stator respectively in an overlapping manner. Typically, the angel wing includes a tip provided at an edge of the angel wing. The tip reduces the clearance area between the angel wing and the discourager resulting in a reduction of the purge flow to a desirable limit for maintaining an acceptable temperature within the wheel space. However, the tip of the angel wing generally generates an undesirable hard rub between the discourager and the tip during a startup of the turbine. The hard rub results in deterioration of the discourager and wear of the angel wing, leading to an increase in the clearance area that further results in an undesirable increase in the purge flow and maintenance costs.

[0004] Therefore, there is a need of an improved system that eliminates the hard rub and addresses the aforementioned issues.

BRIEF DESCRIPTION

[0005] In one embodiment a gas turbine is provided. The gas turbine includes a stator configured to guide a flow of an incoming gas. The gas turbine also includes a rotor configured to expand the incoming gas and extract kinetic energy from the incoming gas. The gas turbine further includes a purge flow bled from a compressor and configured to reduce a temperature of a wheel space by limiting ingestion of the incoming gas. The gas turbine also includes an angel wing disposed between the rotor and the stator and configured to act as a sealing surface between the rotor and the stator. The gas turbine further includes a fan blade disposed on a surface of the angel wing at an axial position and configured to generate a recirculation zone of the purge flow, wherein the recirculation zone reduces a volume of a successive purge flow entering the wheel space.

[0006] In another embodiment a method of providing a gas turbine is provided. The method includes providing a stator configured to guide a flow of an incoming gas. The method

also includes providing a rotor configured to expand the incoming gas and extract kinetic energy from the incoming gas. The method further includes providing a purge flow bled from a compressor and configured to reduce a temperature of a wheel space by limiting ingestion of the incoming gas. The method also includes providing an angel wing disposed between the rotor and the stator and configured to act as a sealing surface between the rotor and the stator. The method further includes providing a fan blade disposed on a surface of the angel wing at an axial position and configured to generate a recirculation zone of the purge flow, wherein the recirculation zone reduces a volume of a successive purge flow entering the wheel space.

DRAWINGS

[0007] These and other features, aspects, and advantages of the present invention will become better understood when the following detailed description is read with reference to the accompanying drawings in which like characters represent like parts throughout the drawings, wherein:

[0008] FIG. 1 is a schematic representation of a wheel space of a conventional turbine provided in a conventional gas turbine.

[0009] FIG. 2 is a partial schematic representation of a gas turbine including an improved design to eliminate a hard rub between an angel wing and a discourager in accordance with an embodiment of the invention.

[0010] FIG. 3 is a magnified view a wheel space of the turbine of FIG. 2 in accordance with an embodiment of the invention.

[0011] FIG. 4 is an isometric view of the discourager and the angel wing in the wheel space of FIG. 3 including a fan blade in accordance with an embodiment of the invention.

[0012] FIG. 5 is a cut section of the discourager and the angel wing in the wheel space of FIG. 4 depicting a height and an axial clearance of the fan blade in accordance with an embodiment of the invention.

[0013] FIG. 6 is a schematic illustration of a change in direction of a purge flow due to a recirculation zone in the wheel space of FIG. 4 in accordance with an embodiment of the invention.

[0014] FIG. 7 is a schematic representation of the discourager and the angel wing including a honeycomb structure and a tip respectively in the wheel space of FIG. 4 in accordance with another embodiment of the invention.

[0015] FIG. 8 is a magnified view of the honeycomb structure 98 of FIG. 7 depicting multiple cavities 102 provided by the honeycomb structure 98 in accordance with an embodiment of the invention.

[0016] FIG. 9 is a flow chart depicting the steps involved in a method for providing a gas turbine of FIG. 2 in accordance with an embodiment of the invention.

DETAILED DESCRIPTION

[0017] As discussed in detail below, embodiments of the present invention include a system and method to eliminate a hard rub and optimize a purge flow in a gas turbine. In one embodiment, the system includes an angel wing without a tip that eliminates the hard rub between the angel wing and a discourager. As referred to herein, the term 'hard rub' is defined as a rub during startup of the turbine between metal components of the angel wing tip and the discourager. Furthermore, a fan blade is disposed on the angel wing that

generates a recirculation zone of the purge flow to reduce a volume of successive purge flows entering a wheel space. As used herein, the term 'purge flow' is defined as a gas flow entering the wheel space from a clearance area to prevent overheating and to maintain an acceptable temperature in the wheel space. As referred to herein, the 'clearance area' is defined as a gap between the discourager and the angel wing. In another embodiment, the angel wing tip is retained to optimize the purge flow in the wheel space. Moreover, a honeycomb structure is disposed on the discourager in an overlapping manner above the angel wing tip to provide a soft rub as compared to the hard rub generated in conventional turbines. As used herein, the term 'soft rub' is defined as a rub during startup of the turbine between the honeycomb structure and the angel wing tip that minimizes the deterioration of the discourager and wear of the angel wing as compared to the hard rub. The embodiments of the present invention would be discussed in greater details below.

