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(54) **POWER AUGMENTATION SYSTEM WITH DYNAMICS DAMPING**

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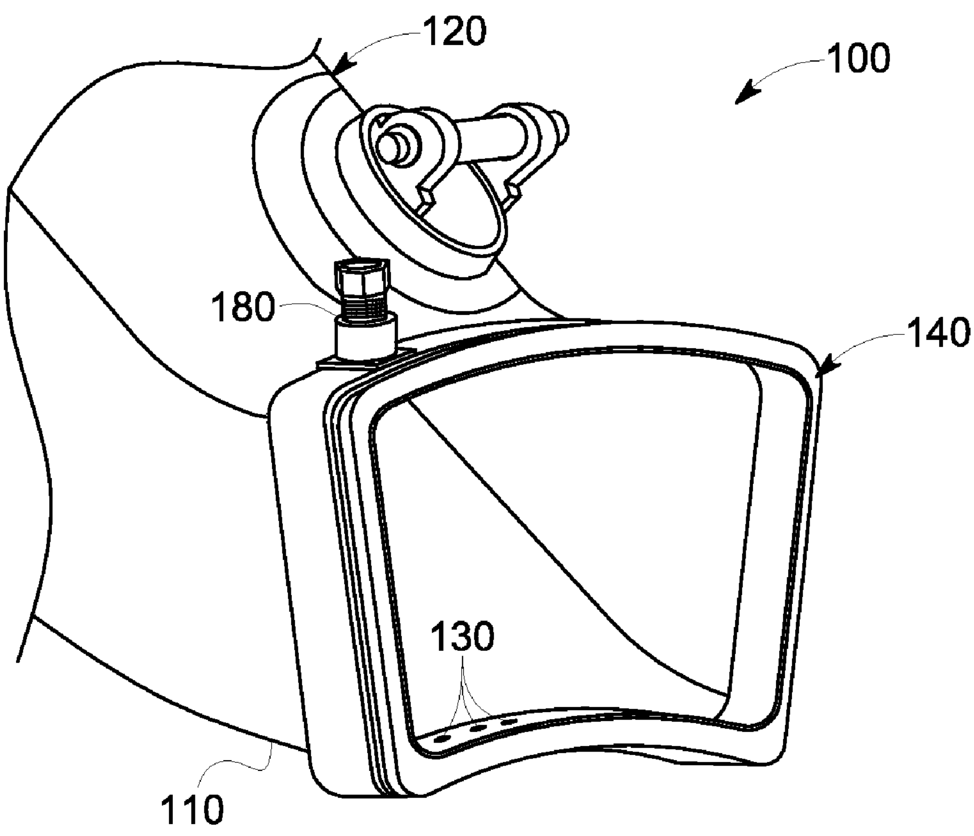
(57) **ABSTRACT**

A power augmentation system for a gas turbine engine which may include a transition piece of a combustor and a steam manifold positioned about the transition piece. The transition piece may include a number of transition piece passageways therethrough and the steam manifold may include a number of manifold passageways therethrough. The manifold passageways align with the transition piece passageways.



