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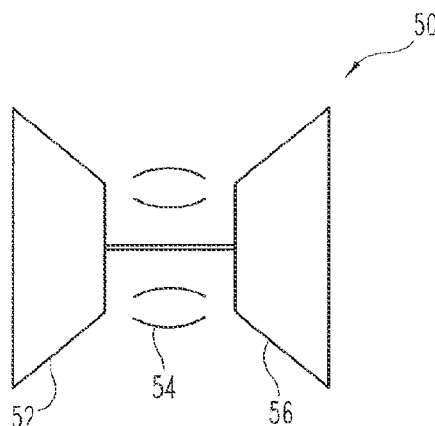


Fig. 1

(57) Abstract: A gas turbine engine having a combustor is disclosed in which a heat exchanger is disposed within the combustor. The heat exchanger can take the form of a fuel/air heat exchanger. In one form the heat exchanger includes a path for cooling air to be conveyed to a location external to the combustor. Cooled cooling air carried through the path can be created through action of heat transfer from the cooling air to a fuel flowing in the heat exchanger. The heat exchanger can include a fuel vaporizer in one form.



GAS TURBINE ENGINE COMBUSTOR HEAT EXCHANGER

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Patent Application No. 61/768,441 filed February 23, 2013, the contents of which are hereby incorporated in their entirety.

TECHNICAL FIELD

[0002] The present disclosure generally relates to gas turbine engine heat exchangers, and more particularly, but not exclusively, to fuel/air heat exchangers.

BACKGROUND

[0003] Providing the ability to retain heat within a combustor and transfer cooled cooling air external to the combustor remains an area of interest. Some existing systems have various shortcomings relative to certain applications. Accordingly, there remains a need for further contributions in this area of technology.

SUMMARY

[0004] One embodiment of the present disclosure is a unique heat exchanger used within a combustor of a gas turbine engine. Other embodiments include apparatuses, systems, devices, hardware, methods, and combinations for exchanging heat between a working fluid in the combustor with a fuel provided to the combustor. Further embodiments, forms, features, aspects, benefits, and advantages of the present application shall become apparent from the description and figures provided herewith.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] FIG. 1 depicts one embodiment of a gas turbine engine.

[0006] FIG. 2 depicts an embodiment of a heat exchanger used in a combustor of the gas turbine engine.

[0007] FIG. 3 depicts another embodiment of a heat exchanger used in a combustor of the gas turbine engine.

DETAILED DESCRIPTION

[0008] For the purposes of promoting an understanding of the principles of the disclosure, reference will now be made to the embodiments illustrated in the drawings and specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of the disclosure is thereby intended. Any alterations and further modifications in the described embodiments, and any further applications of the principles of the disclosure as described herein are contemplated as would normally occur to one skilled in the art to which the disclosure relates.

[0009] With reference to Fig. 1, a gas turbine engine 50 is disclosed having a compressor 52, combustor 54, and turbine 56 and can be used in some embodiments as a power source. In one non-limiting form the gas turbine engine 50 is used as a powerplant for an aircraft. As used herein, the term “aircraft” includes, but is not limited to, helicopters, airplanes, unmanned space vehicles, fixed wing vehicles, variable wing vehicles, rotary wing vehicles, unmanned combat aerial vehicles, tailless aircraft, hover crafts, and other airborne and/or extraterrestrial (spacecraft) vehicles. Further, the present disclosures are contemplated for utilization in other applications that may not be coupled with an aircraft such as, for example, industrial applications, power generation, pumping sets, naval propulsion, weapon systems, security systems, perimeter defense/security systems, and the like known to one of ordinary skill in the art.

[0010] The gas turbine engine 50 can take a variety of forms in various embodiments. Though depicted as an axial flow single spool engine, in some forms the gas turbine engine 50 can have multiple spools and/or can be a centrifugal or mixed centrifugal/axial flow engine. In some forms the engine 50 can be a turboprop, turbofan, or turboshaft engine. Furthermore, the engine can be an adaptive cycle and/or variable cycle engine. Other variations are also contemplated.

[0011] Turning now to Fig. 2, a schematic is depicted of one embodiment of the combustor 54 which includes a heat exchanger 58 disposed therein. The heat exchanger 58 can be used to exchange heat between multiple fluid flow paths at a variety of temperatures, flow rates, pressures, etc. In one non-limiting form the heat exchanger is a fuel/air heat exchanger, an operation of which will be discussed further below after a description of one form of the combustor 54.

