United States Patent Application Publication	20250264218
Kind Code	A1
Publication Date	August 21, 2025
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COMBUSTOR ASSEMBLY INCLUDING A FUEL INJECTION SYSTEM FOR A TURBOMACHINE

Abstract

A combustor assembly for a turbomachine includes a combustor housing defining a combustion chamber. The combustor housing includes an inlet portion, an outlet portion, and an axial axis extending between the inlet portion and the outlet portion. A first annular plenum is arranged at the inlet portion. The first annular plenum includes a first inlet and a first outlet. A second annular plenum radially spaced from the first annular plenum is arranged at the inlet portion. The second annular plenum includes a second inlet, a second outlet, a vortex inducing member arranged between the second inlet and the second outlet, and a fuel outlet. The second outlet includes a pre-filming surface that forms an annular ring of fuel that enters the second annular plenum through the fuel outlet and passes from the second annular plenum into a swirling fluid passing through the first outlet and the second outlet.

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Family ID: **1000008770504**

Appl. No.: **18/442159**

Filed: **February 15, 2024**

Publication Classification

Int. Cl.: **F23R3/14** (20060101); **F02C7/22** (20060101); **F23R3/28** (20060101)

U.S. Cl.:

CPC **F23R3/14** (20130101); **F02C7/22** (20130101); **F23D5/06** (20130101); **F23R3/286** (20130101); F05D2240/35 (20130101)

Background/Summary

BACKGROUND

[0001] The subject disclosure relates to the art of turbomachines and, more particularly, to a combustor assembly including a fuel injection system for a turbomachine.

[0002] Turbomachines include a compressor, a combustor, and a turbine. The compressor compresses air which is combined with fuel in the combustor to create a mixture that is ignited to create high pressure gases. The high pressure gases expand through the turbine creating energy that may be used to power an airplane, a generator, or the like. The combustor includes multiple fuel injectors that direct an amount of fuel into compressed gases provided by the compressor. The amount of fuel and air mix in a combustion chamber of the combustor, are atomized, and then ignited.

[0003] The fuel injectors are typically arranged in a ring and inserted through a combustor housing. The injectors are annularly spaced about the combustion chamber. Given the geometry of the injectors, the fuel is injected into the compressed air at discrete locations and atomized. The spacing of the injectors creates fuel streams that enter axially into the combustion chamber. When ignited, hot spots and cold zones are generated in the combustion chamber. The cold zones are formed between injection streams. Hot and cold zones lead to less than efficient combustion, increased NOx emissions, as well as a decrease in an overall operational life of the turbine.

BRIEF DESCRIPTION

[0004] A combustor assembly for a turbomachine, in accordance with a non-limiting example, includes a combustor housing defining a combustion chamber. The combustor housing includes an inlet portion, an outlet portion, and an axial axis extending between the inlet portion and the outlet portion. A first annular plenum is arranged at the inlet portion. The first annular plenum includes a first inlet and a first outlet. A second annular plenum radially spaced from the first annular plenum is arranged at the inlet portion. The second annular plenum includes a second inlet, a second outlet, a vortex inducing member arranged between the second inlet and the second outlet, and a fuel outlet. The second outlet includes a pre-filming surface that forms an annular ring of fuel that enters the second annular plenum through the fuel outlet and passes from the second annular plenum into a swirling fluid passing through the first outlet and the second outlet.

[0005] In accordance with additional or alternative embodiments, the vortex inducing member includes a plurality of guide vanes extending between the second inlet and the second outlet.

[0006] In accordance with additional or alternative embodiments, the plurality of guide vanes are arranged in an annular array.

[0007] In accordance with additional or alternative embodiments, the fuel outlet is arranged between the plurality of guide vanes and the second outlet.

[0008] In accordance with additional or alternative embodiments, a fuel injector extends into the fuel outlet, the fuel injector including a first portion extending radially relative to the axial axis and a second portion extending from the first portion at a non-zero angle relative to axial axis.

[0009] In accordance with additional or alternative embodiments, the fuel injector includes an injector outlet at the second portion, the injector outlet guiding an amount of fuel along a pathway towards the pre-filming surface, the pathway including an axial component and a circumferential component.

