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Inventor(s)	Kramer; Stephen K. et al.

Steam cooling turbine stator vane array

Abstract

An assembly is provided for a turbine engine. This assembly includes a turbine vane array and a cooling system. The turbine vane array includes an inner platform, an outer platform and a plurality of turbine vanes extending between and connected to the inner platform and the outer platform. The turbine vanes include a first turbine vane, and the first turbine vane includes a first passage and a second passage. The cooling system is configured to direct a first fluid into the first passage and a second fluid into the second passage. The first fluid includes air and steam during a first mode. The second fluid includes the air without the steam during the first mode.

Inventors: **Kramer; Stephen K. (Cromwell, CT), Smith; Lance L (West Hartford, CT), Boardman; Gregory (Owens Cross Roads, AL), Dai; Zhongtao (West Hartford, CT)**

Applicant: **Raytheon Technologies Corporation** (Farmington, CT)

Family ID: **1000008766354**

Assignee: **RTX Corporation (Farmington, CT)**

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Primary Examiner: Kramer; Devon C

Assistant Examiner: Meiller; Sean V

Attorney, Agent or Firm: Getz Balich LLC

Background/Summary

BACKGROUND OF THE DISCLOSURE

1. Technical Field

(1) This disclosure relates generally to a turbine engine and, more particularly, to utilizing steam during operation of the turbine engine.

2. Background Information

(2) As government emissions standards tighten, interest in alternative fuels for gas turbine engines continues to grow. There is interest, for example, in fueling a gas turbine engine with hydrogen (H.sub.2) fuel rather than a traditional hydrocarbon fuel such as kerosine to reduce greenhouse

emissions. Combustion products produced by combusting hydrogen (H.sub.2) fuel include water vapor. Various systems and methods are known in the art for recovering the water vapor. Various system and methods are also known in the art for producing and utilizing steam from the recovered water vapor. While these known systems and methods have various advantages, there is still room in the art for improvement.

SUMMARY OF THE DISCLOSURE

(3) According to an aspect of the present disclosure, an assembly is provided for a turbine engine. This assembly includes a turbine vane array and a cooling system. The turbine vane array includes an inner platform, an outer platform and a plurality of turbine vanes extending between and connected to the inner platform and the outer platform. The turbine vanes include a first turbine vane, and the first turbine vane includes a first passage and a second passage. The cooling system is configured to direct a first fluid into the first passage and a second fluid into the second passage. The first fluid includes air and steam during a first mode. The second fluid includes the air without the steam during the first mode.

(4) According to another aspect of the present disclosure, another assembly is provided for a turbine engine. This assembly includes a turbine vane array, a structure and a steam injector. The turbine vane array includes an inner platform, an outer platform and a plurality of turbine vanes extending between and connected to the inner platform and the outer platform. The turbine vanes include a first turbine vane. The first turbine vane includes a sidewall, a passage and a plurality of cooling apertures. The passage extends within the first turbine vane along the sidewall. The cooling apertures extend through the sidewall and are fluidly coupled with the passage. The structure forms an air plenum with the outer platform. The air plenum is radially outboard of the outer platform and is fluidly coupled with the passage through an inlet to the passage in the outer platform. The steam injector is configured to direct steam into the passage. A tip of the steam injector is disposed at the inlet to the passage.

(5) According to still another aspect of the present disclosure, another assembly is provided for a turbine engine. This assembly includes a combustor, a vane array and a cooling system. The combustor includes a combustion chamber. The vane array is arranged at an outlet from the combustion chamber. The vane array includes an inner platform, an outer platform and a plurality of vanes. The inner platform forms an inner peripheral boundary of a flowpath through the vane array. The outer platform forms an outer peripheral boundary of the flowpath through the vane array. Each of the vanes extends across the flowpath from the inner platform to the outer platform. The vanes include a first vane with an internal passage. The cooling system is configured to direct a fluid into the internal passage. The fluid includes air and steam.

(6) The fluid may include the air and the steam during a first mode of operation. The fluid may only include the air during a second mode of operation.

(7) The passage may be a first passage, and the first turbine vane may also include a second passage discrete from the first passage. The air plenum may be fluidly coupled with the second passage through an inlet to the second passage in the outer platform.

(8) The assembly may also include a turbine section. The turbine vane array may be arranged at an inlet to the turbine section.

(9) The first fluid may include the air without the steam during a second mode. The second fluid may include the air without the steam during the second mode.

(10) The cooling system may include a steam injector. A tip of the steam injector may be disposed at an inlet to the first passage. The cooling system may be configured to direct the steam into the first passage through the steam injector.

(11) The cooling system may include a steam injector projecting partially into the first passage. The cooling system may be configured to direct the steam into the first passage through the steam injector.

