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(54) SYSTEMS AND METHODS FOR FACILITATING ONBOARDING OF BUCKET COOLING FLOWS

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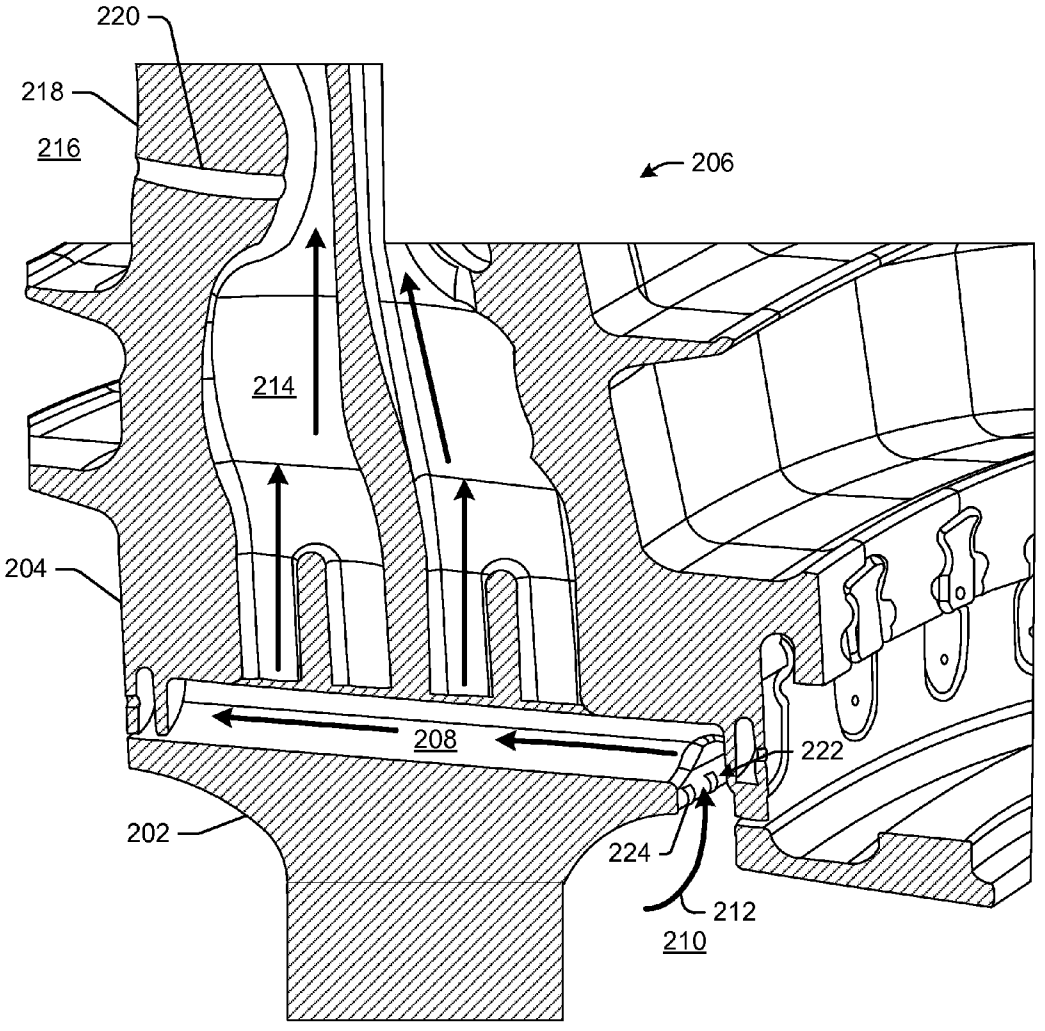
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(57) **ABSTRACT**

Systems and methods Embodiments for facilitating onboarding of a cooling fluid are disclosed herein. According to one embodiment, a system may include a rotor assembly, a wheel space cavity adjacent to the rotor assembly, and a bucket shank cavity in fluid communication with the wheel space cavity. The system may also include at least one protrusion disposed on the rotor assembly in the wheel space cavity. The at least one protrusion may be configured to direct the cooling fluid radially from the wheel space cavity to the bucket shank cavity to minimize pressure loss in the cooling fluid.