[0010] In accordance with additional or alternative embodiments, the plurality of guide vanes extend at a first non-zero angle relative to the axial axis and the second portion of the fuel injector extends at a second non-zero angle relative to the axial axis, the second non-zero angle being substantially identical to the first non-zero angle.

[0011] In accordance with additional or alternative embodiments, the second annular plenum is

radially inwardly offset relative to the first annular plenum.
[0012] In accordance with additional or alternative embodiments, the vortex inducing member comprises a guide ring arranged between the first annular plenum and the second annular plenum, the guide ring including a plurality of fuel guide slots that direct fuel from the fuel outlet along a pathway towards the pre-filming surface, the pathway including an axial component and a circumferential component.
[0013] In accordance with additional or alternative embodiments, a fuel injector having an injector outlet extends through the injector outlet, the injector directing fuel toward the vortex inducing member along an axis that is substantially perpendicular to the axial axis.
[0014] A turbomachine, in accordance with a non-limiting example, includes a compressor, a turbine mechanically connected to the compressor, and a combustor assembly fluidically connected to the compressor and the turbine. The combustor assembly includes a combustor housing defining a combustion chamber. The combustor housing includes an inlet portion, an outlet portion, and an axial axis extending between the inlet portion and the outlet portion. A first annular plenum is arranged at the inlet portion. The first annular plenum includes a first inlet and a first outlet. A second annular plenum, radially spaced from the first annular plenum, is arranged at the inlet portion. The second annular plenum includes a second inlet, a second outlet, a vortex inducing member arranged between the second inlet and the second outlet, and a fuel outlet. The second outlet includes a pre-filming surface that forms an annular ring of fuel that enters the second annular plenum through the fuel outlet and passes from the second annular plenum into a swirling fluid passing through the first outlet and the second outlet.
[0015] In accordance with additional or alternative embodiments, the vortex inducing member includes a plurality of guide vanes extending between the second inlet and the second outlet.
[0016] In accordance with additional or alternative embodiments, the plurality of guide vanes are arranged in an annular array.
[0017] In accordance with additional or alternative embodiments, the fuel outlet is arranged between the plurality of guide vanes and the second outlet.
[0018] In accordance with additional or alternative embodiments, a fuel injector extends into the fuel outlet, the fuel injector including a first portion extending radially relative to the axial axis and a second portion extending from the first portion at a non-zero angle relative to axial axis.
[0019] In accordance with additional or alternative embodiments, the fuel injector includes an injector outlet at the second portion, the injector outlet guiding an amount of fuel along a pathway towards the pre-filming surface, the pathway including an axial component and a circumferential component.
[0020] In accordance with additional or alternative embodiments, the plurality of guide vanes extend at a first non-zero angle relative to the axial axis and the second portion of the fuel injector extends at a second non-zero angle relative to the axial axis, the second non-zero angle being substantially identical to the first non-zero angle.
[0021] In accordance with additional or alternative embodiments, the second annular plenum is radially inwardly offset relative to the first annular plenum.
[0022] In accordance with additional or alternative embodiments, the vortex inducing member comprises a guide ring arranged between the first annular plenum and the second annular plenum, the guide ring including a plurality of fuel guide slots that direct fuel from the fuel outlet along a pathway towards the pre-filming surface, the pathway including an axial component and a circumferential component.
[0023] In accordance with additional or alternative embodiments, a fuel injector having an injector outlet extends through the fuel outlet, the injector directing fuel toward the vortex inducing member along an axis that is substantially perpendicular to the axial axis.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] The following descriptions should not be considered limiting in any way. With reference to the accompanying drawings, like elements are numbered alike:

[0025] FIG. **1** is a schematic diagram of a turbomachine including a combustor assembly having a fuel injection system, in accordance with a non-limiting example;

[0026] FIG. **2** is a cross-sectional view of the fuel injection system mounted in the combustor assembly, in accordance with a non-limiting example;

[0027] FIG. **3** is a partial cross-sectional view of the combustor assembly and fuel injection system without the fuel injector, in accordance with a non-limiting example;

[0028] FIG. **4** is a partial cross-sectional view of the combustor assembly and fuel injection system of FIG. **3** with the fuel injector installed, in accordance with a non-limiting example;