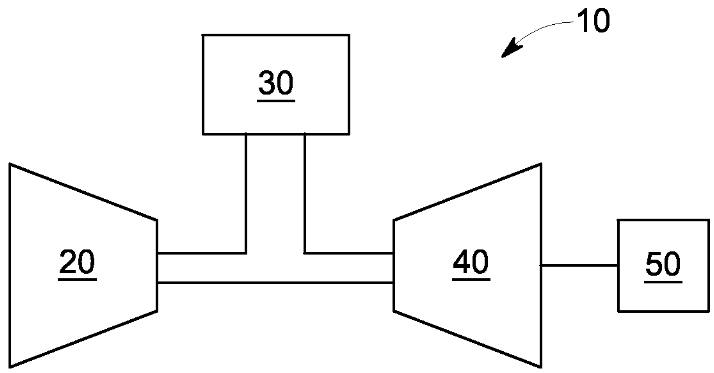


FIG. 1

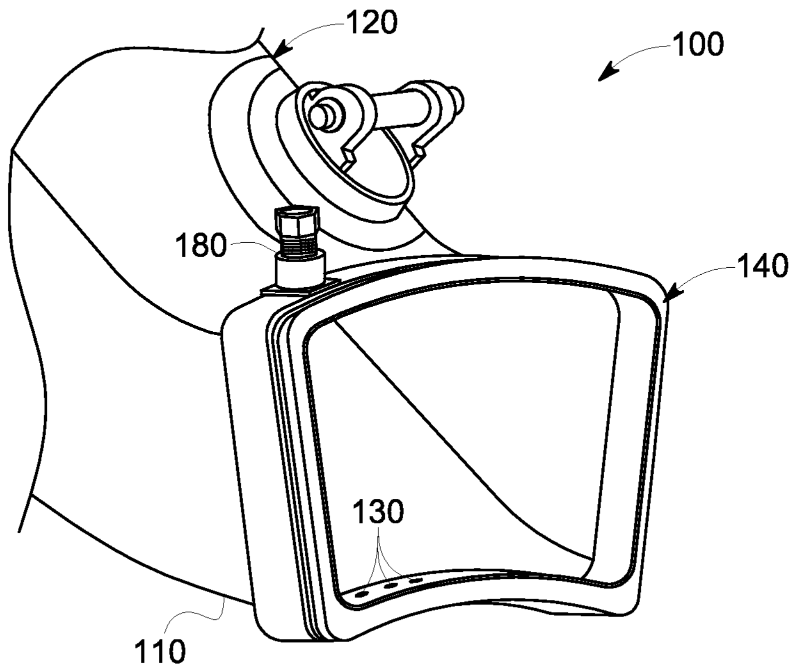


FIG. 2

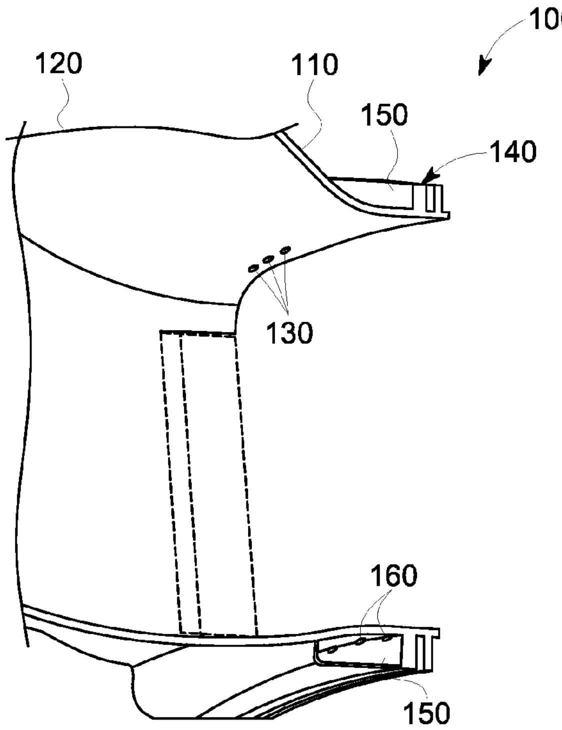

100
120
110
150
140
130
160
150

FIG. 3

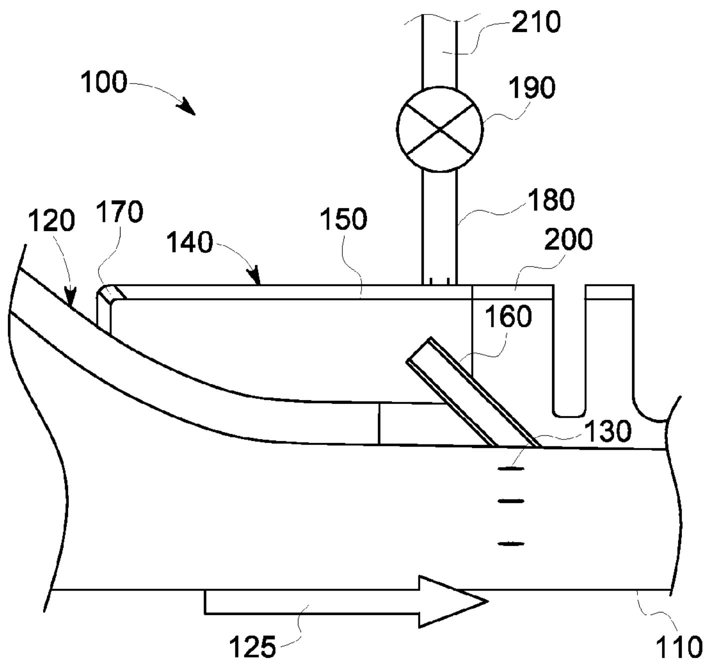

210
100
190
180
120
170
140
150
200
160
130
125
110

FIG. 4

POWER AUGMENTATION SYSTEM WITH DYNAMICS DAMPING

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This is a national stage application under 35 U.S.C. §371(c) prior-filed co-pending PCT patent application serial number PCT/RU2011/00226, filed on Mar. 31, 2011, the entire contents of which are incorporated herein by reference.

