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(54) **SYSTEM AND METHOD FOR SUPPLYING A WORKING FLUID TO A COMBUSTOR**

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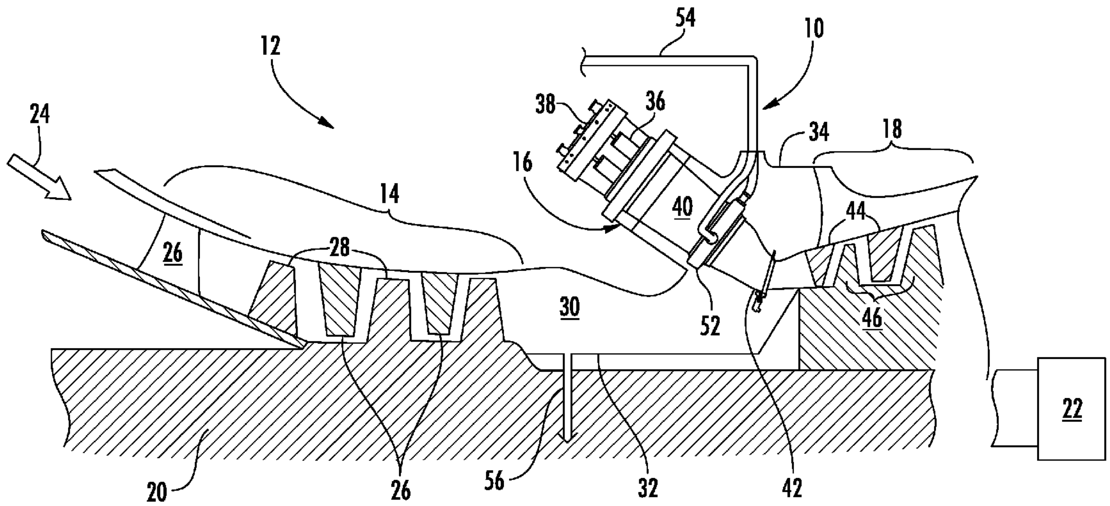
(57) **ABSTRACT**

A system for supplying a working fluid to a combustor includes a fuel nozzle, a combustion chamber, and fuel injectors circumferentially arranged around the combustion chamber. A combustor casing surrounds the combustion chamber. A distribution manifold encloses the fuel injectors, and a plenum passes through the combustor casing. A method for supplying a working fluid to a combustor includes flowing a working fluid from a compressor through a combustion chamber, diverting a portion of the working fluid into a plenum, and flowing the diverted portion of the working fluid outside of the compressor and the combustor. The method further includes flowing the diverted portion of the working fluid through a combustor casing and through a distribution manifold that encloses fuel injectors circumferentially arranged around the combustion chamber.