[0029] FIG. **5** is a cross-sectional view of an injection end of the fuel injector of FIG. **4**, in accordance with a non-limiting example;

[0030] FIG. **6** is a partial perspective view of the combustor assembly and fuel injection system, in accordance with a non-limiting example;

[0031] FIG. **7** is a partial cross-sectional view of a combustor assembly and fuel injection system, in accordance with another non-limiting example;

[0032] FIG. **8** is a partial cross-sectional view of a combustor assembly and fuel injection system, in accordance with yet another non-limiting example;

[0033] FIG. **9** is a partial cross-sectional view of a first portion of the fuel injection system of FIG. **8**, in accordance with a non-limiting example; and

[0034] FIG. **10** is a partial perspective view of a second portion of the fuel injection system of FIG. **8**, in accordance with a non-limiting example.

DETAILED DESCRIPTION

[0035] A detailed description of one or more embodiments of the disclosed apparatus and method are presented herein by way of exemplification and not limitation with reference to the Figures.

[0036] A turbomachine, in accordance with a non-limiting example, is indicated generally at **10** in FIG. **1**. Turbomachine **10** includes a compressor **14** mechanically connected to a turbine **16** through a shaft **18**. Compressor **14** is also fluidically connected to turbine **16** through a combustor assembly **20**. Combustor assembly **20** combines compressed air from compressor **14** with a fuel to form a combustible mixture. The combustible mixture is ignited in combustor assembly **20** and passed into turbine **16** as high pressure high temperature gases. The high temperature high pressure gases expand through turbine **16** creating power that may be used, for example, to provide thrust to an aircraft.

[0037] Referring to FIG. **2** and with continued reference to FIG. **1**, combustor assembly **20** includes a combustor housing **30** having an outer surface **32** and an inner surface **34** that defines a combustion chamber **36**. Combustion chamber **36** includes an inlet portion **38** connected to compressor **14** and a source of fuel **39** and an outlet portion **40**. In a non-limiting example, inlet portion **38** is spaced from outlet portion **40** along an axial axis “A”. Combustor assembly **20** includes a first annular plenum **46** and a second annular plenum **48**. In a non-limiting example, first annular plenum **46** defines an outer air plenum (not separately labeled) and second annular plenum **48** defines an inner air plenum (also not separately labeled). As will be detailed more fully herein, first annular plenum **46** and second annular plenum **48** create and introduce an annular ring of fuel that is atomized and combusted in combustion chamber **36**.

[0038] In a non-limiting example, first annular plenum **46** includes a first inlet **56** and a first outlet **58** that is spaced from first inlet **56** along axial axis “A”. First outlet **58** is arranged at a first non-zero angle relative to axial axis “A”. In a non-limiting example, the first non-zero angle forces first

outlet **58** to direct an airflow radially inwardly and axially along combustion chamber **36**. Second annular plenum **48** includes a second inlet **60** and a second outlet **62** spaced from second inlet **60** along axial axis “A”. Second outlet **62** is arranged at a second non-zero angle relative to axial axis “A”. As will be detailed more fully herein, the second non-zero angle forces an air fuel mixture radially outwardly and circumferentially into combustion chamber **36** to mix with and be atomized by air passing from first outlet **58**. Second annular plenum **48** also includes a fuel outlet **64** that is disposed between second inlet **60** and second outlet **62** in accordance with a non-limiting example.

[0039] As shown in FIGS. **3** and **4** and with continued reference to FIG. **2**, a vortex inducing member **68** is arranged at inlet portion **38**. Vortex inducing member **68** defines, in part, second annular plenum **48**. Vortex inducing member **68** includes a plurality of guide vanes **74** arranged between second inlet **60** and second outlet **62**. Guide vanes **74** may be spaced circumferentially about second annular plenum **48** and arranged to impart a swirling motion to air passing through second annular plenum **48**. In a non-limiting example, second outlet **62** includes a first section **78** defining a pre-filming surface **80** and a second section **82** defining a guide surface **84**. As discussed herein, first outlet **58** and second outlet **62** form converging airflows that meet in combustion chamber **36**. At this point, it should be understood that the term “pre-filming surface” describes a surface onto which a fuel is spread into an annular liquid sheet prior to being introduced into a high velocity airstream.