(12) The cooling system may include a steam rail extending within the first passage. The cooling

system may be configured to direct the steam into the first passage through the steam rail.
(13) The cooling system may include a plurality of steam injectors. The cooling system may be configured to direct the steam into the first passage through the steam injectors.
(14) An air plenum may be disposed radially outboard of and formed by the outer platform. The cooling system may be configured to direct the air into the first passage through the air plenum.
(15) The cooling system may be configured to direct the air into the second passage through the air plenum.
(16) The first turbine vane may extend longitudinally between a leading edge and a trailing edge. The first passage may be arranged at the leading edge.
(17) The first turbine vane may extend longitudinally between a leading edge and a trailing edge. The second passage may be arranged at the trailing edge.
(18) The first turbine vane may extend longitudinally between a leading edge and a trailing edge. The first passage may be disposed longitudinally between the leading edge and the second passage.
(19) The first passage may be fluidly discrete from the second passage within the first turbine vane.
(20) The first passage may be fluidly coupled with a plurality of cooling apertures through a sidewall of the first turbine vane.
(21) The assembly may also include a combustor, and the combustor may include a combustion chamber. The turbine vane array may be arranged at an outlet from the combustion chamber.
(22) The inner platform may form an inner peripheral boundary of a flowpath through the turbine vane array. The outer platform may form an outer peripheral boundary of the flowpath through the turbine vane array. Each of the turbine vanes may extend across the flowpath between the inner platform and the outer platform.
(23) The present disclosure may include any one or more of the individual features disclosed above and/or below alone or in any combination thereof.
(24) The foregoing features and the operation of the invention will become more apparent in light of the following description and the accompanying drawings.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) FIG. **1** is a partial schematic illustration of a gas turbine engine.
(2) FIG. **2** is a partial schematic illustration of a combustor section between a compressor section and a turbine section.
(3) FIG. **3** is a perspective illustration of a combustor.
(4) FIG. **4** is a partial sectional illustration of a combustor wall.
(5) FIG. **5** is a schematic illustration of a fuel system configured with the combustor section.
(6) FIG. **6** is a partial sectional illustration of the turbine engine at a stator vane array between the combustor and a high pressure turbine rotor.
(7) FIG. **7** is a schematic cross-sectional illustration of the stator vane array.
(8) FIG. **8** is a cross-sectional illustration of a stator vane.
(9) FIG. **9** is a schematic illustration of a steam system arranged with the stator vane array.
(10) FIGS. **10-12** are partial sectional illustrations of the stator vane arranged with various steam injectors.
(11) FIG. **13** is a partial sectional illustration of a steam injector with multiple outlets.
DETAILED DESCRIPTION
(12) FIG. **1** is a side sectional illustration of a gas turbine engine **20** for an aircraft propulsion system. This turbine engine **20** extends axially along an axial centerline **22** between a forward, upstream end **24** and an aft, downstream end **26**. The turbine engine **20** includes a fan section **28**, a compressor section **29**, a combustor section **30** and a turbine section **31**. The compressor section **29**

of FIG. **1** includes a low pressure compressor (LPC) section **29**A and a high pressure compressor (HPC) section **29**B. The turbine section **31** of FIG. **1** includes a high pressure turbine (HPT) section **31**A and a low pressure turbine (LPT) section **31**B.

(13) The engine sections **28-31**B of FIG. **1** are arranged sequentially along the axial centerline **22** within an engine housing **32**. This engine housing **32** includes an inner case **34** (e.g., a core case) and an outer case **36** (e.g., a fan case). The inner case **34** may house one or more of the engine sections **29**A-**31**B; e.g., a core of the turbine engine **20**. The outer case **36** may house at least the fan section **28**.

(14) Each of the engine sections **28**, **29**A, **29**B, **31**A and **31**B includes a respective bladed rotor **38-42**. Each of these bladed rotors **38-42** includes a plurality of rotor blades arranged circumferentially around and connected to one or more respective rotor disks and/or hubs. The rotor blades, for example, may be formed integral with or mechanically fastened, welded, brazed, adhered and/or otherwise attached to the respective rotor disk(s) and/or the respective hub(s).

(15) The fan rotor **38** is connected to a geartrain **44**, for example, through a fan shaft **46**. The geartrain **44** and the LPC rotor **39** are connected to and driven by the LPT rotor **42** through a low speed shaft **47**. The HPC rotor **40** is connected to and driven by the HPT rotor **41** through a high speed shaft **48**. The engine shafts **46-48** are rotatably supported by a plurality of bearings; e.g., rolling element and/or thrust bearings. Each of these bearings is connected to the engine housing **32** by at least one stationary structure such as, for example, an annular support strut.

(16) During engine operation, air enters the turbine engine **20** through an airflow inlet **50** into the turbine engine **20**. This air is directed through the fan section **28** and into a core flowpath **52** and a bypass flowpath **54**. The core flowpath **52** extends sequentially through the engine sections **29**A-**31**B (e.g., the engine core) from an inlet **56** into the core flowpath **52** to an exhaust **58** from the core flowpath **52**. The air within the core flowpath **52** may be referred to as “core air”. The bypass flowpath **54** extends through a bypass duct, and bypasses the engine core. The air within the bypass flowpath **54** may be referred to as “bypass air”.