[0012] The combustor 54 can take any variety of configurations and generally includes an inner combustion portion 60 in which a fuel and working fluid are mixed and combusted, and an exterior portion 64 in which generally no combustion occurs. The combustor is configured to receive working fluid through passage 59 and deliver working fluid to passage 61. The passage 59 can be a compressor passage and the passage 61 can be a turbine passage.

[0013] The inner combustion portion 60 can take on any variety of configurations, one non-limiting embodiment of which is shown below in FIG. 3. In various embodiments the inner combustion portion 60 can be defined by walls, liners, domes, cans, or combinations thereof. In some forms the structures that define the inner combustion portion 60 need not be solid but can be perforated, have slots, holes, etc. for the passage of working fluid such as air. The various openings provided for air entrance to the inner combustion portion 60 can be used to convey working fluid to participate directly in the combustion process, and/or can be used for dilution air, cooling air, etc. In one non-limiting form the inner combustion portion 60 can be defined by liners offset from each other that are coupled through a combustor dome. In some embodiments of the combustor 54, fuel injectors or nozzles can protrude through the structure that defines the inner combustion portion 60. It will be generally understood that the inner combustion portion 60 can include areas that do not locally include a combustion process, but that nevertheless the inner combustion portion 60 is in part defined by structure that generally separates it from the exterior portion 64. In one non-limiting example, some upstream areas of the inner combustion portion 60 that are substantially free from fuel will not include a combustion process, but nevertheless that area will generally be considered part of the inner combustion portion 60.

[0014] The exterior portion 64 extends between the inner combustion portion 60 and one or more structures that define the exterior portion 64. The exterior portion 64 may not be the same size and shape at all axial/circumferential locations relative to the inner combustion portion 60. In fact, the exterior portion may not entirely surround the inner combustion portion 60. The exterior portion 64 can be defined by various structures of the gas turbine engine. For example, the exterior portion 64 can be defined by a casing, compressor discharge such as through a diffuser, for example, a turbine inlet end, etc. In general it will be understood that the exterior portion 64 includes a boundary for a flow path for working fluid

that is located outside of the inner combustion portion 60 but that nonetheless is a flow path for fluid that is eventually expelled such as through the turbine 56.

[0015] Fuel can be delivered to the inner combustion portion 60 through a variety of manners including via an injector, nozzle, etc. in any of various states, such as liquid, vapor, mixed, etc. The schematic embodiment disclosed in FIG. 3 depicts a fuel passage 62 which conveys a fuel from a location outside of the combustor 54 to a location into the inner combustion portion 60. In the illustrated schematic embodiment of FIG. 2, the fuel passage 62 traverses the exterior portion 64 and is routed through the heat exchanger 58 prior to being mixed with working fluid and combusted in the inner combustion portion 60. The heat exchanger 58 can include one or more fluid paths that are located in the exterior portion 64, the inner combustion portion 60, intermediate the two portions 60 and 64, or combinations thereof. One non-limiting embodiment of a fluid flow path for fuel in the heat exchanger 58 is described below.

[0016] In one embodiment a working fluid that is flowed within the heat exchanger 58, and which gives up heat to the fuel flowing within or from the fuel passage 62, is carried away from the combustor via cooling passage 69. The cooling passage 69 can take a variety of shapes and sizes and can include any number of turns/bends/etc. within and prior to exiting the combustor 54. One non-limiting embodiment of the cooling passage 69 is described below in FIG. 3.

[0017] FIG. 3 depicts an embodiment of the combustor 54 in which the compressor 52 and turbine 56 are depicted as axial flow turbomachinery components. Other forms and combinations of the compressor 52 and turbine 56 are contemplated herein, whether of the centrifugal or mixed axial-centrifugal types. The combustor 54 of the illustrated embodiment is depicted as a straight flow-through combustor and is of the annular configuration, but other forms of the combustor 54 are also contemplated in other embodiments. A compressor discharge, via a diffuser 66 in the illustrated embodiment, provides compressed air to the combustor 54; a turbine inlet, via a turbine inlet guide vane 68 in the illustrated embodiment, receives working fluid from the combustor 54.

[0018] The combustor 54 depicted in FIG. 3 includes an outer casing 70, outer liner 72, inner liner 74, and inner casing 76. A fuel injector 78 extends into the combustor 54 to deliver fuel to the inner combustion portion 60. In one form the fuel injector 78 delivers fuel

to within the inner combustion portion 60 in a liquid form, or combination liquid and vapor. The liquid can be present as a stream, film, droplets, etc. In the illustrated embodiment the fuel injector 78 conveys fuel to a vaporizer 80 within which any fuel introduced to the vaporizer in liquid form can turn from the liquid to a vapor. Various configurations of the vaporizer 80 are contemplated beyond the embodiment depicted in FIG. 3.