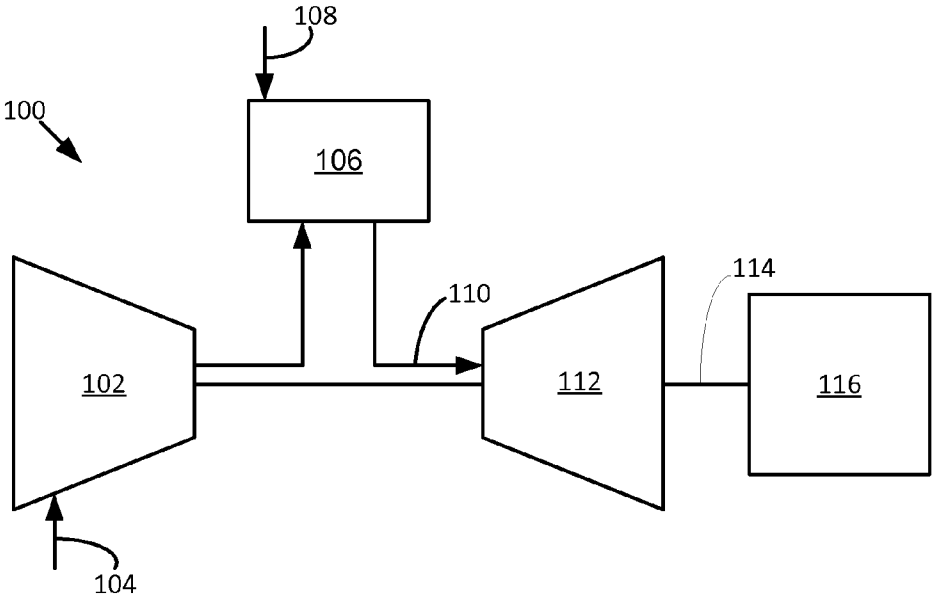


FIG. 1

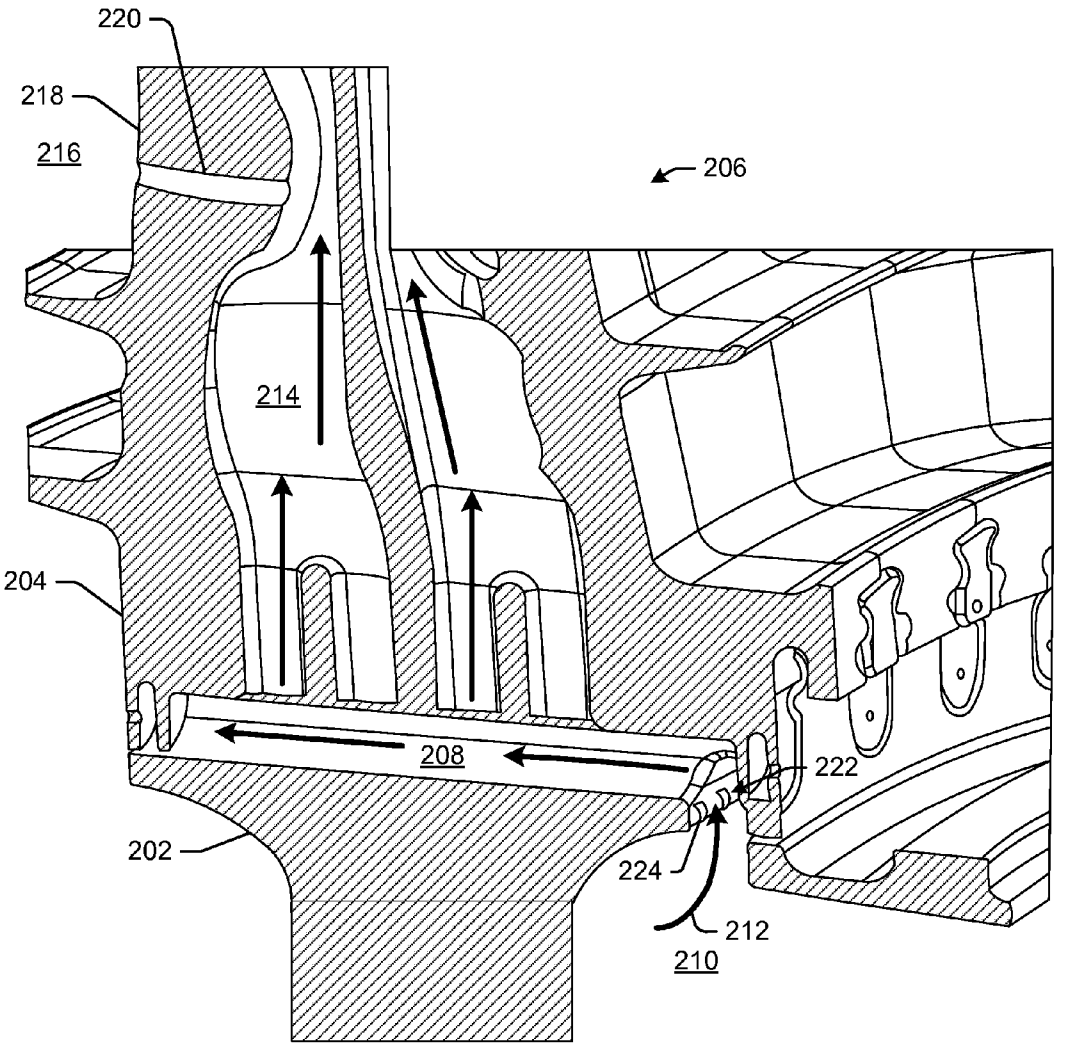


FIG. 2

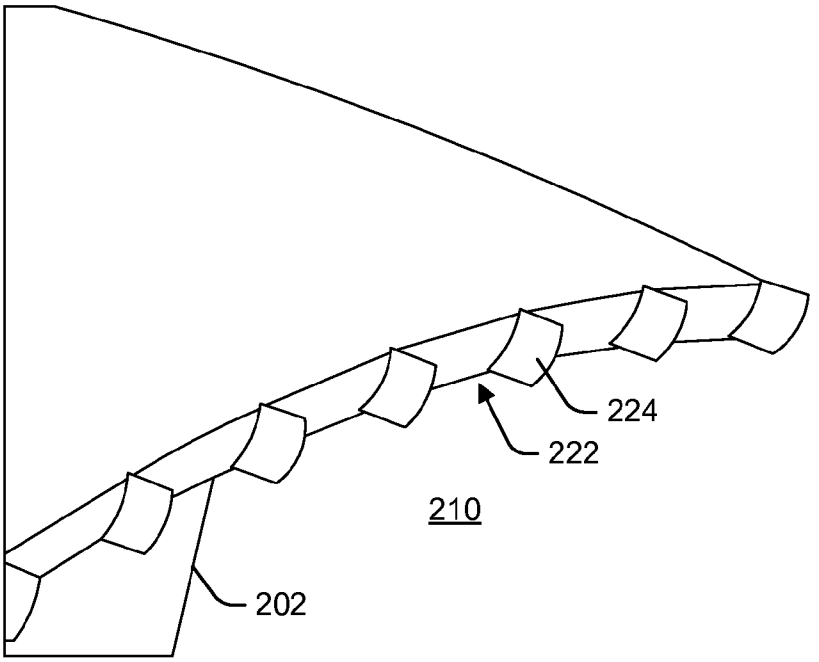


FIG. 3

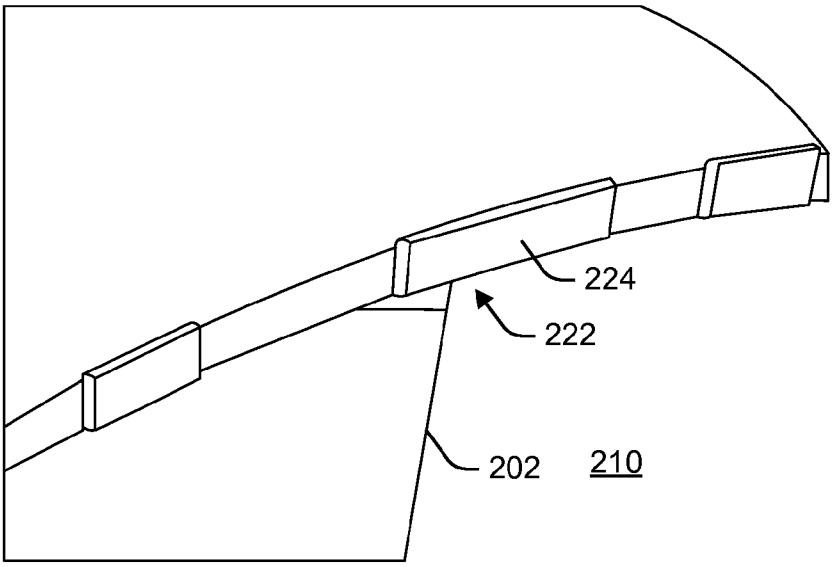


FIG. 4

SYSTEMS AND METHODS FOR FACILITATING ONBOARDING OF BUCKET COOLING FLOWS

FIELD OF THE DISCLOSURE

[0001] Embodiments of the disclosure relate generally to gas turbine engines and more particularly to systems and methods for facilitating onboarding of bucket purging and cooling flows.

BACKGROUND OF THE DISCLOSURE

[0002] Gas turbines are widely used in industrial and commercial operations. A typical gas turbine includes a compressor at the front, one or more combustors around the middle, and a turbine at the rear. The compressor imparts kinetic energy to the working fluid (e.g., air) to produce a compressed working fluid at a highly energized state. The compressed working fluid exits the compressor and flows to the combustors where it mixes with fuel and ignites to generate combustion gases having a high temperature and pressure. The hot combustion gases flow to the