[0018] FIG. 1 is a schematic representation of a conventional turbine 10 depicting an angel wing 12 and a discourager 14 in a wheel space 16 of the turbine 10. The wheel space 16 is partially defined by a stator 18 and a rotor 20 that form a path of an incoming gas flow 22. The stator 18 guides the incoming gas flow 22 to a rotor inlet (not shown). The rotor 20 extracts work from the incoming gas flow 22 and drives the turbine 10. In an example, the incoming gas flow 22 includes a hot gas flow. Furthermore, the stator 18 and the rotor 20 include structures protruding outwardly from the stator 18 and the rotor 20 to form the discourager 14 and the angel wing 12 respectively. The discourager 14 and the angel wing 12 are disposed in an overlapping manner relative to each other such that a gap is provided between the discourager 14 and the angel wing 12. Such gap is referred to herein as a clearance area 24.

[0019] In operation, a portion of the incoming gas flow 22 attempts to flow via the clearance area 24 towards the wheel space 16 known as an ingested gas that leads to overheating of the metal components of the wheel space 16. The ingestion of the incoming gas flow 22 is regulated by providing a purge flow 26 from the wheel space 16, which purge flow 26 is at a higher pressure and a lower temperature compared to the incoming gas flow 22. The purge flow 26 is provided from the clearance area 24 to block the ingestion of the incoming gas flow 22 and to mix with the incoming gas flow 22 to maintain an acceptable temperature in the wheel space 16.

[0020] Furthermore, an optimum purge flow 26 needs to be maintained for efficient operation of the gas turbine (not shown). The optimum purge flow 26 is maintained by providing a desirable clearance area 24 in the wheel space 16. The angel wing 12 includes a tip 28 at an edge of the angel wing 12 that provides the desirable clearance area 24. In one embodiment, the tip 28 of a desirable height is provided to maintain the desirable clearance area 24 that allows the optimum purge flow 26 to pass via the desired clearance area 24. The optimum purge flow 26 passes via the desirable clearance area 24 to obstruct the ingestion of the incoming gas flow 22 and further maintain the acceptable temperature in the wheel space 16.

[0021] However, the tip 28 of the angel wing 12 often creates a hard rub with the discourager 14 during startup of the turbine 10 resulting in deterioration of the discourager 14 and wear of the angel wing 12. The hard rub increases maintenance costs and reduces life of the angel wing 12 and the

discourager 14. Therefore, a system and method that eliminates the hard rub and also optimizes the purge flow 26 is discussed below in detail.

[0022] FIG. 2 is a partial schematic representation of a gas turbine including an improved design to eliminate a hard rub between an angel wing and a discourager in accordance with an embodiment of the invention. The gas turbine 40 includes a compressor 42, a combustor 44 and a turbine 46. In operation of the gas turbine 40, an incoming gas flow 50 enters the turbine from the combustor 44. The turbine 46 receives the incoming gas flow 50 and extracts kinetic energy from the incoming gas flow 50. The turbine 46 further includes an angel wing (not shown) and a discourager (not shown) within a wheel space 48 to reduce ingestion of the incoming gas flow 50 to the wheel space 48. In one embodiment, a tip of the angel wing is removed to eliminate a hard rub between the tip and the discourager during startup. Furthermore, a purge flow 52 is bled from the compressor 42 and is purged into the wheel space 48 to reduce the ingestion of the incoming gas flow 50 and maintain the acceptable temperature in the wheel space 48. The angel wing includes a fan blade (not shown) that generates a recirculation zone (not shown) of the purge flow 52 and reduces a volume of the successive purge flow 52 entering within the wheel space 48. The angel wing and the discourager in the wheel space 48 are described in greater detail in FIG. 3 below.