[0040] As will be detailed more fully herein, pre-filming surface **80** receives an amount of fuel from fuel outlet **64**. The amount of fuel is spread out onto pre-filming surface **80** forming a continuous annular liquid sheet or ring that is carried by air passing through second plenum **48** into air passing from first plenum **46** and immediately atomized forming an air fuel mixture that is then combusted to form the high pressure, high temperature gases having a substantially uniform temperature that are directed into and expanded through turbine **16**.

[0041] Referring to FIGS. **4** and **5** and with continued reference to FIGS. **2** and **3**, combustor assembly **20** includes a fuel injector **98** arranged in a fuel injector passage **100** (FIG. **3**) extending through combustor housing **30** and terminating at fuel outlet **64**. As shown in FIG. **5**, fuel injector **98** includes a fuel passage **104** having a first portion **106** that extends radially outwardly relative to axial axis “A” and a second portion **108** that is arranged at a non-zero angle relative to first portion **106**. Second portion **108** includes an injector outlet **112**. A continuous air gap **118** is arranged radially outwardly of, extends along, and encircles fuel passage **104**. The number and arrangement of air gaps may vary. Air gaps **118** and **120** provide a thermal buffer between fuel flowing through fuel passage **110** and adjacent surfaces of combustor assembly **20**.

[0042] Fuel flows from the source of fuel **39** into fuel injector **98**. The fuel enters fuel passage **104** and is passed from injector outlet **112**. The fuel exits fuel injector **98** and flows along a pathway towards second outlet **62**. The fuel spreads out onto pre-filming surface **80** forming a continuous annular liquid sheet or ring that is carried by air passing through second plenum **48** into air passing from first plenum **46** as shown in FIG. **6** and is immediately atomized forming an air fuel mixture that is then combusted to form the high pressure, high temperature gases having a substantially uniform temperature that are directed into and expanded through turbine **16**.

[0043] At this point it should be understood that while shown as having two annular plenums, the number of annular plenums arranged at inlet portion **38** of combustor housing **30** may vary as shown in FIG. **7**. A combustor assembly **126** shown in FIG. **7** includes a first annular plenum **130**, a second annular plenum **132** arranged radially inwardly of first annular plenum **130**, a third annular plenum **136** arranged radially inwardly of second annular plenum **132**, and a fourth annular plenum **138** arranged radially inwardly of third annular plenum **136**. A first vortex inducing member **140** is arranged in second annular plenum **132** and a second vortex inducing member **142** is arranged in fourth annular plenum **138**.

[0044] A fuel injector **144** having a first portion **146**, a second portion **148**, and a third portion **150** extends through combustor assembly **126**. First portion **146** extends radially outwardly relative to

combustor axis “A”, second portion **148** and third portion **150** extend at a non-zero angle relative to first portion **146**. Second portion **148** includes a first injector outlet (not shown) arranged at first vortex inducing member **140** and third portion **150** includes a second injector outlet (also not shown) arranged at second vortex inducing member **142**. Injector **144** may be operated to introduce a first annular air/fuel mixture and/or a second annular air/fuel mixture into combustor assembly **126** to establish a more robust and flexible control of high temperature/high pressure gases being passed into turbine **16**.

[0045] Instead of passing fuel through an angled injector outlet into a swirling air flow, a combustor assembly **152** as shown in FIG. **8** may be arranged to impart a swirl to the fuel prior to being introduced into the swirling airflow to promote atomization. Combustor assembly **152** includes a first annular plenum **154** and a second annular plenum **156**. Second annular plenum **156** is arranged radially inwardly of first annular plenum **154** relative to combustor axis “A”. A vortex inducing member **160** is arranged between first annular plenum **154** and second annular plenum **156**.

[0046] First annular plenum **154** includes a first inlet **163** and a first outlet **165**. First outlet extends at a first non-zero angle, having an axial component and a radial component, relative to combustor axis “A”. Second annular plenum **156** includes a second inlet **168** and a second outlet **170**. Second annular plenum **156** includes plurality of passages **172** extend at a second non-zero angle, having an axial component and a circumferential component, relative to axial axis “A”.

