

FUEL AIR PREMIXER FOR GAS TURBINE ENGINE

BACKGROUND

[0001] The present disclosure relates to a gas turbine engine and, more particularly, to a fuel-air premixer therefor.

[0002] Gas turbine engines, such as those powering modern commercial and military aircraft, include a compressor for pressurizing an airflow, a combustor for burning a hydrocarbon fuel in the presence of the pressurized air, and a turbine for extracting energy from the resultant combustion gases. The combustor generally includes radially spaced inner and outer liners that define an annular combustion chamber therebetween. Arrays of circumferentially distributed combustion air holes penetrate multiple axial locations along each liner to radially admit the pressurized air into the combustion chamber. A plurality of circumferentially distributed fuel air premixer project into a forward section of the combustion chamber to supply fuel mixed with pressurized air.

[0003] Future gas turbine combustors may be required to meet aggressive emission requirements, particularly NO_x. Combustor schemes under development to achieve these goals will require a high degree of fuel/air mixing prior to combustion. The high combustor inlet temperatures may thereby lead to short autoignition time scales such that the fuel/air mixing must occur in a very short time.

SUMMARY

[0004] A fuel-air premixer for a combustor of a turbine engine according to one aspect of the present disclosure includes a central passage along an axis. The central passage is operable to communicate an unswirled airflow. An outer annular passage is located around the axis. The outer annular passage includes a multiple of first swirl vanes that are operable to communicate a first swirled airflow in a first direction. An inner annular passage is located around the axis between the central passage and the outer annular passage. The inner annular passage includes a multiple of second swirl vanes that are operable to communicate a second swirled airflow in a second direction different than the first direction.

[0005] In a further embodiment of the above, the multiple of first swirl vanes and the multiple of second swirl vanes define respective chord directions C1 and C2 that are transverse to the axis and to each other.

[0006] In a further embodiment of any of the above, the fuel-air premixer includes a swirler body extending around the outer annular passage, the inner annular passage, and the central passage.

[0007] In a further embodiment of any of the above, the multiple of first swirl vanes extend between the swirler body and a splitter plate, the multiple of second swirl vanes extend between the splitter plate and a central nozzle body that defines the central passage.

[0008] In a further embodiment of any of the above, the swirler body radially contracts downstream of the central nozzle body.

[0009] In a further embodiment of any of the above, the central nozzle body includes a multiple of fuel passages disposed radially outboard and parallel to the central passage.

[0010] In a further embodiment of any of the above, the multiple of fuel passages include respective fuel orifices that each extend in a radial direction.

[0011] In a further embodiment of any of the above, the fuel orifices are located downstream of the splitter plate.

[0012] In a further embodiment of any of the above, the fuel orifices are located downstream of the splitter plate at an axial distance greater than approximately five (5) diameters of the fuel orifices.

[0013] In a further embodiment of any of the above, the swirler body radially contracts downstream of the central nozzle body.

[0014] In a further embodiment of any of the above, the swirler body is axially spaced from the central nozzle body.

[0015] A gas turbine engine according to one aspect of the present disclosure includes a compressor section, a combustor in fluid communication with the compressor section and a turbine section in fluid communication with the combustor. The combustor includes a fuel-air premixer having a central passage along an axis. The central passage is operable to communicate an unswirled airflow. An outer annular passage is located around the axis. The outer annular passage includes a multiple of first swirl vanes that are operable to communicate a first swirled airflow in a first direction. An inner annular passage is located around the axis

between the central passage and the outer annular passage. The inner annular passage includes a multiple of second swirl vanes that are operable to communicate a second swirled airflow in a second direction different than the first direction.

[0016] A method of communicating fuel and air to a combustor of a turbine engine according to one aspect of the present disclosure includes communicating an unswirled airflow along an axis, communicating a first swirled airflow in a first direction around the unswirled airflow, communicating a second swirled airflow in a second direction different than the first direction forming a turbulent region and injecting fuel into the turbulent region.