(17) The core air is compressed by the LPC rotor **39** and the HPC rotor **40** and directed into a (e.g., annular) combustion chamber **60** of a (e.g., annular) combustor **62** in the combustor section **30**. Fuel is injected by one or more fuel injector assemblies **64** (one visible in FIG. **1**) into the combustion chamber **60** and mixed with the compressed core air to provide a fuel-air mixture. This fuel-air mixture is ignited and combustion products thereof flow through and sequentially cause the HPT rotor **41** and the LPT rotor **42** to rotate before being directed out of the turbine engine **20** through the core exhaust **58**. The rotation of the HPT rotor **41** and the LPT rotor **42** respectively drive rotation of the HPC rotor **40** and the LPC rotor **39** and, thus, compression of the air received from the core inlet **56**. The rotation of the LPT rotor **42** also drives rotation of the fan rotor **38**, which propels the bypass air through the bypass flowpath **54** and out of the turbine engine **20** through an exhaust **66** from the bypass flowpath **54**. The propulsion of the bypass air may account for a majority of thrust generated by the turbine engine **20**.

(18) FIG. **2** illustrate a portion of the combustor section **30** along the core flowpath **52** between the HPC section **29**B and the HPT section **31**A. This combustor section **30** includes the combustor **62**, a diffuser plenum **68** and the one or more injector assemblies **64** (one visible in FIG. **2**). Briefly, the combustor **62** is disposed within (e.g., surrounded by) the diffuser plenum **68**. This diffuser plenum **68** receives the compressed core air from the HPC section **29**B for subsequent provision into the combustion chamber **60**. Each injector assembly **64** of FIG. **2** includes a fuel injector **70** mated with an air swirler structure **72**. The fuel injector **70** injects the fuel into the combustion chamber **60**. The air swirler structure **72** directs some of the core air from the diffuser plenum **68** into the combustion chamber **60** in a manner that facilitates mixing the core air with the injected fuel. One or more igniters (not shown) ignite the fuel-air mixture within the combustion chamber **60**. One or more quench apertures **74**A, **74**B (generally referred to as “**74**”) (e.g., dilution holes) in each wall **76**A, **76**B (generally referred to as “**76**”) of the combustor **62** direct additional core air from the

diffuser plenum **68** into the combustion chamber **60** to facilitate substantially complete burnout of (e.g., make stoichiometrically lean) the combustion products; e.g., the ignited fuel-air mixture.

(19) The combustor **62** may be configured as an annular combustor; e.g., an annular floating wall combustor. The combustor **62** of FIGS. **2** and **3**, for example, includes an annular combustor bulkhead **78**, the tubular inner combustor wall **76**A ("inner wall"), and the tubular outer combustor wall **76**B ("outer wall"). The bulkhead **78** of FIG. **2** extends radially between and to the inner wall **76**A and the outer wall **76**B. The bulkhead **78** may be connected (e.g., mechanically fastened or otherwise attached) to the inner wall **76**A and/or the outer wall **76**B. Each combustor wall **76** projects axially along the axial centerline **22** out from the bulkhead **78** towards the HPT section **31**A. The inner wall **76**A of FIG. **2**, for example, projects axially to and may be connected to an (e.g., tubular) inner platform **80**A of a downstream stator vane array **82** in the HPT section **31**A. The outer wall **76**B of FIG. **2** projects axially to and may be connected to an (e.g., tubular) outer platform **80**B of the downstream stator vane array **82**. With the arrangement of FIG. **2**, the combustion chamber **60** is formed by and extends radially within the combustor **62** between and to the inner wall **76**A and the outer wall **76**B. The combustion chamber **60** is formed by and extends axially (in an upstream direction along the core flowpath **52**) into the combustor **62** from the stator vane array **82** to the bulkhead **78**. The combustion chamber **60** also extends within the combustor **62** circumferentially about (e.g., completely around) the axial centerline **22**, which may configure the combustion chamber **60** as a full-hoop annulus.

(20) Referring to FIG. **4**, any one or more or all of the walls **76**A, **76**B, **78** may each be configured as a multi-walled structure; e.g., a hollow, dual-walled structure. Each wall **76**A, **76**B, **78** of FIG. **4**, for example, includes a combustor wall shell **84**, a combustor wall heat shield **86** (e.g., a liner) and one or more combustor wall cooling cavities **88** (e.g., impingement cavities) formed by and (e.g., radially and/or axially) between the shell **84** and the heat shield **86**. Each cooling cavity **88** of FIG. **4** is fluidly coupled with the diffuser plenum **68** through one or more cooling apertures **90** in the shell **84**; e.g., impingement apertures. Each cooling cavity **88** of FIG. **4** is fluidly coupled with the combustion chamber **60** through one or more cooling apertures **92** in the heat shield **86**; e.g., effusion apertures. Of course, various other multi-walled combustor wall structures are known in the art, and the present disclosure is not limited to any particular ones thereof. Furthermore, it is contemplated any one or more or all of the walls **76**A, **76**B and/or **78** of FIG. **2** may each alternatively be configured as a single-walled structure. The shell **84** of FIG. **4**, for example, may be omitted and the heat shield **86** may form a single walled liner/wall. However, for ease of description, each wall **76**A, **76**B, **78** may each be described below as the hollow, dual-walled structure.

(21) Referring to FIG. **5**, the turbine engine **20** includes a fuel system **94** for delivering the fuel to the combustor **62**. This fuel system **94** includes a fuel source **96** and the one or more fuel injectors **70**. The fuel source **96** of FIG. **5** includes a fuel reservoir **98** and/or a fuel flow regulator **100**; e.g., a valve and/or a pump. The fuel reservoir **98** is configured to store the fuel before, during and/or after turbine engine operation. The fuel reservoir **98**, for example, may be configured as or otherwise include a tank, a cylinder, a pressure vessel, a bladder or any other type of fuel storage container. The fuel flow regulator **100** is configured to direct and/or meter a flow of the fuel from the fuel reservoir **98** to one or more or all of the fuel injectors **70**. The fuel injectors **70** may be arranged circumferentially about the axial centerline **22** in an array. Each fuel injector **70** is configured to direct the fuel received from the fuel source **96** into the combustion chamber **60** for combustion.