[0047] Plurality of passages **172** are arranged between second inlet **168** and second outlet **170** as shown in FIG. **9**. The first non-zero angle and the second non-zero angle impart a swirling motion to fluid passing through corresponding ones of first annular plenum **154** and second annular plenum **156**. A pre-filming member **174** is arranged about second outlet **170**. Pre-filming member **174** extends over vortex inducing member **160**. Pre-filming member **174** includes a pre-filming surface **178** arranged axially outwardly of second outlet **170** along combustor axis “A”. A heat shield **184** extends about pre-filming member **174** providing a thermal barrier to fuel passing into combustion chamber **36**.

[0048] As shown in FIG. **9**, a fuel passage **196** is arranged between first annular plenum **154** (FIG. **8**) and second annular plenum **156** (FIG. **8**). A fuel outlet **198** is provided in fuel passage **196**. Vortex inducing member **160** is arranged in fuel passage **196**. Vortex inducing member **160** is shown in the form of a guide ring, FIG. **10**, (not separately labeled) including a first end section **202** arranged at fuel outlet **198** and a second end section **204** axially inwardly spaced from pre-filming surface **178**. A fuel plenum **206** is formed in vortex inducing member **160** at first end section **202**. Fuel plenum **206** is arranged radially inwardly of fuel outlet **198**. Vortex inducing member **160** includes a vortex inducing portion **210** arranged between fuel plenum **206** and second end section **204**. Vortex inducing portion **210** includes a plurality of fuel guide slots **212**, as shown in FIG. **10**, that extend at a non-zero angle relative to axial axis “A”.

[0049] A fuel injector **220** is arranged in combustor assembly **152**. Fuel injector **220** extends radially through combustor assembly **152** to an injector outlet **222** arranged at fuel plenum **206**. Fuel flows from the source of fuel (not shown) into fuel injector **220**. The fuel flows into fuel plenum **206** and is passed into the plurality of fuel guide slots **212** of vortex inducing portion **210**. The fuel exits the plurality of fuel guide slots **212** at second end section **204** and passes to outlet member **174**. The fuel spreads out onto pre-filming surface **178** forming a continuous annular liquid sheet or ring that is carried by air passing through second plenum **156** into air passing from first plenum **154** and is immediately atomized forming an air fuel mixture.

[0050] At this point, it should be appreciated that instead of introducing multiple discrete fuel injections into a combustion chamber, the non-limiting examples described herein create a continuous or substantially continuous annular ring of atomized fuel that is then combusted to form the high pressure, high temperature gases having a substantially uniform temperature that are directed into and expanded through turbine **16**. The substantially uniform temperatures created by

forming and combusting an annular atomized fuel/air mixture enhances turbine efficiency reduces localized component wear, and increases an overall operational life of the turbomachine.
[0051] The term “about” is intended to include the degree of error associated with measurement of the particular quantity based upon the equipment available at the time of filing the application.
[0052] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the present disclosure. As used herein, the singular forms “a”, “an” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms “comprises” and/or “comprising,” when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, element components, and/or groups thereof.
[0053] While the present disclosure has been described with reference to an exemplary embodiment or embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the present disclosure. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the present disclosure without departing from the essential scope thereof. Therefore, it is intended that the present disclosure not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this present disclosure, but that the present disclosure will include all embodiments falling within the scope of the claims.