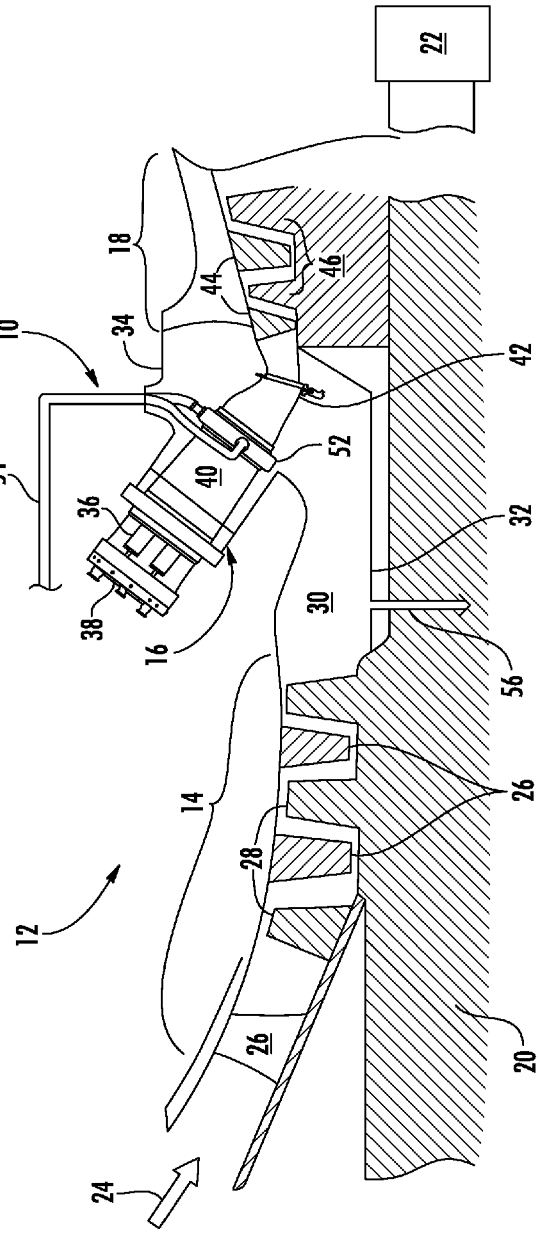


FIG. 1

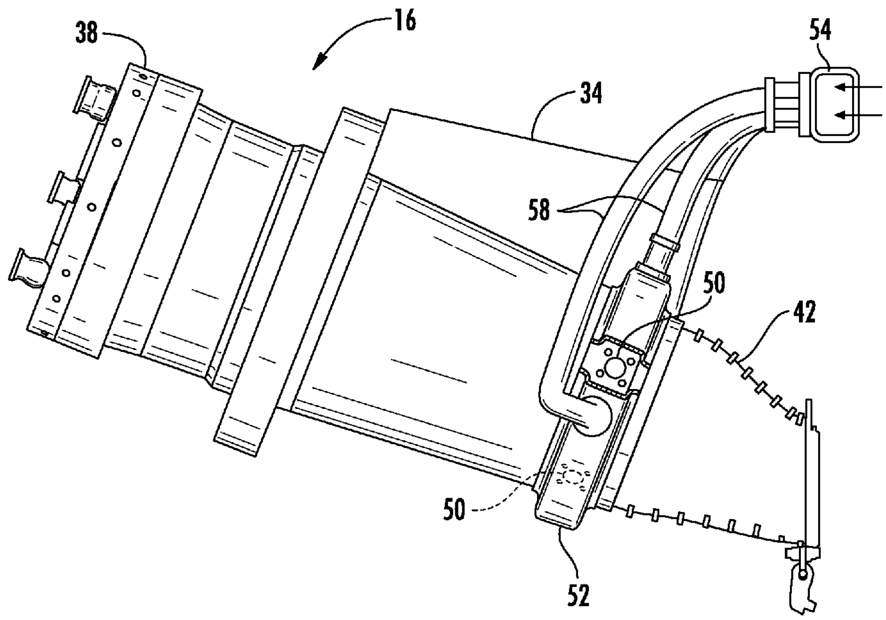


FIG. 2

SYSTEM AND METHOD FOR SUPPLYING A WORKING FLUID TO A COMBUSTOR

FIELD OF THE INVENTION

[0001] The present invention generally involves a system and method for supplying a working fluid to a combustor.

BACKGROUND OF THE INVENTION

[0002] Combustors are commonly used in industrial and power generation operations to ignite fuel to produce combustion gases having a high temperature and pressure. For example, gas turbines typically include one or more combustors to generate power or thrust. A typical gas turbine used to generate electrical power includes an axial compressor at the front, one or more combustors around the middle, and a turbine at the rear. Ambient air may be supplied to the compressor, and rotating blades and stationary vanes in the compressor progressively impart kinetic energy to the working fluid (air) to produce a compressed working fluid at a highly energized state. The compressed working fluid exits the compressor and flows through one or more nozzles into a combustion chamber in each combustor where the compressed working fluid mixes with fuel and ignites to generate combustion gases having a high temperature and pressure. The combustion gases expand in the turbine to produce work. For example, expansion of the combustion gases in the turbine may rotate a shaft connected to a generator to produce electricity.