[0017] A further embodiment of the above includes radially injecting the fuel outward relative to the axis into the turbulent region at a location approximately equivalent to a one-quarter auto-ignition time relative to an end of a swirler body.

[0018] A further embodiment of any of the above includes choking the unswirled airflow, the first swirled airflow and the second swirled airflow downstream of the turbulent region.

[0019] A further embodiment of any of the above includes providing essentially zero net swirl at an end of a swirler body that receives the unswirled airflow, the first swirled airflow and the second swirled airflow.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] Various features will become apparent to those skilled in the art from the following detailed description of the disclosed non-limiting embodiment. The drawings that accompany the detailed description can be briefly described as follows:

[0021] Figure 1 is a schematic cross-section of a gas turbine engine;

[0022] Figure 2 is a perspective partial sectional view of an exemplary annular combustor that may be used with the gas turbine engine shown in Figure 1;

[0023] Figure 3 is a sectional view of a fuel air premixer; and

[0024] Figure 4 is a schematic view of a premixer length with respect to an auto-ignition time.

DETAILED DESCRIPTION

[0025] Figure 1 schematically illustrates a gas turbine engine 20. The gas turbine engine 20 is disclosed herein as a two-spool turbofan that generally incorporates a fan section 22, a compressor section 24, a combustor section 26 and a turbine section 28. Alternative engines might include an augmentor section (not shown) among other systems or features. The fan section 22 drives air along a bypass flowpath while the compressor section 24 drives air along a core flowpath for compression and communication into the combustor section 26 then expansion through the turbine section 28. Although depicted as a turbofan gas turbine engine in the disclosed non-limiting embodiment, it should be understood that the concepts described herein are not limited to use with turbofans as the teachings may be applied to other types of turbine engines and land-based engines.

[0026] The engine 20 generally includes a low speed spool 30 and a high speed spool 32 mounted for rotation about an engine central longitudinal axis A relative to an engine static structure 36 via several bearing systems 38. It should be understood that various bearing systems 38 at various locations may alternatively or additionally be provided.

[0027] The low speed spool 30 generally includes an inner shaft 40 that interconnects a fan 42, a low pressure compressor 44 and a low pressure turbine 46. The inner shaft 40 is connected to the fan 42 through a geared architecture 48 to drive the fan 42 at a lower speed than the low speed spool 30. The high speed spool 32 includes an outer shaft 50 that interconnects a high pressure compressor 52 and high pressure turbine 54. A combustor 56 is arranged between the high pressure compressor 52 and the high pressure turbine 54. The inner shaft 40 and the outer shaft 50 are concentric and rotate about the engine central longitudinal axis A which is collinear with their longitudinal axes.

[0028] The core airflow is compressed by the low pressure compressor 44 then the high pressure compressor 52, mixed and burned with fuel within the combustor 56, then expanded over the high pressure turbine 54 and low pressure turbine 46. The turbines 54, 46 rotationally drive the respective low speed spool 30 and high speed spool 32 in response to the expansion.

[0029] With reference to Figure 2, the combustor 56 generally includes an outer combustor liner 60 and an inner combustor liner 62. The outer combustor liner 60 and the inner

combustor liner 62 are spaced inward from a combustor case 64 such that a combustion chamber 66 is defined there between. The combustion chamber 66 is generally annular in shape and is defined between combustor liners 60, 62.

[0030] The outer combustor liner 60 and the combustor case 64 define an outer annular plenum 76 and the inner combustor liner 62 and the combustor case 64 define an inner annular plenum 78. It should be understood that although a particular combustor is illustrated, other combustor types with various combustor liner panel arrangements will also benefit herefrom. It should be further understood that the disclosed cooling flow paths are but an illustrated embodiment and should not be limited only thereto.