[0023] FIG. 3 is a magnified view of the wheel space 48 in the turbine of FIG. 2 in accordance with an embodiment of the invention. The wheel space 48 includes the discourager 58 and the angel wing 60 protruding horizontally from a stator 54 and a rotor 56. As illustrated, the angel wing 60 does not include the tip. The absence of the tip of the angel wing 60 increases a clearance area 62 that results in an undesirable increase in the purge flow 52 (FIG. 2) to the wheel space 48. Accordingly, a fan blade 64 is disposed on the angel wing 60 to generate a recirculation zone (not shown) that maintains a desired amount of the purge flow 52. The disposition of the fan blade 64 is discussed in greater details with respect to FIG. 4.

[0024] FIG. 4 is an isometric view of the discourager 58 and the angel wing 60 in the wheel space 48 of the turbine 16 of FIG. 3 including the fan blade 64 in accordance with an embodiment of the invention. It may be noted that the wheel space 48 may include more components apart from the discourager 58 and the angel wing 60 as illustrated in FIG. 3. The angel wing 60 includes the fan blade 64 disposed on a surface 66 of the angel wing 60 at an axial position 67 relative to an axis 68 of the angel wing 60. In operation, the purge flow 52 enters the wheel space 48 via the clearance area 62. The fan blade 64 interacts with the purge flow 52 at a desired angle such that a direction 70 of the purge flow 52 is changed to a recirculation direction 72 to form a recirculation zone 74. In one embodiment, the desired angle is the axial position 67 of the fan blade 64. The recirculation zone 74 acts as a fluidic barrier to the successive purge flows entering the wheel space 48 via the clearance area 62 resulting in a reduction of the clearance area 62 that leads to reduction in the volume of the successive purge flows entering the wheel space 48. The fan blade 64 is described in greater detail with respect to FIG. 5 below.

[0025] FIG. 5 is a cross-section of the discourager 58 and the angel wing 60 in the wheel space 48 of FIG. 4 depicting a height 76 and an axial clearance 78 of the fan blade 64 (FIG. 4) in accordance with an embodiment of the invention. In one

embodiment, the height 76 of the fan blade 64 can be adjusted adequately to modify a height of the recirculation zone 74 (FIG. 4) to reduce the clearance area 62 to a desired level for optimizing the purge flow 52. For example, the desired reduction in the successive purge flow may include a reduction of about zero percent to about one hundred percent in the volume of the successive purge flow entering the wheel space 48. In another embodiment, the axial clearance 78 is provided to eliminate a hard rub between the discourager 58 and the fan blade 64. The height 76 and the axial clearance 78 of the fan blade 64 may be modified during designing and building phase of the gas turbine 40 to generate a desired recirculation zone 74. The recirculation zone 74 could be better understood with respect to FIG. 6 below.

[0026] FIG. 6 is a schematic illustration of a change in direction 70 of the purge flow due to the recirculation zone 74 in the wheel space 48 of FIG. 4 in accordance with an embodiment of the invention. The wheel space 48 receives a continuous purge flow 52. For simplicity of understanding, the continuous purge flow 52 is divided into a first purge flow 80 and a successive second purge flow 82 that arrive at the clearance area 62 within an interval of time. The first purge flow 80 arrives initially at the clearance area 62. As illustrated herein, a portion of the first purge flow 80 termed as a 'recirculation purge flow' 84 interacts with the fan blade 64 and forms the recirculation zone 74 as described above in detail with respect to FIG. 4-5. The recirculation zone 74 forms a fluidic barrier in the clearance area 62 and reduces the clearance area 62 to a desired effective clearance area 88. Furthermore, a portion of the first purge flow 80 apart from the recirculation purge flow 84 that flows in the direction 70 termed as a 'non-recirculating purge flow' 86 enters the wheel space 48 and mixes with the incoming gas 50 for ingestion.

[0027] Successively, a second purge flow 82 approaches the effective clearance area 88. Specifically, a portion of the second purge flow 82 encountering the recirculation zone 74, termed as a 'diverted purge flow 90' is directed in a reverse flow direction 92 by the recirculation zone 74 and is restricted from entering the wheel space 48. A remaining portion of the second purge flow 82 apart from the diverted purge flow 90, termed as a 'wheel space purge flow 94' flows via the effective clearance area 88 into the wheel space 48 and mixes with the incoming gas 50 to maintain the acceptable temperature in the wheel space 48 and avoid overheating. The process of providing the first purge flow 80 and the second purge flow 82 should be considered continuous for the operation of the gas turbine 40. Furthermore, the incoming gas 50 also flows in a reverse incoming gas direction 96 due to the recirculation zone 74. In a particular embodiment, the purge flow 52 may also be optimized by providing a tip on the angel wing and disposing a honeycomb structure on the discourager. The aforementioned embodiment would be discussed in greater details with respect to FIG. 7 below.