[0003] Various design and operating parameters influence the design and operation of combustors. For example, higher combustion gas temperatures generally improve the thermodynamic efficiency of the combustor. However, higher combustion gas temperatures also promote flashback or flame holding conditions in which the combustion flame migrates towards the fuel being supplied by the nozzles, possibly causing severe damage to the nozzles in a relatively short amount of time. In addition, higher combustion gas temperatures generally increase the disassociation rate of diatomic nitrogen, increasing the production of nitrogen oxides (NO_X). Conversely, a lower combustion gas temperature associated with reduced fuel flow and/or part load operation (turndown) generally reduces the chemical reaction rates of the combustion gases, increasing the production of carbon monoxide and unburned hydrocarbons.

[0004] In a particular combustor design, one or more fuel injectors, also known as late lean injectors, may be circumferentially arranged around the combustion chamber downstream from the nozzles. A portion of the compressed working fluid exiting the compressor may flow through the fuel injectors to mix with fuel to produce a lean fuel-air mixture. The lean fuel-air mixture may then be injected into the combustion chamber for additional combustion to raise the combustion gas temperature and increase the thermodynamic efficiency of the combustor.

[0005] The late lean injectors are effective at increasing combustion gas temperatures without producing a corresponding increase in the production of NO_X. However, the pressure and flow of the compressed working fluid exiting the compressor may vary substantially around the circumference of the combustion chamber. As a result, the fuel-air ratio flowing through the late lean injectors can vary considerably, mitigating the beneficial effects otherwise created by the late lean injection of fuel into the combustion chamber. Previous attempts have been made to achieve a more uniform flow of working fluid through the late lean injectors. For example, scoops or shrouds have been installed over a portion of the fuel injectors to more evenly regulate the flow of working fluid through the fuel injectors. However, an improved system and method for reducing the variation in the pressure and/or flow of the working fluid flowing through the late lean injectors would be useful.

BRIEF DESCRIPTION OF THE INVENTION

[0006] Aspects and advantages of the invention are set forth below in the following description, or may be obvious from the description, or may be learned through practice of the invention.

[0007] One embodiment of the present invention is a system for supplying a working fluid to a combustor that includes a fuel nozzle and a combustion chamber downstream from the fuel nozzle. A plurality of fuel injectors are circumferentially arranged around the combustion chamber downstream from the fuel nozzle. A combustor casing circumferentially surrounds at least a portion of the combustion chamber. A distribution manifold encloses the plurality of fuel injectors, and a plenum passes through the combustor casing to provide fluid communication for a working fluid to flow to the distribution manifold.

[0008] Another embodiment of the present invention is a system for supplying a working fluid to a combustor that includes a compressor and a combustor downstream from the compressor. The combustor includes a combustion chamber and a plurality of fuel injectors circumferentially arranged around the combustion chamber. A combustor casing surrounds at least a portion of the combustor to contain a working fluid flowing from the compressor to the combustor. A distribution manifold encloses the plurality of fuel injectors, and a plenum passes through the combustor casing to provide fluid communication for a portion of the working fluid to flow to the distribution manifold.

[0009] The present invention may also include a method for supplying a working fluid to a combustor. The method includes flowing a working fluid from a compressor through a combustion chamber, diverting a portion of the working fluid into a plenum, and flowing the diverted portion of the working fluid outside of the compressor and the combustor. The method further includes flowing the diverted portion of the working fluid through a combustor casing that circumferentially surrounds at least a portion of the combustion chamber and flowing the diverted portion of the working fluid through a distribution manifold that encloses a plurality of fuel injectors circumferentially arranged around the combustion chamber.