(22) The fuel delivered by the fuel system **94** may be a non-hydrocarbon fuel; e.g., a hydrocarbon free fuel. Examples of the non-hydrocarbon fuel include, but are not limited to, hydrogen fuel (e.g., hydrogen (H.sub.2) gas) and ammonia fuel (e.g., ammonia (NH.sub.3) gas). The turbine engine **20** of FIG. **1** may thereby be configured as a non-hydrocarbon turbine engine; e.g., a hydrocarbon free turbine engine. The present disclosure, however, is not limited to non-hydrocarbon turbine engines.

The fuel delivered by the fuel system **94**, for example, may alternatively be a hydrocarbon fuel such as, but not limited to, kerosene or jet fuel. The turbine engine **20** of FIG. **1** may thereby be configured as a hydrocarbon turbine engine. Alternatively, the fuel system **94** may be configured as a multi-fuel system operable to deliver, individually or in combination, multiple different fuels (e.g., a non-hydrocarbon fuel and a hydrocarbon fuel, etc.) for combustion within the combustion chamber **60**. The turbine engine **20** of FIG. **1** may thereby be configured as a multi-fuel turbine engine; e.g., a dual-fuel turbine engine. However, for ease of description, the fuel delivered by the fuel system **94** may be described below as the non-hydrocarbon fuel; e.g., the hydrogen fuel.

(23) Referring to FIG. **6**, the stator vane array **82** may be configured as a first turbine vane array in the turbine section **31**. The stator vane array **82** of FIG. **6**, for example, is disposed at (e.g., on, adjacent or proximate) an outlet from the combustion chamber **60** at a downstream end of the combustor **62**/an inlet to the turbine section **31**. The stator vane array **82** is arranged along the core flowpath **52** and/or along the axial centerline **22** between the combustor **62** and a first stage of the HPT rotor **41**. The stator vane array **82** is configured to turn and/or otherwise condition the combustion products exhausted from the combustion chamber **60** for interacting with the HPT rotor **41** and its first stage. The stator vane array **82** of FIG. **6** includes the inner platform **80**A, the outer platform **80**B and a plurality of stator vanes **102**; e.g., hollow turbine vanes.

(24) Referring to FIG. **7**, the inner platform **80**A extends circumferentially about (e.g., completely around) the axial centerline **22**, which axial centerline **22** may also be an axial centerline of the inner platform **80**A. The inner platform **80**A extends radially between and to an inner side **104** of the inner platform **80**A and an outer side **106** of the inner platform **80**A. At the inner platform outer side **106**, the inner platform **80**A of FIG. **6** forms a radial inner peripheral boundary of the core flowpath **52** longitudinally within (and through) the stator vane array **82**. The inner platform **80**A extends longitudinally along the core flowpath **52** (e.g., axially along the axial centerline **22**) between and to an upstream end **108** of the inner platform **80**A and a downstream end **110** of the inner platform **80**A.

(25) The outer platform **80**B of FIG. **7** extends circumferentially about (e.g., completely around) the axial centerline **22**, which axial centerline **22** may also be an axial centerline of the outer platform **80**B. The outer platform **80**B extends radially between and to an inner side **112** of the outer platform **80**B and an outer side **114** of the outer platform **80**B. At the outer platform inner side **112**, the outer platform **80**B of FIG. **6** forms a radial outer peripheral boundary of the core flowpath **52** longitudinally within (and through) the stator vane array **82**. The outer platform **80**B extends longitudinally along the core flowpath **52** (e.g., axially along the axial centerline **22**) between and to an upstream end **116** of the outer platform **80**B and a downstream end **118** of the outer platform **80**B.

(26) The outer platform **80**B of FIG. **6** is spaced radially outboard of the inner platform **80**A. The outer platform **80**B is longitudinally aligned with and/or longitudinally (e.g., axially) overlaps at least a portion or an entirety of the inner platform **80**B, and vice versa. Referring to FIG. **7**, the outer platform **80**B circumscribes the inner platform **80**A. With this arrangement, the core flowpath **52** may have an annular geometry when viewed, for example, in a first reference plane perpendicular to the axial centerline **22**.

(27) The stator vanes **102** are distributed circumferentially about the axial centerline **22** in a (e.g., circular) array, which axial centerline **22** may also be an axial centerline of the array of stator vanes **102**. The stator vanes **102** are arranged within the core flowpath **52**. Each stator vane **102** of FIG. **7**, for example, extends (e.g., radially) between and to the inner platform **80**A and the outer platform **80**B. Each stator vane **102** is also connected to (e.g., formed integral with or otherwise fixedly attached to) the inner platform **80**A and/or the outer platform **80**B. With this arrangement, each stator vane **102** extends (e.g., generally radially) across the core flowpath **52** from the inner platform **80**A to the outer platform **80**B.