[0019] The cooling passage 69 is configured to extend between an area in thermal communication with fuel delivered internal to the combustor 54 to one or more areas outside of the combustor 54. In the illustrated embodiment, the cooling passage 69 extends from an area in thermal communication with the vaporizer 80, to an inner part of the inner casing 76 before cooling fluid is split to flow aft to the turbine 56 and forward to the compressor 52. In other embodiments the cooling passage 69 can extend along an outer portion of the inner casing 76. In still other embodiments, the cooling passage 69 can extend across the exterior portion 64 in other locations besides the area depicted in the illustrated embodiment. For example, the cooling passage 69 can extend across the portion 64 on a side opposite the inner combustion portion 60 depicted in the figure. In other alternative and/or additional embodiments the cooling passage 69 can extend near one of the passages 59, 61. Any variety of other locations, configurations, orientations, etc. of the cooling passage 69 as it exits the combustor 54 are contemplated herein. As seen in the illustrated embodiment, the cooling passage 69 extends across the outer combustion portion 64 as it extends downstream and away from the area that it is in thermal communication with the fuel (in the illustrated embodiment, the vaporizer 80 serves as part of the heat exchange between the fuel and working fluid in the cooling passage 69). In one form the cooling passage 69 is a closed off flow path separate from the outer combustion portion 64.

[0020] The cooling passage 69 includes an inlet 82 structured to receive working fluid from the passage 59 which is in the form of a compressor discharge through a diffuser in the embodiment of FIG. 3. The inlet 82 can have a variety of shapes and sizes, and in one form can be integrated with one or more components of the combustor. The inlet 82 is offset from a dome 84, but in some forms one or more parts of the inlet 82 can be formed from the dome. For example, the inlet 82 can include an outer lip offset from the dome 84, while the dome 84 itself forms the inner lip. In this manner the inlet 82 can take the form of a scoop. Other configurations are contemplated herein. The inlet 82 can be positioned upstream of, coincident with, or downstream of an area of heat exchange between working fluid that gives

up heat and the fuel that absorbs it. One or more cooling passages 69 can be arranged in the combustor(s) 54 of the gas turbine engine 50.

[0021] In the illustrated embodiment cooled cooling air is routed from the cooling passage 69 to both the compressor 52 and the turbine. In other embodiments the cooling passage 69 can route cooled cooling air to either, or both, of the compressor and turbine. In addition, the cooling air that is routed within the cooling passage 69 can be pulled from working fluid that would be provided to the inner combustion portion 60 and/or from the working fluid that would be routed to the outer combustion portion 64.

[0022] While the disclosure has been illustrated and described in detail in the drawings and foregoing description, the same is to be considered as illustrative and not restrictive in character, it being understood that only the preferred embodiments have been shown and described and that all changes and modifications that come within the spirit of the disclosures are desired to be protected. It should be understood that while the use of words such as preferable, preferably, preferred or more preferred utilized in the description above indicate that the feature so described may be more desirable, it nonetheless may not be necessary and embodiments lacking the same may be contemplated as within the scope of the disclosure, the scope being defined by the claims that follow. In reading the claims, it is intended that when words such as “a,” “an,” “at least one,” or “at least one portion” are used there is no intention to limit the claim to only one item unless specifically stated to the contrary in the claim. When the language “at least a portion” and/or “a portion” is used the item can include a portion and/or the entire item unless specifically stated to the contrary.