[0031] The combustor liners 60, 62 contain the flame for direction toward the turbine section 28. Each combustor liner 60, 62 generally includes a support shell 68, 70 which supports one or more liner panels 72, 74 mounted to a hot side of the respective support shell 68, 70. The liner panels 72, 74 define a liner panel array which may be generally annular in shape. Each of the liner panels 72, 74 may be generally rectilinear and manufactured of, for example, a nickel based super alloy or ceramic material.

[0032] The combustor 56 further includes a forward assembly 80 immediately downstream of the compressor section 24 to receive compressed airflow therefrom. The forward assembly 80 generally includes an annular hood 82, a bulkhead assembly 84, a multiple of premixers 86 (one shown) and a multiple of fuel nozzle guides 90 (one shown) along an opening 92. In this example, the premixer 86 is shown at the forward assembly 80. It is to be understood, however, that the location and size of the premixers 86 can vary depending on the particular design of the combustor. Put another way, the size and number of premixers 86 can be varied from the illustrated example and one or more premixers 86 can additionally or alternatively be located through either or both of the support shells 68, 70.

[0033] The annular hood 82 extends radially between, and is secured to, the forwardmost ends of the liners 60, 62. The annular hood 82 includes a multiple of circumferentially distributed hood ports 94 that accommodate the respective fuel-air premixer 86 and introduce air into the forward end of the combustion chamber 66. Each fuel-air premixer 86 may be secured to the outer case 64 and projects through one of the hood ports 94 and through the opening 92 of the respective fuel nozzle guide 90. It should be understood that various additional or alternative structure may also be utilized.

[0034] Each of the fuel nozzle guides 90 is circumferentially aligned with one of the hood ports 94 to project through the bulkhead assembly 84. Each bulkhead assembly 84 includes a bulkhead support shell 96 secured to the liners 60, 62, and a multiple of circumferentially distributed bulkhead heat shield segments 98 secured to the bulkhead support shell 96 around the central opening 92.

[0035] The forward assembly 80 introduces primary core combustion air into the forward end of the combustion chamber 66 while the remainder enters the outer annular plenum 76 and the inner annular plenum 78. The multiple of premixers 86 and surrounding structure generate a swirling, intimately blended fuel-air mixture that supports combustion in the combustion chamber 66.

[0036] With reference to Figure 3, each of the multiple of fuel-air premixers 86 include a swirler body 100, a central nozzle body 102, a main nozzle body 104, a multiple of fuel conduits 106, a splitter plate 108, a multiple of first swirl vanes 110 and a multiple of second swirl vanes 112. The multiple of fuel conduits 106 extend between the central nozzle body 102 and the main nozzle body 104 to permit airflow into the central nozzle body 102. That is, the multiple of fuel conduits 106 are essentially tubes which are of minimal cross-sectional area so as to not block airflow thereby. The swirler body 100 includes a convergent section 100C that generally corresponds with a frusto-conical end 102A of the nozzle body 102 to maintain relatively high airflow velocities to prevent flashback. It should be appreciated that additional or alternative components may also be utilized.

[0037] A central passage 114 is defined along a premixer axis P within the central nozzle body 102. The central passage 114 facilitates the communication of unswirled airflow into the swirler body 100. An outer annular passage 116 is defined around the axis P between the swirler body 100 and the splitter plate 108. The multiple of first swirl vanes 110 extend between the swirler body 100 and the splitter plate 108 to facilitate the communication of a first swirled airflow into the swirler body 100. An inner annular passage 118 is defined around the axis P between the splitter plate 108 and the central nozzle body 102. The multiple of second swirl vanes 112 extend between the splitter plate 108 and the central nozzle body 102 to facilitate the communication of a second swirled airflow into the swirler body 100.