(28) Referring to FIG. **6**, each stator vane **102** includes a vane airfoil **120**, one or more internal

cooling passages **122** and **124** and one or more cooling apertures **126**. The vane airfoil **120** extends spanwise (e.g., radially) between and to the inner platform **80**A and the outer platform **80**B. The vane airfoil **120** extends longitudinally (e.g., chordwise, generally axially) between and to a leading edge **128** of the respective stator vane **102** and a trailing edge **130** of the respective stator vane **102**. Referring to FIG. **8**, the vane airfoil **120** extends laterally (e.g., generally circumferentially) between and to opposing lateral sides **132** and **134** of the vane airfoil **120**. The first airfoil side **132** may be concave and configured as a pressure side of the vane airfoil **120**. The second airfoil side **134** may be convex and configured as a suction side of the vane airfoil **120**. Each of these airfoil sides **132** and **134** extends longitudinally between and may meet at the leading edge **128** and the trailing edge **130**.

(29) The stator vane **102** and its vane airfoil **120** of FIG. **8** include a tubular sidewall **136** and an internal divider **138**. The sidewall **136** may form an exterior of the stator vane **102** and its vane airfoil **120**. The sidewall **136** of FIG. **8**, for example, includes an exterior surface of the vane airfoil **120** that forms the leading edge **128**, the trailing edge **130** and the airfoil sides **132** and **134**. The divider **138** is disposed within an internal cavity of the sidewall **136**. This divider **138** extends laterally across the internal cavity between opposing side portions of the sidewall **136**. The divider **138** may thereby divide the internal cavity into the first passage **122** and the second passage **124**. The divider **138** of FIG. **8** may be longitudinally aligned with (or upstream of) a throat of the stator vane array **82**. Referring to FIG. **6**, the divider **138** may extend spanwise along an entire length of the vane airfoil **120**. The divider **138** may thereby fluidly separate the first passage **122** from the second passage **124** within the stator vane **102** and its vane airfoil **120**.

(30) The first passage **122** may be arranged at the leading edge **128**. The second passage **124** may be arranged at the trailing edge **130**. With this arrangement, the first passage **122** is disposed longitudinally between the leading edge **128** and the second passage **124**. The second passage **124** is disposed longitudinally between the first passage **122** and the trailing edge **130**. More particularly, the first passage **122** of FIG. **6** extends longitudinally within the vane airfoil **120** between and to a leading edge portion of the sidewall **136** and the divider **138**. The second passage **124** of FIG. **6** extends longitudinally within the vane airfoil **120** between and to a trailing edge portion of the sidewall **136** and the divider **138**. Referring to FIG. **8**, each internal passage **122**, **124** may extend laterally within the vane airfoil **120** between the opposing side portions of the sidewall **136**.

(31) Referring to FIG. **6**, the first passage **122** projects spanwise into the stator vane array **82** and the respective stator vane **102** from an inlet **140** into the first passage **122**. This first passage inlet **140** may be formed by a port (e.g., an opening) through the outer platform **80**B. The first passage inlet **140** may thereby fluidly couple the first passage **122** to an air plenum **142** radially outboard of the outer platform **80**B. The first passage **122** is also fluidly coupled with the core flowpath **52** through, for example, the cooling apertures **126**. In particular, each cooling aperture **126** extends through the sidewall **136** from the first passage **122** to the core flowpath **52**. The cooling apertures **126** may thereby collectively form an outlet from the first passage **122**. Here, the cooling apertures **126** are arranged along and about the leading edge portion of the sidewall **136**. However, in other embodiments, it is contemplated the first passage outlet may also or alternatively be formed by a port **144** in the inner platform **80**B where, for example, the first passage **122** is fluidly coupled with one or more other turbine engine components.

(32) The second passage **124** projects spanwise into the stator vane array **82** and the respective stator vane **102** from an inlet **146** into the second passage **124**. This second passage inlet **146** may be formed by another port (e.g., an opening) through the outer platform **80**B. The second passage inlet **146** may thereby fluidly couple the second passage **124** to the air plenum **142**. The second passage **124** is also fluidly coupled with one or more other turbine engine components through an outlet **148** from the second passage **124**. This second passage outlet **148** may be formed by a port in the inner platform **80**A. However, in other embodiments, it is contemplated the second passage

