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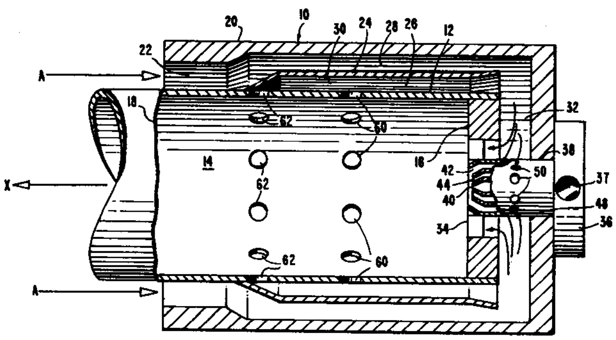
(54) Axially compact gas turbine burner and method for cooling same.

(57) A compact burner apparatus and method for cooling same includes a burner chamber having an injection end and an exit end with a burner wall extending there between, and a source of combustion air at the exit end. The burner apparatus further includes an outer casing for conveying air along the periphery of the burner wall for convective cooling, a longitudinal duct for channeling the combustion air away from the burner wall from a location between the injection end and exit end to the relatively hot injection end, and then channeling a portion of the combustion air back along the burner wall. The apparatus still further includes apertures in the burner chamber for admitting the combustion air portion as a secondary air flow.



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BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to gas turbine burners, particularly burners for gas turbines which are intended for vehicular applications.

Description of the Prior Art

Gas turbine burners for supplying hot combustion gases to the turbine component are known. These burners typically mix pressurized air with fuel injected through nozzles in a cylindrical or annular-shaped combustion chamber, combust the mixture, and dilute the combustion gases with additional pressurized air to achieve a desired gas temperature prior to admission to the turbine. To maintain combustion chamber wall temperatures at an acceptable level, these burners typically inject pressurized air along the inside of the combustion chamber wall to provide an insulating cooling film. However, the use of such "film cooling" can degrade burner performance by causing uneven burner exit temperature patterns, as would be understood by one skilled in the art.

In any event, pressurized air must be injected within the burner for mixing with fuel for combustion. It is difficult to intermix air and fuel for combustion and dilute the resulting combustion products, without a relatively lengthy burner chamber. Nevertheless, it has become highly desirable to use gas turbine engines in circumstances where high efficiency is needed but where mounting space is restricted and reduced engine weight is highly desirable. Therefore, a burner having a relatively small longitudinal dimension would be an important and useful component for such engines.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide a burner having a reduced longitudinal dimension to conserve space or to use with smaller engine designs.

It is another object of the present invention to provide a burner permitting rapid mixing of the elements of combustion despite having a relatively short longitudinal dimension.

It is another object of the present invention to provide a substantially uniform temperature on the burner inner casing.

It is also an object of the present invention to provide a burner having a more even burner exit temperature pattern than various systems in which films of air are the cooling medium.

Additional objects and advantages of the present invention will be set forth in part in the description that follows and in part will be obvious from the description or may be learned by practice of the invention. The objects and advantages of the invention may be realized and obtained by the methods and apparatus particularly pointed out in the appended claims.

The present invention overcomes the problems of the prior art and achieves the objects listed above by means of an entirely convectively cooled gas turbine burner having low hot gas axial velocities and a novel cooling air flow pattern. The burner apparatus invention, as embodied and as broadly described herein, for combusting fuel and for supplying hot combustion gases to a turbine component comprises a burner chamber having an injection end, an exit end, and a burner wall extending axially therebetween,

means for conveying the combustion air from the exit end along the burner wall for convectively cooling the wall prior to admission of the combustion air into the interior of the burner chamber, and fuel injection means located at the burner chamber injection end for mixing fuel with a portion of the conveyed combustion air. Specifically, the conveying means including ducting means for decreasing the temperature, and increasing the mass flow rate, of the combustion air used to convectively cool the portion of the burner wall adjacent the injection end of the burner chamber, and the ducting means including a longitudinal member concentrically surrounding the burner wall and sealingly attached at one end thereof to the burner wall at a location between the exit end and the injection end. The longitudinal member is spaced from the burner wall from the location of the sealing attachment to the injection end, and the flow of the compressed air used for cooling is in the direction toward the injection end over the burner wall portion between the exit end and the attachment location, and in the direction away from the injection end for the burner wall portion between the attachment location and the injection end. further including

Preferably, the burner apparatus further includes means for directing air from the space between the longitudinal member and the burner wall into the burner chamber to provide secondary air flow, the directing means including two series of apertures, the series being axially spaced from one another and from the injection end and dividing the burner chamber into three functionally distinct areas, namely, a primary area proximate the injection end providing for diffusion and expansion of the air-fuel mixture, a secondary area axially adjacent the primary area for mixing the air-fuel mixture with a part of the air from the secondary air of the air-fuel mixture, and a tertiary area axially adjacent the secondary area for diluting combustion gases formed in the secondary area with another part of the air from the secondary air flow.

It is also preferred that in the gas turbine burner apparatus the primary area and the secondary area contain a weight ratio of fuel to air of about 9.5% and about 5.5%, respectively, and that the combustion gases flow along the axis of the burner chamber between about 125 to about 175 feet per second.

It is still further preferred that the convectively cooled gas turbine burner apparatus diffusion zone between the injection end and the proximate one of the two series of apertures has an axial length of about 60% to about 120% of the diameter of the burner chamber, and that the mixing and combustion zone between the two series of apertures has an axial length of about 30% of the diameter of the burner chamber.