CLAIMS

1. An apparatus comprising:
 - a gas turbine engine having a compressor configured to be rotated with a turbine and a combustor disposed in flow communication between the compressor and turbine, wherein the combustor includes a fuel delivery device structured to deliver fuel to a location within the combustor to be mixed with air and combusted;
 - a fuel/air heat exchanger disposed internal to the combustor and having a plurality of exchanger fluid flow paths to flow fuel and air; and
 - a cooling air passage within the combustor and structured to convey cooled cooling air developed as a result of an exchange of heat between the fuel and air within the fuel/air heat exchanger, the cooling air passage oriented to pass the cooled cooling air through a downstream portion that extends to a location external to the combustor.
2. The apparatus of claim 1, wherein the combustor includes an inner construction within which a combustion process occurs and an outer periphery offset from the inner construction and between which is formed an intermediate flow space, wherein the cooling air passage extends from the inner construction to the outer periphery.
3. The apparatus of claim 2, wherein the inner construction includes a liner, the outer periphery includes a casing disposed radially inward of the liner, and wherein the cooled cooling air extends in a radially inner direction from the liner to the casing.
4. The apparatus of claim 2, wherein the outer periphery is defined by a casing in a first side and a second side, a compressor discharge flow end, and a turbine inlet flow end, and wherein the cooled cooling air is used in at least one of the turbine and compressor.
5. The apparatus of claim 2, wherein a liner of the inner construction is integral with the fuel/air heat exchanger such that an inner side of the liner is in thermal contact with a fuel and an outer side of the liner is in thermal contact with a cooling air to develop the cooled cooling air.

6. The apparatus of claim 5, wherein the fuel/air heat exchanger is structured to vaporize fuel.
7. The apparatus of claim 5, wherein the fuel/air heat exchanger is integrated with a dome of the combustor.
8. An apparatus comprising:
 - a gas turbine engine that includes a combustor having a combustor flow space, the combustor flow space including a plurality of flow paths each structured to receive a flow of working fluid from an upstream turbomachinery component, a first flow path of the plurality of flow paths structured to convey working fluid within an interior combustion zone, a second flow path of the plurality of flow paths structured to convey working fluid on an opposing side of a combustion zone member that separates the second flow path from the first flow path, and a third flow path of the plurality of flow paths structured to convey a cooled cooling fluid away from the combustor flow space and to a location external to the combustor flow space; and
 - a heat exchanger disposed within the combustor flow space configured to extract heat from a cooling fluid to form the cooled cooling fluid.
9. The apparatus of claim 8, wherein the heat exchanger is a fuel/air heat exchanger, and wherein the fuel/air heat exchanger is in thermal communication with the cooling fluid passing through the third flow path.
10. The apparatus of claim 9, wherein the third flow path extends toward a casing of the combustor, and wherein the combustion zone member is one of a dome and a liner.
11. The apparatus of claim 9, wherein the heat exchanger is integrated into a dome of the combustor, and wherein at least a portion of the third flow path extends into the second flow path.
12. The apparatus of claim 11, wherein the heat exchanger is structured to change phase of a fuel as heat is transferred from the cooling fluid to the fuel.

13. The apparatus of claim 11, wherein the third flow path extends toward a compressor of the gas turbine engine.
14. The apparatus of claim 11, wherein the third flow path extends to provide cooling to a component of a turbine of the gas turbine engine.
15. The apparatus of claim 8, wherein the heat exchanger removes cooled cooling fluid developed within to the combustor to a location external to the combustor.
16. The apparatus of claim 15, wherein the heat exchanger exchanges heat between a fuel in a fuel passage and a cooling fluid such that the fuel increases in temperature and the cooling fluid decreases in temperature thus forming the cooled cooling fluid.
17. A method comprising:
 - receiving a flow of working fluid into a combustor that originates from a turbomachinery component structured to changes a pressure of a working fluid, the turbomachinery component forming part of an operating gas turbine engine;
 - splitting the flow to form a combustion flow and a cooling fluid;
 - providing fuel to an interior of a combustor, the fuel routed through a heat exchanger located internal to the combustor;
 - within the interior of the combustor, exchanging heat between the fuel and the cooling fluid to form a cooled cooling fluid; and
 - downstream of the heat exchanger, flowing the cooling fluid through an enclosed passage disposed between a combustion zone of the combustor and a flow path internal to the combustor but exterior to the combustion zone.
18. The method of claim 17, wherein the exchanging takes place across a structure that separates an interior combustion region of the combustor.
19. The method of claim 17, which further includes routing the cooled cooling fluid to a rotating component of the gas turbine engine.