[0028] FIG. 7 is a schematic representation of the discourager 58 and the angel wing 60 including a honeycomb structure 98 and a tip 100 respectively in the wheel space 48 of FIG. 4 in accordance with another embodiment of the invention. In one embodiment, the angel wing 60 includes the tip 100 protruding at an edge of the surface 66 of the angel wing 60 to reduce the volume of the successive purge flow 52 entering the wheel space 48. Furthermore, the honeycomb structure 98 is disposed on a honeycomb surface 101 of the discourager 58 in an overlapping manner relative to the angel wing tip 100. The honeycomb structure 98 is provided

between the tip 100 and the discourager 58 to eliminate the hard rub between the tip 100 and the discourager 58. In one embodiment, the honeycomb structure 98 includes multiple cavities 102. The multiple cavities 102 enable the honeycomb structure 98 to generate a soft rub during the startup of the turbine 46 that results in a negligible deterioration of the discourager 58 and wear of the angel wing 60 as compared to the hard rub in the conventional turbines 10. Furthermore, the honeycomb structure 98 and the tip reduce the clearance area 62 to a honeycomb clearance area 103 to reduce the volume of the successive purge flow 52 entering the wheel space 48.

[0029] In another embodiment, the angel wing 60 includes a fan blade 104 disposed at an axial position 106 opposite to the axial position 67 relative to the axis 68 of the angel wing 60. The fan blade 104 generates a recirculation zone 108 in an opposite recirculation direction 110 relative to the recirculation direction 76 in the same manner as discussed above in detail. In a particular embodiment, the fan blade 104 acts as an additional feature to further reduce the volume of the successive purge flows 52 entering the wheel space 48.

[0030] FIG. 8 is a magnified view of the honeycomb structure 98 of FIG. 7 depicting multiple cavities 102 provided by the honeycomb structure 98 in accordance with an embodiment of the invention. The honeycomb structure 98 includes the multiple cavities 102 that generate multiple vortices 112 in a purge flow path 114 that provide additional viscous losses to the purge flow 52. The purge flow 52 enters the clearance area (not shown) and occupies a space in the multiple cavities 102 resulting in additional resistance to the purge flow 52 leading to an increase in efficiency relative to a conventional gas turbine.

[0031] FIG. 9 is a flow chart depicting the steps involved in a method 120 for providing a gas turbine of FIG. 2 in accordance with an embodiment of the invention. The method 120 includes providing a stator configured to guide a flow of an incoming gas in step 122. The method 120 also includes providing a rotor configured to expand the incoming gas and extract kinetic energy from the incoming gas in step 124. Furthermore, a purge flow is bled from a compressor to reduce a temperature of a wheel space by limiting ingestion of the incoming gas in step 126. The method 120 further includes disposing an angel wing between the stator and the rotor to act as a sealing surface between the rotor and the stator in step 128. In an embodiment, a horizontal structure extending outwardly from the rotor provided to form the angel wing. In another embodiment, a tip protruding vertically at an edge of the surface of the angel wing is provided. In yet another embodiment, a discourager is disposed on the stator above the angel wing in an overlapping manner. In an exemplary embodiment, a honeycomb structure is disposed between the tip and the discourager. The method 120 further includes disposing a fan blade on a surface of the angel wing at an axial position that generates a recirculation zone of the purge flow, wherein the recirculation zone is configured to reduce a volume of successive purge flows entering the wheel space in step 130. In one embodiment, a height of the fan blade relative to the angel wing and adequate to generate the recirculation zone is provided. In an exemplary embodiment, the fan blade is disposed on an outward annular surface. In another embodiment, a cooling gas is provided as a purge flow.

[0032] The various embodiments of a system and method to eliminate a hard rub and reduce a purge flow in a gas turbine described above thus provide a gas turbine that optimizes a

purge flow and eliminates hard rub resulting in high efficiency and low maintenance costs. The gas turbine includes an angel wing without a tip that results in elimination of the hard rub resulting in less maintenance costs. Furthermore, the gas turbine includes a fan blade that generates a recirculation zone of the purge flow to act as a fluidic barrier and reduce a clearance area of the turbine. The recirculation zone blocks the successive purge flows and optimize the purge flow entering the wheel space via the clearance area. Thus, these techniques eliminates hard rub and optimizes the purge flow resulting in increased life and less maintenance costs of the turbine.