[0038] The multiple of first swirl vanes 110 and the multiple of second swirl vanes 112 define respective chord directions C1 and C2 (shown schematically) that are transverse to

the axis P and to each other. The transverse orientation generates annular swirled airflows. In this example, the airflows generated by the first swirl vanes 110 and the second swirl vanes 112 have component vectors in opposite directions to generate a highly turbulent region in the vicinity of an orifice 120 from each of a multiple of fuel passages 122 within the fuel conduits 106 and central nozzle body 102. For example, the multiple of first swirl vanes 110 generate annular swirled flow in a clockwise direction and the multiple of second swirl vanes 112 generate annular swirled flow in a counter-clockwise direction, or vice versa. The highly turbulent region facilitates the mixing of the radially injected fuel but then the counter-swirling essentially cancel each other out to provide an essentially zero net swirl at an end 100A of the swirler body 100.

[0039] The fuel orifices 120 from each of the multiple of fuel passages 122 extend in a radial direction toward the highly turbulent region. The orifices 120 are axially located at a location L (Figure 4) approximately equivalent to a one-quarter ($\frac{1}{4}$) auto-ignition time relative to an end 100A of the swirler body 100 or, described another way, the orifices 120 are located downstream of the splitter plate 108 at an axial distance greater than approximately five (5) diameters of one of the orifices 120, assuming that the orifices 120 are of equivalent diameters. If the orifices 120 are not of equivalent diameters, the five (5) diameter axial distance can be with regard to an average diameter of the orifices 120, smallest diameter of the orifices or largest diameter of the orifices, for example.

[0040] The given location L limits or essentially eliminates the potential for the fuel/air mixture to auto-ignite within the premixer 86. High-efficiency engines may operate at high pressure ratios, and may have high combustor inlet temperatures. These high temperatures can lead to reduced auto-ignition times, which represent a practical limit to the residence time of the fuel/air mixture in the premixer 86. However, the given location L that corresponds to a one-quarter ($\frac{1}{4}$) auto-ignition ensures that the residence time is well below the auto-ignition time.

[0041] The fuel-air premixer 86 achieves effective fuel/air mixing through injection of the fuel jets F into the high-shear region R where the counter-swirling air flows meet. This mixing layer is characterized by high levels of turbulence, which operate to further atomize the fuel into small droplets and to disperse those droplets through the swirler body 100. Small droplets evaporate quickly, and once the fuel has been vaporized, the turbulent air flow acts to mix the fuel vapor with the air.

[0042] The fuel-air premixer 86 efficiently mixes liquid fuel with air by the end of the swirler body 100 to enable low pollutant emissions through minimization of lean or rich excursions from the design fuel/air ratio that would lead to higher emissions. The liquid fuel is mostly vaporized by the end 100A of the premixer 86, especially at high power operating conditions to improve mixing and reduce pollutant. The mixing of the fuel and air generated by the swirl vanes 110 and 112 also limits or eliminates flame "flash back" into the premixer 86. That is, the highly turbulent region in the vicinity of the orifice 120 from the fuel passages 122 within the fuel conduits 106 and central nozzle body 102 and cancellation of the counter-swirling to provide an essentially zero net swirl at an end 100A of the swirler body 100 limit or eliminate regions of low or negative velocity that would otherwise allow the flame to propagate from the combustor upstream into the premixer, where significant damage may be the result.

[0043] The premixer 86 is also relatively uncomplicated to manufacture, simple and scaleable as many low-emissions combustor designs use a large number of premixers in a staged array.

[0044] It should be understood that relative positional terms such as "forward," "aft," "upper," "lower," "above," "below," and the like are with reference to the normal operational attitude of the vehicle and should not be considered otherwise limiting.

[0045] Although the different non-limiting embodiments have specific illustrated components, the embodiments of this invention are not limited to those particular combinations. It is possible to use some of the components or features from any of the non-limiting embodiments in combination with features or components from any of the other non-limiting embodiments.

[0046] It should be understood that like reference numerals identify corresponding or similar elements throughout the several drawings. It should also be understood that although a particular component arrangement is disclosed in the illustrated embodiment, other arrangements will benefit herefrom.

[0047] Although particular step sequences are shown, described, and claimed, it should be understood that steps may be performed in any order, separated or combined unless otherwise indicated and will still benefit from the present disclosure.