outlet may also or alternatively be formed by one or more additional cooling apertures **150** through the sidewall **136**.
(33) The air plenum **142** of FIG. **6** is formed by and extends radially between (a) the stator vane array **82** and its outer platform **80**B and (b) another structure of the turbine engine **20** such as, but not limited to, the inner case **34** or an outer cooling air duct wall. The air plenum **142** may extend axially along the stator vane array **82** and its outer platform **80**B. The air plenum **142** may extend circumferentially about (e.g., completely around, circumscribe) the stator vane array **82** and its outer platform **80**B. The air plenum **142** may thereby be configured as an annulus adjacent and radially outboard of the passage inlets **140** and **146**. It is contemplated, however, the air plenum **142** may alternatively be configured into a plurality of arcuate segments, where each segment may overlap and be fluidly coupled with the internal cooling passages **122** and **124** in one or more of the stator vanes **102**.
(34) During turbine engine operation, the stator vane array **82** and its stator vanes **102** are subject to the relatively hot combustion products flowing out of the combustion chamber **60** into the HPT section **31**A. The turbine engine **20** therefore include a cooling system **152** for cooling (e.g., transferring heat energy out of) the stator vane array **82** and its stator vanes **102**. The cooling system **152** of FIG. **6** includes an air cooling circuit **154**, the air plenum **142** and the internal cooling passages **122** and **124**. The air cooling circuit **154** receives cooling air from a cooling air source **156**, and routes the cooling air to the air plenum **142**. The air plenum **142** (e.g., functioning as a manifold) distributes the cooling air received from the air cooling circuit **154** to the internal cooling passages **122** and **124**. The cooling system **152** is thereby configured to direct cooling fluid (here, the cooling air) into each of the internal cooling passages **122** and **124** from the cooling air source **156** to cool the stator vane array **82** and its stator vanes **102**. The cooling air source **156** may be the combustor section **30** where, for example, the cooling air is bled from the diffuser plenum **68** or elsewhere upstream of the combustion chamber **60**. Of course, various other cooling air sources are known in the art, and the present disclosure is not limited to any particular ones thereof.
(35) Combustion product temperatures may continue to increase in an effort to improve engine efficiency and/or facilitate improved turbine engine performance, particularly when using alternative fuels such as hydrogen fuel or the like. However, bleeding additional air from the core flowpath **52** (or otherwise) to provide additional cooling may be counterproductive since that bleed air is no longer primarily used for the combustion process. The cooling system **152** therefore also includes a steam system **158** as shown in FIG. **9** to provide supplemental cooling for at least the stator vane array **82** and its stator vanes **102**. This steam system **158** includes a steam source **160**, a steam delivery circuit **162** and one or more steam injectors **164**, where each of the steam injectors **164** may be associated with a respective one of the first passages **122**.
(36) The steam source **160** is configured to provide the steam to the steam delivery circuit **162** during turbine engine operation and, more particularly, during steam system operation. The steam source **160**, for example, may be configured as or otherwise include an evaporator **166**, which may be or otherwise include a fluid-to-fluid heat exchanger and/or an electrical heater. The evaporator **166** is configured to evaporate water into the steam during steam system operation. The water may be received from various sources. The steam source **160** of FIG. **9**, for example, includes a water reservoir **168** fluidly coupled with and upstream of the evaporator **166**. This water reservoir **168** is configured to store the water before, during and/or after turbine engine operation. Examples of the water reservoir **168** include, but are not limited to, a tank, a cylinder, a pressure vessel, a bladder or any other type of water storage container. Briefly, the water may be supplied to the water reservoir **168** by recovering water vapor from the combustion products flowing through the core flowpath **52** (see FIG. **1**) and/or from another water source onboard or offboard an aircraft.
(37) The steam delivery circuit **162** of FIG. **9** includes a supply circuit **170** and one or more feed circuits **172**, where each feed circuit **172** is associated with a respective one of the steam injectors **164**. The supply circuit **170** of FIG. **9** extends from an outlet from the steam source **160** to an

interface with the respective feed circuits **172** such as a manifold. At the interface, the feed circuits **172** may be fluidly coupled in parallel to and downstream of the supply circuit **170**. Each of the feed circuits **172** extends from the interface to an inlet of a respective one of the steam injectors **164**. The steam delivery circuit **162** thereby fluidly couples the steam source **160** to the respective steam injectors **164**.
(38) The steam directed through the steam delivery circuit **162** may be regulated based on cooling needs for the stator vane array **82** and/or based on a mode of turbine engine operation. The steam delivery circuit **162** of FIG. **9**, for example, includes a steam flow regulator **174**. The steam flow regulator **174** is arranged (e.g., fluidly coupled inline) with the supply circuit **170**. The steam flow regulator **174** is configured to selectively direct and/or meter a flow of the steam from the steam source **160** to the steam injectors **164**. For example, the steam flow regulator **174** may be configured as or otherwise include a control valve. This control valve may fully open, may fully close and/or may move to one or more partially open positions. While the steam flow regulator **174** is illustrated in FIG. **9** as being part of the supply circuit **170**, that steam flow regulator **174** may alternatively be arranged at the interface between the supply circuit **170** and the feed circuits **172**, at an inlet to the supply circuit **170**, or otherwise. One or more or all of the feed circuits **172** may also or alternatively be provided with its own steam flow regulator **174**. Furthermore, it is contemplated the steam delivered to one or more or all of the steam injectors **164** may still also or alternatively be regulated by adjusting an amount of steam provided (e.g., produced) by the steam source **160**.
(39) Referring to FIG. **6**, each steam injector **164** is arranged with a respective one of the first passages **122**. Each steam injector **164** of FIG. **6**, for example, extends axially along a centerline axis **176** of the respective steam injector **164** (e.g., radially inward relative to the axial centerline **22**) to a tip **178** of the respective steam injector **164**. This injector tip **178** may be disposed at the respective first passage inlet **140**. The injector tip **178**, for example, may be axially aligned with (or slightly above or below) the respective first passage inlet **140** along the centerline axis **176**. However, a gap **180** is still provided into the respective first passage **122** along the steam injector **164** to maintain the fluid coupling between the air plenum **142** and the respective first passage **122**. Here, the gap **180** is an annulus that extends along and circumscribes the steam injector **164**. The gap **180**, however, may alternatively be a (e.g., arcuate) slot or other aperture where, for example, the steam injector **164** is disposed to a side of the first passage inlet **140**.
(40) The steam injector **164** of FIG. **6** includes an internal steam passage **182** and at least (or only) one outlet **184** from the steam passage **182**. The steam passage **182** extends axially along the centerline axis **176** within the steam injector **164** to its steam passage outlet **184** at the injector tip **178**. The steam passage **182** is fluidly coupled with and downstream of a respective one of the feed circuits **172**. The steam injector **164** of FIG. **6** is configured to direct steam received from the feed circuit **172** out of the steam passage outlet **184** and into the respective first passage **122** (e.g., through the first passage inlet **140**). The steam may be directed out of the steam injector **164** and its steam passage outlet **184** as a jet of the steam, or as a diffuse flow of the steam.
(41) With the foregoing arrangement, the cooling system **152** may direct a first cooling fluid ("first fluid") into each first passage **122** and a second cooling fluid ("second fluid") into each second passage **124**. The second fluid may be different than the first fluid during one or more modes of turbine engine operation. For example, when the turbine engine **20** is operating at medium throttle or high throttle (e.g., for aircraft cruise or aircraft takeoff), the first fluid may include both the cooling air and a select quantity of the steam. The second fluid on the other hand may only or primarily (e.g., due to slight leakage out of the first passage **122** via the air plenum **142**) include the cooling air; e.g., with very little or no steam. However, the second fluid may be the same as the first fluid during one or more other modes of turbine engine operation. For example, when the turbine engine **20** is operating at low throttle or idle (e.g., during engine warmup, engine cooldown or for aircraft descent), both the first fluid and the second fluid may only or primarily include the