[0010] Those of ordinary skill in the art will better appreciate the features and aspects of such embodiments, and others, upon review of the specification.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] A full and enabling disclosure of the present invention, including the best mode thereof to one skilled in the art, is set forth more particularly in the remainder of the specification, including reference to the accompanying figures, in which:

[0012] FIG. **1** is a simplified side cross-section view of a system according to one embodiment of the present invention; and

[0013] FIG. **2** is a simplified side view of the combustor shown in FIG. **1** according to one embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0014] Reference will now be made in detail to present embodiments of the invention, one or more examples of which are illustrated in the accompanying drawings. The detailed description uses numerical and letter designations to refer to features in the drawings. Like or similar designations in the drawings and description have been used to refer to like or similar parts of the invention. As used herein, the terms "first", "second", and "third" may be used interchangeably to distinguish one component from another and are not intended to signify location or importance of the individual components. In addition, the terms "upstream" and "downstream" refer to the relative location of components in a fluid pathway. For example, component A is upstream from component B if a fluid flows from component A to component B. Conversely, component B is downstream from component A if component B receives a fluid flow from component A.

[0015] Each example is provided by way of explanation of the invention, not limitation of the invention. In fact, it will be apparent to those skilled in the art that modifications and variations can be made in the present invention without departing from the scope or spirit thereof For instance, features illustrated or described as part of one embodiment may be used on another embodiment to yield a still further embodiment. Thus, it is intended that the present invention covers such modifications and variations as come within the scope of the appended claims and their equivalents.

[0016] Various embodiments of the present invention include a system and method for supplying a working fluid to a combustor. In general, the system includes multiple late lean injectors that circumferentially surround a combustion chamber. The system diverts or flows a portion of the working fluid from a common location and routes the diverted portion of the working fluid to a distribution manifold that surrounds the late lean injectors. By drawing the working fluid from one common location and delivering it to the distribution manifold, the system reduces variations in the pressure and/or flow rate of the diverted working fluid at each late lean injector to produce a more uniform fuel-air mixture injected into the combustion chamber. Although exemplary embodiments of the present invention will be described generally in the context of a combustor incorporated into a gas turbine for purposes of illustration, one of ordinary skill in the art will readily appreciate that embodiments of the present invention may be applied to any combustor and are not limited to a gas turbine combustor unless specifically recited in the claims.

[0017] FIG. **1** provides a simplified cross-section view of a system **10** according to one embodiment of the present invention. As shown, the system **10** may be incorporated into a gas turbine **12** having a compressor **14** at the front, one or more combustors **16** radially disposed around the middle, and a turbine **18** at the rear. The compressor **14** and the turbine **18** typically share a common rotor **20** connected to a generator **22** to produce electricity.

[0018] The compressor **14** may be an axial flow compressor in which a working fluid **24**, such as ambient air, enters the compressor **14** and passes through alternating stages of stationary vanes **26** and rotating blades **28**. A compressor casing **30** contains the working fluid **24** as the stationary vanes **26** and rotating blades **28** accelerate and redirect the working fluid **24** to produce a continuous flow of compressed working fluid **24**. The majority of the compressed working fluid **24** flows through a compressor discharge plenum **32** to the combustor **16**.

[0019] The combustor **16** may comprise any type of combustor known in the art. For example, as shown in FIG. **1**, a combustor casing **34** may circumferentially surround some or all of the combustor **16** to contain the compressed working fluid **24** flowing to the combustor **16**. One or more fuel nozzles **36** may be radially arranged in an end cover **38** to supply fuel to a combustion chamber **40** downstream from the fuel nozzles **36**. Possible fuels include, for example, one or more of blast furnace gas, coke oven gas, natural gas, vaporized liquefied natural gas (LNG), hydrogen, and propane. The compressed working fluid **24** may flow from the compressor discharge plenum **32** along the outside of the combustion chamber **40** before reaching the end cover **38** and reversing direction to flow through the fuel nozzles **36** to mix with the fuel. The mixture of fuel and compressed working fluid **24** flows into the combustion chamber **40** where it ignites to generate combustion gases having a high temperature and pressure. The combustion gases flow through a transition piece **42** to the turbine **18**.