TECHNICAL FIELD

[0002] The present application relates generally to gas turbine engines and more particularly relates to a steam manifold positioned about a transition piece of a combustor so as to provide power augmentation and dynamics damping.

BACKGROUND OF THE INVENTION

[0003] Using a lean fuel air mixture is a known method of decreasing NO_x emissions and currently is in use in multiple designs of gas turbine combustion systems. The lean fuel air mixture includes an amount of fuel premixed with a large amount of excess air. Although such a lean mixture reduces the amount of NO_x emissions, high frequency combustion instabilities may result. Such instabilities may be referred to as combustion dynamics. These instabilities may be caused by burning rate fluctuations and may create damaging pressure oscillations that may impact on gas turbine durability. As a result of these instabilities, damping or resonating devices may be used with the combustor.

[0004] Providing additional mass flow into a gas turbine is a known method of enhancing overall gas turbine engine power output and efficiency. Steam injection is commonly used for this purpose. For instance, about a five percent (5%) steam addition to a gas turbine combined cycle system may result in about a ten percent (10%) output increase. Issues may arise, however, because the steam may impact on flame stability and freeze CO oxidation in the combustor. As such, the use of steam injection may limit overall emissions and turndown capabilities of gas turbines.

[0005] There is therefore a desire for improved combustion dynamics damping as well as power augmentation systems and methods. Preferably, such systems and methods may increase overall system performance and efficiency while reducing combustion dynamics.

SUMMARY OF THE INVENTION

[0006] The present application thus provides a power augmentation system for a gas turbine engine. The power augmentation system may include a transition piece of a combustor and a steam manifold positioned about the transition piece. The transition piece may include a number of transition piece passageways therethrough and the steam manifold may include a number of manifold passageways therethrough. The manifold passageways may align with the transition piece passageways.

[0007] The present application further provides a power augmentation system for a gas turbine engine. The power augmentation system may include a transition piece of a combustor and a steam manifold positioned about the transition piece. The transition piece may include a number of apertures extending therethrough and the steam manifold may include a number of tubes extending therethrough such that the apertures align with the tubes. The tubes may include a predetermined size based upon the frequency of the combustor.

[0008] The present application further provides a power augmentation system for a gas turbine engine. The power augmentation system may include a combustor and a steam manifold positioned about the combustor. The combustor may include a number of apertures extending therethrough and the steam manifold may include a number of tubes extending therethrough. The tubes may include a predetermined size based upon the frequency of the combustor.

[0009] These and other features and improvements of the present application will become apparent to one of ordinary skill in the art upon review of the following detailed description when taken in conjunction with the several drawings and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. **1** is a schematic view of a gas turbine engine.

[0011] FIG. **2** is a perspective view of a steam manifold system as is described herein.

[0012] FIG. **3** is a side cross-sectional view of the steam manifold system of FIG. **2**.

[0013] FIG. **4** is a further side cross-sectional view of the steam manifold system of FIG. **2**.

DETAILED DESCRIPTION

[0014] Referring now to the drawings, in which like numbers refer to like elements throughout the several views, FIG. **1** shows a schematic view of a gas turbine engine **10**. As is known, the gas turbine engine **10** may include a compressor **20** to compress an incoming flow of air. The compressor **20** delivers the compressed flow of air to a combustor **30**. The combustor **30** mixes the compressed flow of air with the compressed flow of fuel and ignites the mixture. (Although only a single combustor **30** is shown, the gas turbine engine **10** may include any number of combustors **30**.) The hot combustion gases are in turn delivered to a turbine **40**. The hot combustion gases drive the turbine **40** so as to produce mechanical work. The mechanical work produced in the turbine **40** drives the compressor **20** and an external load **50** such as an electrical generator and the like. The gas turbine engine **10** may use natural gas, various types of syngas, and other types of fuel. The gas turbine engine **10** may have many other configurations and may use other types of components. Multiple gas turbine engines **10**, other types of turbines, and other types of power generation equipment may be used herein together.