cooling air; e.g., the steam to the feed circuits **172** may be shut off. With this operability, the cooling system **152** may provide additional cooling capability using the steam as needed, but regularly provide the air cooling throughout the engine cycle. Note, providing air cooling may be particularly useful at turbine engine startup where, for example, the steam may not be available until after the turbine engine **20** is warmed up.

(42) In some embodiments, referring to FIGS. **10** and **11**, one or more or each steam injector **164** may project axially along its centerline axis **176** (e.g., radially) through the respective first passage inlet **140** and partially into the first passage **122**. The steam injector **164** of FIG. **10**, for example, is configured as a steam stinger. The steam injector **164** of FIG. **11**, for example, is configured as a steam rail.

(43) In some embodiments, referring to FIGS. **6** and **10**, one or more or each steam injector **164** may be configured with its steam passage outlet **184** (or outlets) at the injector tip **178**. In other embodiments, referring to FIG. **11**, the steam passage outlet(s) **184** may be disposed along a length of the respective steam injector **164**. With such an arrangement, the steam may be delivered to multiple zones along a span of the respective stator vane **102**. In addition, the steam may be directed out of the steam injector **164** to impinge against the respective sidewall **136** to further enhance the steam cooling capability.

(44) In some embodiments, referring to FIG. **9** (see also FIGS. **6**, **10** and **11**), each first passage **122** may be associated with a single one of the steam injectors **164**. In other embodiments, referring to FIG. **12**, one or more or each first passage **122** may be associated with multiple of the steam injectors **164**. Each of the steam injectors **164** of FIG. **12**, for example, may be arranged with and configured to independently direct the steam into the respective first passage **122**. In addition or alternatively, while the steam injectors **164** of FIGS. **6**, **10** and **12** are shown with a single steam passage outlet **184**, it is contemplated any one of these steam injectors **164** may alternatively include multiple steam passage outlets **184** to provide further targeted and/or diffuse steam injection; e.g., see FIG. **13**.

(45) The cooling system **152** may be included in various turbine engines other than the one described above. The cooling system **152**, for example, may be included in a geared turbine engine where a geartrain connects one or more shafts to one or more rotors in a fan section, a compressor section and/or any other engine section. Alternatively, the cooling system **152** may be included in a turbine engine configured without a geartrain; e.g., a direct drive turbine engine. The cooling system **152** may be included in a geared or non-geared turbine engine configured with a single spool, with two spools (e.g., see FIG. **1**), or with more than two spools. The turbine engine may be configured as a turbofan engine, a turbojet engine, a turboprop engine, a turboshaft engine, a propfan engine, a pusher fan engine or any other type of turbine engine. The turbine engine may alternatively be configured as an auxiliary power unit (APU) or an industrial gas turbine engine. The present disclosure therefore is not limited to any particular types or configurations of turbine engines.

(46) While various embodiments of the present disclosure have been described, it will be apparent to those of ordinary skill in the art that many more embodiments and implementations are possible within the scope of the disclosure. For example, the present disclosure as described herein includes several aspects and embodiments that include particular features. Although these features may be described individually, it is within the scope of the present disclosure that some or all of these features may be combined with any one of the aspects and remain within the scope of the disclosure. Accordingly, the present disclosure is not to be restricted except in light of the attached claims and their equivalents.