turbine where they expand to produce work. Consequently, the turbine is exposed to very high temperatures due to the hot combustion gases. As a result, the various turbine components, such as the turbine buckets, typically need to be cooled. In some instances, a portion of the compressed air may be diverted from the compressor to one or more components of the gas turbine engine for cooling purposes. The diverted air may be divided into any number of cooling flows or circuits. As the cooling flows pass through the gas turbine engine, they may experience pressure drops, which may decrease efficiency. Accordingly, there is a need to provide improved cooling systems and methods that eliminate or reduce pressure losses in the cooling flows.

BRIEF DESCRIPTION OF THE DISCLOSURE

[0003] Some or all of the above needs and/or problems may be addressed by certain embodiments of the disclosure. According to one embodiment, there is disclosed a turbine system for facilitating onboarding of a cooling fluid. The system may include a rotor assembly, a wheel space cavity adjacent to the rotor assembly, and a bucket shank cavity in fluid communication with the wheel space cavity. The system may also include at least one protrusion disposed on the rotor assembly in the wheel space cavity. The at least one protrusion may be configured to direct the cooling fluid radially from the wheel space cavity to the bucket shank cavity to minimize pressure loss in the cooling fluid.

[0004] According to another embodiment, there is disclosed a turbine system for facilitating smooth onboarding of a cooling fluid. The system may include a rotor assembly and a number of buckets attached to the rotor assembly. Each of the buckets may include a bucket shank cavity therein. The system may also include a wheel space cavity adjacent to the rotor assembly. The bucket shank cavity may be in fluid communication with the wheel space cavity. The system may also include a number of protrusions disposed on the rotor assembly in the wheel space cavity. The protrusions may be configured to direct the cooling fluid radially from the wheel space cavity to the bucket shank cavities.