[0048] The foregoing description is exemplary rather than defined by the limitations within. Various non-limiting embodiments are disclosed herein, however, one of ordinary skill

in the art would recognize that various modifications and variations in light of the above teachings will fall within the scope of the appended claims. It is therefore to be understood that within the scope of the appended claims, the disclosure may be practiced other than as specifically described. For that reason the appended claims should be studied to determine true scope and content.

CLAIMS

1. A fuel-air premixer for a combustor of a turbine engine comprising:
 - a central passage along an axis, said central passage operable to communicate an unswirled airflow;
 - an outer annular passage around said axis, said outer annular passage including a multiple of first swirl vanes operable to communicate a first swirled airflow in a first direction;
 - an inner annular passage around said axis between said central passage and said outer annular passage, said inner annular passage including a multiple of second swirl vanes operable to communicate a second swirled airflow in a second direction different than said first direction; and
 - a swirler body extending around said outer annular passage, said inner annular passage, and said central passage, wherein:
 - said multiple of first swirl vanes extend between said swirler body and a splitter plate, said multiple of second swirl vanes extend between said splitter plate and a central nozzle body that defines said central passage, and
 - said central nozzle body includes fuel orifices at a location L that is greater than approximately five (5) diameters of said fuel orifices from said splitter plate and that corresponds to a one-quarter ($\frac{1}{4}$) auto-ignition time relative to an end of said swirler body.
2. The fuel-air premixer as recited in claim 1, wherein said multiple of first swirl vanes and said multiple of second swirl vanes define respective chord directions C1 and C2 that are transverse to said axis and to each other.
3. The fuel-air premixer as recited in claim 1, wherein said swirler body radially contracts downstream of said central nozzle body.
4. The fuel-air premixer as recited in claim 3, wherein said central nozzle body includes a multiple of fuel passages disposed radially outboard and parallel to said central passage.
5. The fuel-air premixer as recited in claim 4, wherein said fuel orifices extend in a radial direction from said multiple of fuel passages.
6. The fuel-air premixer as recited in claim 1, wherein said swirler body is spaced in the axial direction from said central nozzle body.

7. A gas turbine engine comprising:
- a compressor section;
 - a combustor in fluid communication with said compressor section; and
 - a turbine section in fluid communication with said combustor,
- said combustor including a fuel-air premixer having a central passage along an axis, said central passage operable to communicate an unswirled airflow, an outer annular passage around said axis, said outer annular passage including a multiple of first swirl vanes operable to communicate a first swirled airflow in a first direction, and an inner annular passage around said axis between said central passage and said outer annular passage, said inner annular passage including a multiple of second swirl vanes operable to communicate a second swirled airflow in a second direction different than said first direction, and a swirler body extending around said outer annular passage, said inner annular passage, and said central passage, wherein:
- said multiple of first swirl vanes extend between said swirler body and a splitter plate,
 - said multiple of second swirl vanes extend between said splitter plate and a central nozzle body that defines said central passage, and
 - said central nozzle body includes fuel orifices at a location L that is greater than approximately five (5) diameters of said fuel orifices from said splitter plate and that corresponds to a one-quarter ($\frac{1}{4}$) auto-ignition time relative to an end of said swirler body.

8. A method of communicating fuel and air to a combustor of a turbine engine comprising:

communicating an unswirled airflow along an axis;

communicating a first swirled airflow in a first direction around the unswirled airflow;

communicating a second swirled airflow in a second direction different than the first direction forming a turbulent region; and

radially injecting the fuel outward relative to the axis into the turbulent region at a location approximately equivalent to a one-quarter auto-ignition time relative to an end of a swirler body.

9. The method as recited in claim 8, further comprising choking the unswirled airflow, the first swirled airflow and the second swirled airflow downstream of the turbulent region.

10. The method as recited in claim 8, further comprising providing essentially zero net swirl at an end of a swirler body that receives the unswirled airflow, the first swirled airflow and the second swirled airflow.