[0033] Of course, it is to be understood that not necessarily all such objects or advantages described above may be achieved in accordance with any particular embodiment. Thus, for example, those skilled in the art will recognize that the systems and techniques described herein may be embodied or carried out in a manner that achieves or optimizes one advantage or group of advantages as taught herein without necessarily achieving other objects or advantages as may be taught or suggested herein.

[0034] Furthermore, the skilled artisan will recognize the interchangeability of various features from different embodiments. For example, a honeycomb structure disposed between the stator and the angel wing with respect to one embodiment can be adapted for use with a horizontal structure extending outwardly from the rotor described with respect to another embodiment of the invention. Similarly, the various features described, as well as other known equivalents for each feature, can be mixed and matched by one of ordinary skill in this art to construct additional systems and techniques in accordance with principles of this disclosure.

[0035] While only certain features of the invention have been illustrated and described herein, many modifications and changes will occur to those skilled in the art. It is, therefore, to be understood that the appended claims are intended to cover all such modifications and changes as fall within the true spirit of the invention.

1. A gas turbine comprising:

- a stator configured to guide a flow of an incoming gas;
- a rotor configured to expand the incoming gas and extract kinetic energy from the incoming gas;
- a purge flow bled from a compressor and configured to reduce a temperature of a wheel space by limiting ingestion of the incoming gas;
- an angel wing disposed between the rotor and the stator and configured to act as a sealing surface between the rotor and the stator; and
- a fan blade disposed on a surface of the angel wing at an axial position and configured to generate a recirculation zone of the purge flow, wherein the recirculation zone reduces a volume of successive purge flows entering the wheel space.

2. The gas turbine of claim 1, wherein the stator comprises a discourager disposed above the angel wing in an overlapping manner.

3. The gas turbine of claim 1, wherein the fan blade is configured to eliminate a hard rub between the discourager and the angel wing.

4. The gas turbine of claim 1, wherein the angel wing comprises a horizontal structure extending outwardly from the rotor.

5. The gas turbine of claim 1, wherein the angel wing comprises a tip protruding vertically at an edge of the surface of the angel wing.

6. The gas turbine of claim 2, wherein the discourager comprises a honeycomb structure disposed between the tip and the discourager.

7. The gas turbine of claim 1, wherein the axial position comprises an inclination angle relative to an axis of the angel wing.

8. The gas turbine of claim 1, wherein the incoming gas comprises a hot gas.

9. The gas turbine of claim 1, wherein the fan blade comprises a height relative to the angel wing and adequate to generate the recirculation zone.

10. The gas turbine of claim 1, wherein the surface comprises an outward annular surface.

11. A method of providing a gas turbine comprising:

- providing a stator configured to guide a flow of an incoming gas;
- providing a rotor configured to expand the incoming gas and extract kinetic energy from the incoming gas;
- providing a purge flow bled from a compressor and configured to reduce a temperature of a wheel space by limiting ingestion of the incoming gas;
- providing an angel wing disposed between the rotor and the stator and configured to act as a sealing surface between the rotor and the stator; and
- providing a fan blade disposed on a surface of the angel wing at an axial position and configured to generate a recirculation zone of the purge flow, wherein the recirculation zone reduces a volume of successive purge flows entering the wheel space.

12. The method of claim 11, further comprising disposing a discourager above the angel wing in an overlapping manner.

13. The method of claim 11, wherein providing the angel wing comprises providing a horizontal structure extending outwardly from the rotor.

14. The method of claim 11, wherein providing the angel wing comprises providing a tip protruding vertically at an edge of the surface of the angel wing.

15. The method of claim 12, wherein disposing the discourager comprises providing a honeycomb structure disposed between the tip and the discourager.

16. The method of claim 11, wherein providing the fan blade comprises providing the fan blade at a height relative to the angel wing and adequate to generate the recirculation zone.

17. The method of claim 11, wherein providing the fan blade disposed on the surface comprises providing the fan blade on an outward annular surface.

18. The method of claim 11, wherein providing a purge flow comprises providing a cooling gas.

* * * * *