[0020] The turbine **18** may include alternating stages of stators **44** and rotating buckets **46**. The first stage of stators **44** redirects and focuses the combustion gases onto the first stage of turbine buckets **46**. As the combustion gases pass over the first stage of turbine buckets **46**, the combustion gases expand, causing the turbine buckets **46** and rotor **20** to rotate. The combustion gases then flow to the next stage of stators **44** which redirects the combustion gases to the next stage of rotating turbine buckets **46**, and the process repeats for the following stages.

[0021] FIG. **2** provides a simplified side view of the combustor **16** shown in FIG. **1** according to one embodiment of the present invention. As shown, the combustor **16** includes a plurality of fuel injectors **50** circumferentially arranged around the combustion chamber **40** downstream from the fuel nozzles **36**. The fuel injectors **50** may receive the same or a different fuel than supplied to the fuel nozzles **36** and mix the fuel with a portion of the compressed working fluid **24** before injecting the mixture into the combustion chamber **40**. In this manner, the fuel injectors **50** supply a lean mixture of fuel and air for additional combustion to raise the temperature, and thus the efficiency, of the combustor **16**.

[0022] A distribution manifold **52** encloses the fuel injectors **50** to shield the fuel injectors **50** from direct impingement by the compressed working fluid **24** flowing out of the compressor **14**. As shown in FIG. **2**, the distribution manifold **52** may circumferentially surround at least a portion of the combustion chamber **40** inside of the combustor casing **34** to contain a portion of the compressed working fluid **24** diverted from a common source and supplied to the fuel injectors **50**. A plenum **54** may connect the distribution manifold **52** to a common source of the diverted compressed working fluid **24** to provide fluid communication for the diverted working fluid **24** to flow to the distribution manifold **52**. For example, as shown more clearly in FIG. **1**, the plenum **54** may include an upstream portion **56** configured to receive or divert a portion of the working fluid **24** from the compressor **14**. The upstream portion **56** may pass through the compressor casing **30** so that at least a portion of the plenum **54** extends outside of the compressor **14** and combustor **16** before passing through the combustor casing **32** to connect to the distribution manifold

52. In particular embodiments, as shown in FIG. 2, the plenum 54 may separate into a plurality of branch lines 58 before or after passing through the combustor casing 34. The branch lines 58 may include, for example, piping or flexible hoses so that each branch line 58 provides a separate fluid communication with the distribution manifold 52. In this manner, the plenum 54 may divert a portion of the compressed working fluid 24 at or close to the discharge pressure of the compressor 14 and deliver this diverted compressed working fluid 24 directly to the fuel injectors 50 inside the distribution manifold 52 with little or no pressure drop in the compressed working fluid 24.

[0023] The system 10 shown and described with respect to FIGS. 1 and 2 may also provide a method for supplying the working fluid 24 to the combustor 16. The method may include flowing the working fluid 24 from the compressor 14 through the combustion chamber 40 and diverting a portion of the working fluid 24 into the plenum 54. The method may further include flowing the diverted portion of the working fluid 24 outside of the compressor 14 and the combustor 16, through the combustor casing 34 that circumferentially surrounds at least a portion of the combustion chamber 40, and through the distribution manifold 52 that encloses the fuel injectors 50 circumferentially arranged around the combustion chamber 40. In particular embodiments, the method may further include flowing the diverted portion of the working fluid 24 through the compressor casing 30, circumferentially around at least a portion of the combustion chamber 40 inside of the distribution manifold 52, and/or separating the diverted portion of the working fluid 24 into the branch lines 58 before or after passing through the combustor casing 34.

[0024] The various embodiments of the present invention may provide one or more technical advantages over existing late lean injection systems. For example, the systems and methods described herein may reduce variations in the pressure and/or flow of the working fluid 24 through each fuel injector 50. As a result, the various embodiments require less analysis to achieve the desired fuel-air ratio through the fuel injectors 50 and enhance the intended ability of the fuel injectors 50 achieve the desired efficiency and reduced emissions from the combustor 16.