[0005] Further, according to another embodiment, there is disclosed a method for facilitating onboarding of a cooling fluid. The method may include positioning a bucket shank cavity in fluid communication with a wheel space cavity. The method may also include positioning a number of protrusions on a rotor assembly in the wheel space cavity. Moreover, the method may include directing the cooling fluid radially from the wheel space cavity to the bucket shank cavity with the protrusions.

[0006] Other embodiments, aspects, and features of the invention will become apparent to those skilled in the art from the following detailed description, the accompanying drawings, and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Reference will now be made to the accompanying drawings, which are not necessarily drawn to scale.

[0008] FIG. **1** is an example schematic view of a gas turbine engine, according to an embodiment of the disclosure.

[0009] FIG. **2** is an example schematic cross-sectional view of a gas turbine assembly, according to an embodiment of the disclosure.

[0010] FIG. **3** is an example schematic perspective view of a portion of a gas turbine rotor assembly, according to an embodiment of the disclosure.

[0011] FIG. **4** is an example schematic perspective view of a portion of a gas turbine rotor assembly, according to an embodiment of the disclosure.

DETAILED DESCRIPTION OF THE DISCLOSURE

[0012] Illustrative embodiments will now be described more fully hereinafter with reference to the accompanying drawings, in which some, but not all embodiments are shown. The disclosure may be embodied in many different forms and should not be construed as limited to the embodiments set forth herein. Like numbers refer to like elements throughout.

[0013] Illustrative embodiments are directed to, among other things, systems and methods for facilitating smooth onboarding of a cooling fluid to one or more turbine buckets. For example, in certain embodiments, a turbine system may include a rotor assembly. A number of buckets may be circumferentially attached to the rotor assembly so as to from a turbine stage, such as, but not limited to, a first turbine stage. In some instances, each of the buckets may include a bucket shank cavity therein. The turbine assembly may also include a wheel space cavity positioned adjacent to the rotor assembly. The wheel space cavity may be in fluid communication with the bucket shank cavities. In this manner, a cooling fluid (such as extracted compressor discharge air) may flow from the wheel space cavity to the bucket shank cavities.

[0014] In certain embodiments, a number of protrusions may be disposed on the rotor assembly in the wheel space cavity. For example, the protrusions may be positioned on the rotor assembly adjacent to one another at an interface between the wheel space cavity and the bucket shank cavities. That is, the protrusions may be spaced apart from one another circumferentially on the rotor assembly at the interface between the wheel space cavity and the bucket shank cavity. In one example, the protrusions may include fins, blocks, pegs, or the like. The protrusions may be any geometric profile. The protrusions may be configured to direct the cooling fluid radially from the wheel space cavity to the bucket shank cavities.

[0015] The protrusions increase the swirl on the flow of cooling fluid by adding tangential velocity and bringing the cooling fluid closer to rotor tangential velocity. When there is

no differential movement between the buckets and the nearby cooling fluid, the cooling fluid smoothly onboards the buckets with limited pressure loss. That is, the protrusions facilitate lower pressure loss and enable smooth onboarding of the flow of cooling fluid into the bucket shank cavities, which increases back flow margin within the buckets.

[0016] In certain embodiments, each of the buckets may include at least one cooling passage in communication with the bucket shank cavity. The cooling passage may be configured to discharge at least a portion of the cooling fluid into a hot gas path. For example, the cooling passage may extend through an airfoil portion of the bucket, which may be disposed within the hot gas path. The airfoil portion of the bucket may include one or more exit ports or holes in communication with the cooling passage so that at least a portion of the cooling fluid may exit the exit ports into the hot gas path. In order to avoid backflow of the combustion gas in the hot gas path into the cooling passage, the cooling fluid in the cooling passage may have a pressure greater than the combustion gas in the hot gas path.

[0017] Turning now to the drawings, FIG. **1** depicts an example schematic view of a gas turbine assembly **100** as may be used herein. The gas turbine assembly **100** may include a gas turbine having a compressor **102**. The compressor **102** may compress an incoming flow of air **104**. The compressor **102** may deliver the compressed flow of air **104** to a combustor **106**. The combustor **106** may mix the compressed flow of air **104** with a pressurized flow of fuel **108** and ignite the mixture to create a flow of combustion gases **110**. Although only a single combustor **106** is shown, the gas turbine engine may include any number of combustors **106**. The flow of combustion gases **110** may be delivered to a turbine **112**. The flow of combustion gases **110** may drive the turbine **112** so as to produce mechanical work. The mechanical work produced in the turbine **112** may drive the compressor **102** via a shaft **114** and an external load **116**, such as an electrical generator or the like.