Claims

1. A combustor assembly for a turbomachine comprising: a combustor housing defining a combustion chamber, the combustor housing including an inlet portion, an outlet portion, and an axial axis extending between the inlet portion and the outlet portion; a first annular plenum arranged at the inlet portion, the first annular plenum including a first inlet and a first outlet; and a second annular plenum, radially spaced from the first annular plenum, is arranged at the inlet portion, the second annular plenum including a second inlet, a second outlet, a vortex inducing member arranged between the second inlet and the second outlet, and a fuel outlet, the second outlet including a pre-filming surface that forms an annular ring of fuel that enters the second annular plenum through the fuel outlet and passes from the second annular plenum into a swirling fluid passing through the first outlet and the second outlet.
2. The combustor assembly according to claim 1, wherein the vortex inducing member includes a plurality of guide vanes extending between the second inlet and the second outlet.
3. The combustor assembly according to claim 2, wherein the plurality of guide vanes are arranged in an annular array.
4. The combustor assembly according to claim 3, wherein the fuel outlet is arranged between the plurality of guide vanes and the second outlet.
5. The combustor assembly according to claim 4, further comprising a fuel injector extending into the fuel outlet, the fuel injector including a first portion extending radially relative to the axial axis and a second portion extending from the first portion at a non-zero angle relative to axial axis.
6. The combustor assembly according to claim 5, wherein the fuel injector includes an injector outlet at the second portion, the injector outlet guiding an amount of fuel along a pathway towards the pre-filming surface, the pathway including an axial component and a circumferential component.
7. The combustor assembly according to claim 5, wherein the plurality of guide vanes extend at a first non-zero angle relative to the axial axis and the second portion of the fuel injector extends at a second non-zero angle relative to the axial axis, the second non-zero angle being substantially identical to the first non-zero angle.
8. The combustor assembly according to claim 7, wherein the second annular plenum is radially

inwardly offset relative to the first annular plenum.

9. The combustor assembly according to claim 1, wherein the vortex inducing member comprises a guide ring arranged between the first annular plenum and the second annular plenum, the guide ring including a plurality of fuel guide slots that direct fuel from the fuel outlet along a pathway towards the pre-filming surface, the pathway including an axial component and a circumferential component.

10. The combustor assembly according to claim 9, further comprising a fuel injector having an injector outlet extending through the injector outlet, the injector directing fuel toward the vortex inducing member along an axis that is substantially perpendicular to the axial axis.

11. A turbomachine comprising: a compressor; a turbine mechanically connected to the compressor; and a combustor assembly fluidically connected to the compressor and the turbine, the combustor assembly comprising: a combustor housing defining a combustion chamber, the combustor housing including an inlet portion, an outlet portion, and an axial axis extending between the inlet portion and the outlet portion; a first annular plenum arranged at the inlet portion, the first annular plenum including a first inlet and a first outlet; and a second annular plenum, radially spaced from the first annular plenum, is arranged at the inlet portion, the second annular plenum including a second inlet, a second outlet, a vortex inducing member arranged between the second inlet and the second outlet, and a fuel outlet, the second outlet including a pre-filming surface that forms an annular ring of fuel that enters the second annular plenum through the fuel outlet and passes from the second annular plenum into a swirling fluid passing through the first outlet and the second outlet.

12. The turbomachine according to claim 11, wherein the vortex inducing member includes a plurality of guide vanes extending between the second inlet and the second outlet.

13. The turbomachine according to claim 12, wherein the plurality of guide vanes are arranged in an annular array.

14. The turbomachine according to claim 13, wherein the fuel outlet is arranged between the plurality of guide vanes and the second outlet.

15. The turbomachine according to claim 14, further comprising a fuel injector extending into the fuel outlet, the fuel injector including a first portion extending radially relative to the axial axis and a second portion extending from the first portion at a non-zero angle relative to axial axis.

16. The turbomachine according to claim 15, wherein the fuel injector includes an injector outlet at the second portion, the injector outlet guiding an amount of fuel along a pathway towards the pre-filming surface, the pathway including an axial component and a circumferential component.

17. The turbomachine according to claim 15, wherein the plurality of guide vanes extend at a first non-zero angle relative to the axial axis and the second portion of the fuel injector extends at a second non-zero angle relative to the axial axis, the second non-zero angle being substantially identical to the first non-zero angle.

18. The turbomachine according to claim 17, wherein the second annular plenum is radially inwardly offset relative to the first annular plenum.

19. The turbomachine according to claim 11, wherein the vortex inducing member comprises a guide ring arranged between the first annular plenum and the second annular plenum, the guide ring including a plurality of fuel guide slots that direct fuel from the fuel outlet along a pathway towards the pre-filming surface, the pathway including an axial component and a circumferential component.

20. The turbomachine according to claim 19, further comprising a fuel injector having an injector outlet extending through the fuel outlet, the injector directing fuel toward the vortex inducing member along an axis that is substantially perpendicular to the axial axis.