[0025] This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to practice the invention, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those skilled in the art. Such other and examples are intended to be within the scope of the claims if they include structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal languages of the claims.

What is claimed is:

1. A system for supplying a working fluid to a combustor, comprising:
- a. a fuel nozzle;
- b. a combustion chamber downstream from said fuel nozzle;
- c. a plurality of fuel injectors circumferentially arranged around said combustion chamber downstream from said fuel nozzle;
- d. a combustor casing that circumferentially surrounds at least a portion of said combustion chamber;
- e. a distribution manifold that encloses said plurality of fuel injectors; and
- f. a plenum that passes through said combustor casing to provide fluid communication for a working fluid to flow to said distribution manifold.

2. The system as in claim 1, wherein said distribution manifold circumferentially surrounds said combustion chamber inside of said combustor casing.

3. The system as in claim 1, wherein said plenum comprises a plurality of branch lines in fluid communication with said distribution manifold.

4. The system as in claim 1, wherein said plenum separates into a plurality of branch lines after passing through said combustor casing.

5. The system as in claim 1, wherein said plenum includes an upstream portion configured to receive the working fluid from a compressor.

6. The system as in claim 1, wherein said plenum includes an upstream portion that passes through a compressor casing.

7. The system as in claim 1, wherein said plenum includes an upstream portion that passes through a compressor casing and at least a portion of said plenum extends outside of the combustor.

8. A system for supplying a working fluid to a combustor, comprising:
- a. a compressor;
- b. a combustor downstream from said compressor, wherein said combustor comprises a combustion chamber and a plurality of fuel injectors circumferentially arranged around said combustion chamber;
- c. a combustor casing that surrounds at least a portion of said combustor to contain a working fluid flowing from said compressor to said combustor;
- d. a distribution manifold that encloses said plurality of fuel injectors; and
- e. a plenum that passes through said combustor casing to provide fluid communication for a portion of the working fluid to flow to said distribution manifold.

9. The system as in claim 8, wherein said distribution manifold circumferentially surrounds said combustion chamber inside said combustor casing.

10. The system as in claim 8, wherein said plenum comprises a plurality of branch lines in fluid communication with said distribution manifold.

11. The system as in claim 8, wherein said plenum separates into a plurality of branch lines after passing through said combustor casing.

12. The system as in claim 8, wherein said plenum includes an upstream portion configured to receive the portion of the working fluid from said compressor.

13. The system as in claim 8, wherein said plenum includes an upstream portion that passes through a compressor casing.

14. The system as in claim 8, wherein said plenum includes an upstream portion that passes through a compressor casing and at least a portion of said plenum extends outside of said compressor and said combustor.

15. A method for supplying a working fluid to a combustor, comprising:
- a. flowing a working fluid from a compressor through a combustion chamber;
- b. diverting a portion of the working fluid into a plenum;
- c. flowing the diverted portion of the working fluid outside of the compressor and the combustor;

d. flowing the diverted portion of the working fluid through a combustor casing that circumferentially surrounds at least a portion of the combustion chamber; and

e. flowing the diverted portion of the working fluid through a distribution manifold that encloses a plurality of fuel injectors circumferentially arranged around the combustion chamber.

16. The method as in claim **15**, further comprising flowing the diverted portion of the working fluid circumferentially around the combustion chamber inside of the distribution manifold.

17. The method as in claim **15**, further comprising separating the diverted portion of the working fluid into a plurality of branch lines in fluid communication with the distribution manifold.

18. The method as in claim **15**, further comprising separating the diverted portion of the working fluid into a plurality of branch lines after passing through the combustor casing.

19. The method as in claim **15**, further comprising flowing the diverted portion of the working fluid through a compressor casing.

20. The method as in claim **15**, further comprising flowing the diverted portion of the working fluid through a compressor casing and outside of the combustor.

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