[0018] The gas turbine engine may use natural gas, various types of syngas, and/or other types of fuels. The gas turbine engine may be any one of a number of different gas turbine engines offered by General Electric Company of Schenectady, N.Y., including, but not limited to, those such as a 7 or a 9 series heavy duty gas turbine engine and the like. The gas turbine engine may have different configurations and may use other types of components. The gas turbine engine may be an aeroderivative gas turbine, an industrial gas turbine, or a reciprocating engine. Other types of gas turbine engines also may be used herein. Multiple gas turbine engines, other types of turbines, and other types of power generation equipment also may be used herein together.

[0019] In certain embodiments, as schematically depicted in FIG. **2**, the turbine **112** of FIG. **1** may include a rotor assembly **202**. A number of buckets **204** may be circumferentially attached to the rotor assembly **202** so as to from a first turbine stage **206**, although the systems and method described herein may be associated with any turbine stage. In some instances, each of the buckets **204** may include a bucket shank cavity **208** therein. A wheel space cavity **210** may be formed within or adjacent to the rotor assembly **202**. The wheel space cavity **210** may be in fluid communication with the bucket shank cavities **208**. In this manner, a cooling fluid **212** (such as extracted compressor discharge air from the compressor **102** of FIG. **1**) may flow from the wheel space cavity **210** to the bucket shank cavities **208**.

[0020] Still referring to FIG. **2**, each of the buckets **204** may include at least one cooling passage **214** therein. The cooling passage **214** may be in communication with the bucket shank cavity **208**. The cooling passage **214** may be configured to discharge at least a portion of the cooling fluid **212** into a hot gas path **216**. For example, the cooling passage **214** may extend through an airfoil portion **218** of the bucket **204**. The airfoil portion **218** may at least partially extend into the hot gas path **216**. The airfoil portion **218** may include one or more exit ports or holes **220** in communication with the cooling passage **214**. In this manner, the cooling fluid **212** may flow from the wheel space cavity **210** to the bucket shank cavities **208**, into the cooling passage **214**, and out of the exit ports or holes **220** into the hot gas path **216**. In order to avoid backflow of the combustion gas in the hot gas path **216** into the cooling passage **214**, the cooling fluid **212** in the cooling passage **214** may have a pressure greater than the combustion gas in the hot gas path **216**.

[0021] Due to the rotation of the rotor assembly **202**, a large pressure drop in the cooling fluid **212** may occur at the interface **222** (or junction) between the wheel space cavity **210** and the bucket shank cavities **208**. The pressure drop may decrease the back flow margin and/or the overall efficiency of the gas turbine engine. In order to eliminate or minimize the pressure drop in the cooling fluid **212** between the wheel space cavity **210** and the bucket shank cavities **208**, a number of protrusions **224** may be disposed on the rotor assembly **202** in the wheel space cavity **210**. For example, the protrusions **224** may be positioned on the rotor assembly **210** at the interface **222** between the wheel space cavity **210** and the bucket shank cavities **208**. The protrusions **224** may be configured to direct the cooling fluid **212** radially from the wheel space cavity **210** to the bucket shank cavities **208**. Directing the cooling fluid **212** radially from the wheel space cavity **210** to the bucket shank cavities **208** may eliminate or reduce the pressure drop of the cooling fluid **212**.

[0022] As schematically depicted in FIGS. **3** and **4**, the protrusions **224** may be spaced apart from one another circumferentially on the rotor assembly **202** at the interface **222** between the wheel space cavity **210** and the bucket shank cavity **208**. In certain embodiments, the protrusions **224** may include fins, blocks, pegs, or the like. The protrusions may be any geometric profile that directs the cooling fluid radially from the wheel space cavity **210** to the bucket shank cavities **208**.