[0015] FIGS. **2-4** show a power augmentation system with dynamics damping or a steam manifold system **100** as is described herein. The steam manifold system **100** may be positioned at an end **110** of a transition piece **120** of the combustor **30**. The transition piece **120** directs a stream of hot exhaust gases **125** from the combustor **30** to the turbine **40** as is described above. The transition piece **120** may have a number of apertures **130** positioned about the end **110** thereof. Any number of the apertures **130** may be used. Some of the apertures **130** may be positioned at an angle with respect to the direction of the stream of hot exhaust gases **125** through the combustor **30**. The angle may be about 30 to about 60 degrees, although any desired angle may be used herein. The apertures **130** may have any desired size or shape as is described in more detail below.

[0016] The steam manifold system **100** may include a steam manifold **140** positioned about the end **110** of the transition piece **120** in the vicinity of the apertures **130**. The steam manifold **140** may have any desired size or shape. The steam manifold **140** may include an internal cavity **150**. The cavity **150** may surround the end **110** of the transition piece **120**. The steam manifold **140** may have a number of tubes **160** on one end thereon. The tubes **160** may be in communication with the apertures **130** of the transition piece **120**. Any number of the tubes **160** may be used. The tubes **160** also may be positioned at an angle with respect to the stream of hot exhaust gases **125**. As above, the angle may be about 30 to about 60 degrees although any angle may be used. The tubes **160** may have any desired size or shape as is described in more detail below. The steam manifold **140** also may have a number of purge holes **170** positioned therein. Any number of the purge holes **170** may be used herein. The purge holes **170** may have any desired size or shape.

[0017] The steam manifold system **100** may have a steam passage **180**. The steam passage **180** may be in communication with the cavity **150** of the steam manifold **140**. The steam passage **180** may have a valve **190** mounted thereon. The steam passage **180** may be mounted on an aft frame **200** of the transition piece **120**. Other positions may be used herein. The steam passage **180** may provide a volume of steam **210** to the cavity **150** of the steam manifold **140**. The quality and characteristics of the steam **210** may vary.

[0018] In use, the steam **210** from the steam passage **180** may pass into the cavity **150** of the steam manifold **140**. Most of the volume of the steam **210** passes through the tubes **160** of the steam manifold **140**, through the apertures **130** of the transition piece **120** and into the stream of hot exhaust gases **125** towards the turbine **40**. A small volume of the steam **210** may pass through the purge holes **170** and into a compressor discharge zone, mix with compressor airflow and then pass into combustor, thus reducing NO_x emission.

[0019] In a secondary mode of operation, the valve **190** of the steam passage **180** may be closed. Air from the compressor discharge zone thus may pass through the purge holes **170**, the cavity **150** the tubes **160** of the steam manifold **140**, and through the apertures **130** of the transition piece **120**.

[0020] The steam manifold system **100** may be used on a MS6001V combustor offered by General Electric Company of Schenectady, N.Y. The steam manifold system **100** may be installed on any type of can, annular, or can-annular type combustion system at the aft end of the transition piece **120** or otherwise.

[0021] Injection of the steam **210** just upstream of the turbine **40** thus provides for enhanced power output and efficiency. The positioning of the steam manifold **140** about the end **110** of the transition piece **120** ensures that the steam **210** is injected downstream of the reaction zone of the combustor **30** and just upstream of the turbine **40**. The injection **40** of the steam **210** thus does not impact on the reaction temperature of the combustor **30** such that CO emissions should not increase. The impact on flame stability also is lessened.

[0022] The steam manifold system **100** also may act as a type of a Helmholtz resonator. A Helmholtz resonator provides a cavity having a sidewall with openings therethrough. The fluid inertia of the gasses within the pattern of the apertures **130** and the tubes **160** may be reacted by the volumetric stiffness of the closed cavity **150** so as to produce a resonance in the velocity of the flow of the steam **210** therethrough. The number, length, diameter, shape, position of the apertures **130**, the tubes **160**, and the volume of the cavity **150** may vary with respect to the damping frequency range. Specifically, the design criteria may include the size of the apertures **130** and the tubes **160**, the diameter of the apertures **130** and the tubes **160**, the number of the apertures **130** and the tubes **160**, the mass flow rate through the cavity **150**, and the volume of the cavity **150**.