Claims

1. An assembly for a turbine engine, comprising: an air source; a steam source; a turbine vane array including an inner platform, an outer platform and a plurality of turbine vanes extending between and connected to the inner platform and the outer platform, the plurality of turbine vanes comprising a first turbine vane, and the first turbine vane including a first passage and a second passage; an air plenum disposed radially outboard of and formed by the outer platform; a cooling system configured to direct a first flow into an interior of the first passage and a second flow into the second passage, the cooling system including a steam injector projecting into the first passage, the steam injector spaced from a sidewall of the first passage and forming an annulus circumscribing the steam injector, the annulus fluidly coupling the air plenum with the first passage, the cooling system configured to direct the steam from the steam source into the first passage through the steam injector, the cooling system configured to direct the air into the first passage through the air plenum, and wherein, during a first mode, the first flow comprises a mixture of air from the air source and steam from the steam source, and the second flow comprises the air from the air source without the steam from the steam source; wherein during operation of the assembly in the first mode, the cooling system directs the first flow into the interior of the first passage.
2. The assembly of claim 1, wherein during a second mode, the first flow comprises the air from the air source without the steam from the steam source; and the second flow comprises the air from the air source without the steam from the steam source.
3. The assembly of claim 1, wherein the steam injector is configured as a steam rail extending within the first passage; and the cooling system is configured to direct the steam from the steam source into the first passage through the steam rail.
4. The assembly of claim 1, wherein the cooling system includes a plurality of steam injectors; and the cooling system is configured to direct the steam from the steam source into the first passage through the plurality of steam injectors.
5. The assembly of claim 1, wherein the cooling system is configured to direct the air from the air source into the second passage through the air plenum.
6. The assembly of claim 1, wherein the first turbine vane extends longitudinally between a leading edge and a trailing edge; and the first passage is arranged at the leading edge.
7. The assembly of claim 1, wherein the first turbine vane extends longitudinally between a leading edge and a trailing edge; and the second passage is arranged at the trailing edge.
8. The assembly of claim 1, wherein the first turbine vane extends longitudinally between a leading edge and a trailing edge; and the first passage is disposed longitudinally between the leading edge and the second passage.
9. The assembly of claim 1, wherein the first passage is fluidly discrete from the second passage within the first turbine vane.
10. The assembly of claim 1, wherein the first passage is fluidly coupled with a plurality of cooling apertures through a sidewall of the first turbine vane.
11. The assembly of claim 1, further comprising: a combustor comprising a combustion chamber; the turbine vane array arranged at an outlet from the combustion chamber; and the air source comprising a diffuser plenum next to the combustor.
12. The assembly of claim 1, wherein the inner platform forms an inner peripheral boundary of a flowpath through the turbine vane array; the outer platform forms an outer peripheral boundary of the flowpath through the turbine vane array; and each of the plurality of turbine vanes extends across the flowpath between the inner platform and the outer platform.
13. An assembly for a turbine engine, comprising: a turbine vane array including an inner platform, an outer platform and a plurality of turbine vanes extending between and connected to the inner platform and the outer platform, the plurality of turbine vanes comprising a first turbine vane, the first turbine vane including a sidewall, a passage and a plurality of cooling apertures, the passage

extending within the first turbine vane along the sidewall, and the plurality of cooling apertures extending through the sidewall and fluidly coupled with the passage; a structure forming an air plenum with the outer platform, the air plenum radially outboard of the outer platform and fluidly coupled with the passage through an inlet to the passage in the outer platform; and a steam injector configured to direct steam into the passage, a tip of the steam injector disposed at the inlet to the passage such that the tip of the steam injector is disposed a first radial distance from the outer platform and a second radial distance from the inner platform that is greater than the first radial distance, and the tip disposed at the inlet axially offset from the sidewall forming a gap, the gap fluidly coupling the air plenum with the passage.

14. The assembly of claim 13, wherein the passage is a first passage, and the first turbine vane further includes a second passage discrete from the first passage; and the air plenum is fluidly coupled with the second passage through an inlet to the second passage in the outer platform.

15. The assembly of claim 13, further comprising: a turbine section; the turbine vane array arranged at an inlet to the turbine section.

16. An assembly for a turbine engine, comprising: a steam source; a diffuser plenum; a combustor comprising a combustion chamber, the combustor disposed in the diffuser plenum; a vane array arranged at an outlet from the combustion chamber, the vane array including an inner platform, an outer platform and a plurality of vanes, the inner platform forming an inner peripheral boundary of a flowpath through the vane array, the outer platform forming an outer peripheral boundary of the flowpath through the vane array, each of the plurality of vanes extending across the flowpath from the inner platform to the outer platform, and the plurality of vanes comprising a first vane with an internal passage; an air plenum radially outboard of the outer platform and fluidly coupled with an interior of the internal passage; and a cooling system configured to direct a fluid into the interior of the internal passage, the cooling system including a steam injector configured to direct steam into the interior of the internal passage, the steam injector disposed at an inlet to the interior of the internal passage and forming an annulus circumscribing the steam injector, and the annulus fluidly coupling the air plenum with the interior of the internal passage; wherein during a first mode of operation, the cooling system directs the fluid into the interior of the internal passage, the fluid comprising both air from the diffuser plenum and steam from the steam source.

17. The assembly of claim 16, wherein during a second mode of operation, the cooling system directs a second fluid into the internal passage, the second fluid comprising the air from the diffuser plenum.