[0023] Although embodiments have been described in language specific to structural features and/or methodological acts, it is to be understood that the disclosure is not necessarily limited to the specific features or acts described. Rather, the specific features and acts are disclosed as illustrative forms of implementing the embodiments.

That which is claimed:

1. A turbine system for facilitating onboarding of a cooling fluid, comprising:

a rotor assembly;

a wheel space cavity adjacent to the rotor assembly;

a bucket shank cavity in fluid communication with the wheel space cavity; and

at least one protrusion disposed on the rotor assembly in the wheel space cavity, wherein the at least one protrusion is configured to direct the cooling fluid from the wheel space cavity to the bucket shank cavity to minimize pressure loss in the cooling fluid.

2. The system of claim 1, wherein the at least one protrusion is positioned on the rotor assembly about an interface between the wheel space cavity and the bucket shank cavity.

3. The system of claim 2, wherein the at least one protrusion comprises a plurality of protrusions.

4. The system of claim 3, wherein the plurality of protrusions are spaced apart adjacent to one another circumferentially on the rotor assembly about the interface between the wheel space cavity and the bucket shank cavity.

5. The system of claim 1, wherein the at least one protrusion comprises a fin.

6. The system of claim 1, further comprising at least one cooling passage in communication with the bucket shank cavity, wherein the at least one cooling passage is configured to discharge at least a portion of the cooling fluid into a hot gas path.

7. The system of claim 6, wherein the cooling fluid comprises a pressure greater than the hot gas path.

8. The system of claim 1, wherein the cooling fluid comprises compressor extraction air.

9. The system of claim 1, wherein the bucket shank cavity is associated with a stage one turbine bucket.

10. A turbine system for facilitating onboarding of a cooling fluid, comprising:

a rotor assembly;

a plurality of buckets attached to the rotor assembly, wherein each of the plurality of buckets comprises a bucket shank cavity therein;

a wheel space cavity adjacent to the rotor assembly, wherein the bucket shank cavities are in fluid communication with the wheel space cavity; and

a plurality of protrusions disposed on the rotor assembly in the wheel space cavity, wherein the plurality of protrusions are configured to direct the cooling fluid from the wheel space cavity to the bucket shank cavities to minimize pressure loss in the cooling fluid.

11. The system of claim 10, wherein the plurality of protrusions are positioned on the rotor assembly about an interface between the wheel space cavity and the bucket shank cavities.

12. The system of claim 11, wherein the plurality of protrusions are spaced apart adjacent to one another circumferentially on the rotor assembly about the interface between the wheel space cavity and the bucket shank cavity.

13. The system of claim 10, wherein the plurality of protrusions comprise fins.

14. The system of claim 10, wherein each of the plurality of buckets comprises at least one cooling passage in communication with the bucket shank cavity, wherein the at least one cooling passage is configured to discharge at least a portion of the cooling fluid into a hot gas path.

15. The system of claim 14, wherein the cooling fluid in the at least one cooling passage comprises a pressure greater than the hot gas path.

16. The system of claim 10, wherein the cooling fluid comprises compressor extraction air.

17. A method for facilitating onboarding of a cooling fluid to a bucket, comprising:

positioning a bucket shank cavity in fluid communication with a wheel space cavity;

positioning a plurality of protrusions on a rotor assembly in the wheel space cavity; and

directing the cooling fluid from the wheel space cavity to the bucket shank cavity with the plurality of protrusions to minimize pressure loss in the cooling fluid.

18. The method of claim 17, further comprising positioning the plurality of protrusions at an interface between the wheel space cavity and the bucket shank cavity.

19. The method of claim 18, further comprising spacing the plurality of protrusions apart circumferentially on the rotor assembly about the interface between the wheel space cavity and the bucket shank cavity.

20. The method of claim 17, further comprising discharging the cooling fluid into a hot gas path through at least one cooling passage in fluid communication with the bucket shank cavity.

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