20. The method of claim 19, wherein the rotating component is one of a turbine and a compressor.

1/2

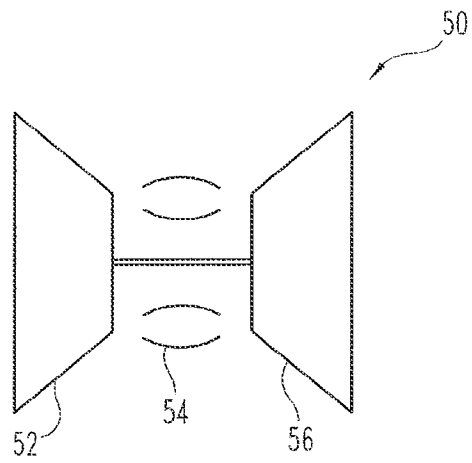


Fig. 1

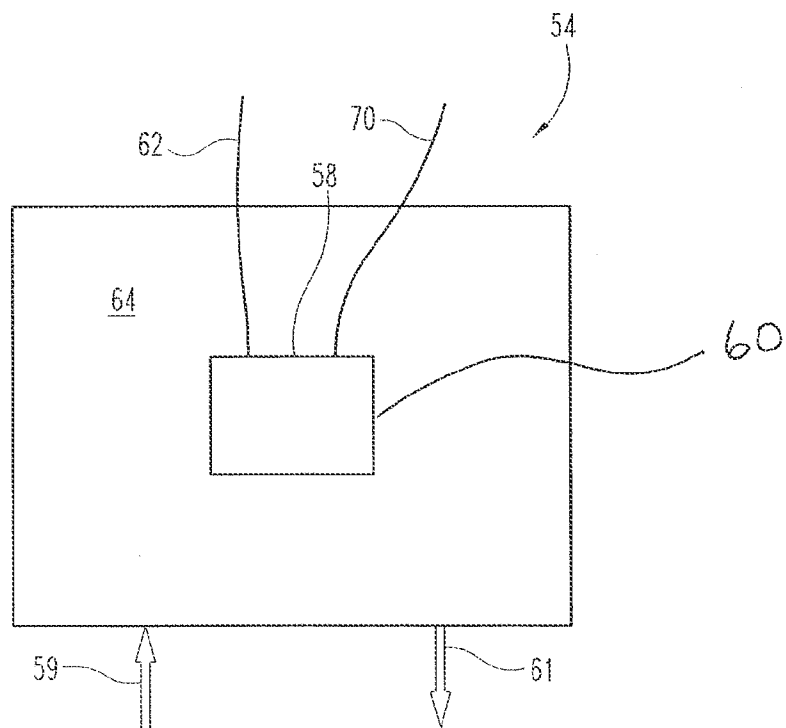


Fig. 2

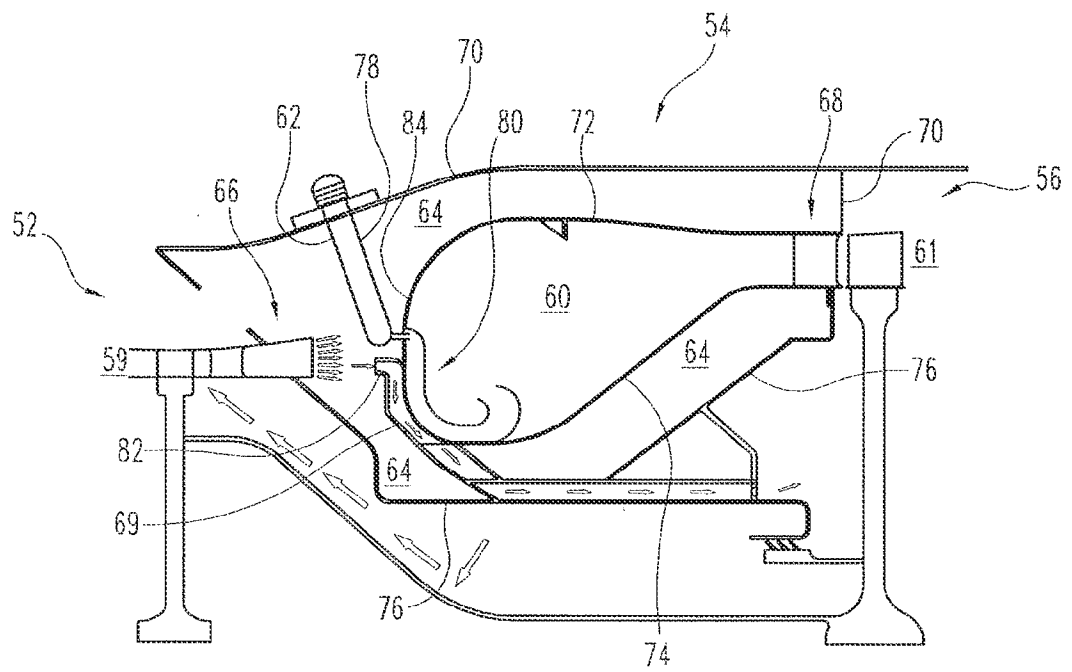


Fig. 3