[0023] The dynamic pulsation spectrum of the combustor **30** may be determined from known testing methods. The apertures **130** and the tubes **160** are sized to allow low velocity steam to discharge into combustor **30**. As such, the dynamic pressure pulsations at any frequency may be dampened by the steam manifold system **100**. Further, the frequencies may be dampened without the use of a separate resonator. Any number of steam manifolds **140** may be used herein such that a number of different frequencies can be dampened.

[0024] The steam manifold system **100** thus provides power augmentation to the gas turbine engine **10** with minimal impact on increasing CO emissions or flame stability. Likewise, the steam manifold system **100** may effectively damp dynamic pulsations in the combustor **30** so as to improve operability and lessen durability risks. The steam manifold system **100** thus generally increases power output while also decreasing forced outages and combustion inspection intervals. As such, the steam manifold system **100** may reduce repair and operation costs.

[0025] It should be apparent that the foregoing relates only to certain embodiments of the present application and that numerous changes and modifications may be made herein by one of ordinary skill in the art without departing from the general spirit and scope of the invention as defined by the following claims and the equivalents thereof.

We claim:

1. A power augmentation system with dynamics damping for a gas turbine engine, comprising:
- a transition piece of a combustor;
- a steam manifold positioned about the transition piece;
- the transition piece comprising a plurality of transition piece passageways therethrough; and
- the steam manifold comprising a plurality of manifold passageways therethrough;
- the plurality of manifold passageways aligning with the plurality of transition piece passageways.

2. The power augmentation system of claim **1**, wherein the plurality of transition piece passageways comprises a plurality of apertures therethrough.

3. The power augmentation system of claim **2**, wherein the plurality of apertures comprises a plurality of angled apertures.

4. The power augmentation system of claim **1**, wherein the steam manifold comprises a cavity therein.

5. The power augmentation system of claim **1**, wherein the plurality of manifold passageways comprises a plurality of tubes.

6. The power augmentation system of claim **5**, wherein the plurality of tubes comprises a plurality of angled tubes.

7. The power augmentation system of claim **1**, wherein the steam manifold comprises a plurality of purge holes.

8. The power augmentation system of claim **1**, wherein the transition piece comprises a frame and wherein the steam manifold comprises a steam passage positioned on the frame.

9. The power augmentation system of claim **1**, wherein the plurality of manifold passageways comprises a predetermined size based upon the frequency of the combustor.

10. A power augmentation system with dynamics damping for a gas turbine engine, comprising:
- a transition piece of a combustor;
- a steam manifold positioned about the transition piece;
- the transition piece comprising a plurality of apertures extending therethrough;
- the steam manifold comprising a plurality of tubes extending therethrough;
- the plurality of tubes comprising a predetermined size based upon the frequency of the combustor; and
- the plurality of apertures aligning with the plurality of tubes.

11. The power augmentation system of claim **10**, wherein the plurality of apertures comprises a plurality of angled apertures.

12. The power augmentation system of claim **10**, wherein the steam manifold comprises a cavity therein.

13. The power augmentation system of claim **10**, wherein the plurality of tubes comprises a plurality of angled tubes.

14. The power augmentation system of claim **10**, wherein the steam manifold comprises a plurality of purge holes.

15. The power augmentation system of claim **10**, wherein the transition piece comprises a frame and wherein the steam manifold comprises a steam passage positioned on the frame.

16. A power augmentation system with dynamics damping for a gas turbine engine, comprising:
- a combustor;
- a steam manifold positioned about the combustor;
- the combustor comprising a plurality of apertures extending therethrough;
- the steam manifold comprising a plurality of tubes extending therethrough; and
- the plurality of tubes comprising a predetermined size based upon the frequency of the combustor.

17. The power augmentation system of claim **16**, wherein the combustor comprises a transition piece and wherein the steam manifold is positioned about the transition piece.

18. The power augmentation system of claim **16**, wherein the plurality of apertures align with the plurality of tubes.

19. The power augmentation system of claim **16**, wherein the plurality of apertures comprises a plurality of angled apertures.

20. The power augmentation system of claim **16**, wherein the plurality of tubes comprises a plurality of angled tubes.

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