Also in accordance with the present invention, as embodied and broadly described herein, the method for convectively cooling an axially compact gas turbine burner having a longitudinal burner wall with an injection end, an exit end, and with the combustion gas flow direction being generally from the injection end axially toward the exit end, and with the burner having a source of combustion air proximate the exit end, comprises the steps of flowing the combustion air along the burner wall in a direction counter to the combustion gas flow direction, from the exit end to a point intermediate the exit and the injection end; directing the combustion air away from the burner wall and toward the injection end; and flowing at least part of the combustion air back along the burner wall in a direction concurrent with the combustion gases, from the injection end to the intermediate point.

Preferably the method includes the further step of directing the concurrent combustion air flow through the burner wall for use as secondary air.

The accompanying drawing, which is incorporated in and constitutes a part of this specification, illustrates an embodiment of the invention and, together with the description, serves to explain the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWING

The Figure is a schematic cross-sectional view of a convectively cooled gas turbine burner made in accordance with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

With initial reference to the Figure, there is shown a gas turbine burner designated generally by the numeral 10. Burner 10 includes a generally cylindrical inner casing 12 defining a burner chamber 14 which is convectively cooled by air used for combustion as will be described in greater detail hereinafter and has a fuel injection end 16 and an exit end 18. An outer casing 20 substantially envelops the inner casing 12, as well as the injection end 16 of the burner chamber 14. Means are provided for injecting fuel within the burner chamber at injection end 16, to be discussed in detail henceforth. In addition, means are provided for admitting air within the burner chamber 14 for combustion as also will be discussed henceforth.

As previously noted, the present invention is directed to a convectively cooled gas turbine burner for combusting fuel and air. In accordance with the present invention, the burner includes means for conveying air along the external periphery of at least a substantial portion of the burner chamber. As embodied herein and as depicted generally in the Figure, the conveying means include a passageway 22 formed between inner casing 12 and outer casing 20. A longitudinal member 24 is attached to the outer surface 26 of the inner casing 12 and is formed between the outer casing 20 and the inner casing 12. The annular longitudinal member 24 defines a second passageway 28 between the longitudinal member 24 and the outer casing 20, as well as a third passageway 30 between the longitudinal member 24 and the inner casing 12. The flow of air, as denoted by arrows A is directed into the first passageway 22, the second passageway 28 and, then, either to a third passageway 30 or to a plenum 32 at the injection end of the burner chamber 14. The flow of air within the first and third passageways 22, 30 along the inner casing 12 convectively cools the heat from combustion generated within the burner chamber 14.

Further, in accordance with the present invention, the burner includes means for admitting a primary flow of air within the burner chamber for combustion. As embodied herein, the burner 10 includes an arrangement of spaced and slanted curvilinear vanes for admitting air within the burner chamber from the plenum 32. The air passes through the vanes 34 in a swirling motion within an angle of about 42° to about 52° relative to the axis X of the burner chamber 14.

Further, the burner 10 includes means proximate the injection end for injecting fuel into the burner chamber for mixing with the primary air flow. The fuel injection means may be any conventional gas turbine fuel injection apparatus providing a fuel spray, preferably at an angle greater than about 100°, that is greater than about 50° to either side of the burner axis X. An acceptable injection unit is one manufactured by Excello Corporation and is depicted in the Figure. The injection means thus includes a fuel injection unit 36 mounted on the outer casing 20 and having a radial fuel inlet 37 (shown with screen filter). The fuel injection unit 36 further includes a housing 38 having an inner and outer air passage 40, 42. Interposed between inner and outer air supply passages 40, 42 (which have swirlers - not shown) is an annular fuel channel 44 preferably concentrically positioned between the inner and outer air supply passages 40, 42, and interconnected with inlet 37. A smooth, thin sheet of film forms on the wall of channel 44 and then is broken into a spray by the swirling air streams from passages 40, 42. The housing 38 includes a series of spaced circumferential slots 50 for admitting air to inner passage 40. Preferably, slots 50 have an angle of at least about 42° relative to the axis X of the burner chamber 14.

Further, in accordance with the present invention, the burner 10 includes means connected to the conveying means for directing a secondary flow of air within the burner chamber 14. As embodied herein and as shown in the Figure, the means for directing a secondary flow of air within the burner chamber 14 include at least two series of apertures 60 and 62 spaced about the circumference of the inner casing 12 along the third passageway 30. Thus, air passing through the second passageway 28 and into plenum 32 provides a primary flow of air within the burner chamber 14. Air passing into the third passageway 30 and through either apertures 60 or apertures 62 provide a secondary flow of air into the burner chamber 14.

Importantly, the operation of a gas turbine burner apparatus according to the present invention will now be described in detail with reference to the Figure. Air flow, as denoted by A in the Figure, is directed into the first passageway 22 by a compressor or similar means at an air velocity of 200 feet per second, which provides a reasonable wall temperature without an unacceptable pressure loss; however, a velocity of 100 to 150 feet per second may be adequate. If a lower wall temperature is desired, the air velocity can be increased or fins (not shown) may be affixed to the outer surface 26 of the inner casing 12 in the first passageway 22 and in the third passageway 30. The air flows from the first passageway 22 into a second passageway 28, which is defined by the outer casing 20 and the longitudinal member 24, the latter member being sized to provide the desired cooling air velocity of about 200 ft/sec of air passing within passageway 30, and the former member being positioned so that the air is conveyed to the burner chamber 14 without creating a significant pressure loss. The air passed to the plenum 32 which enters the burner chamber 14 through vanes 34, imparts a swirling motion and constitutes the primary flow of air into the burner chamber 14. This primary air flow is directed into the burner chamber 14 from the vanes 34 at an angle greater than about 50° relative to the axis X of the burner chamber 14.

The fuel injection unit 36 receives air and fuel through an inner and outer air passage 40, 42 and fuel channel 44, respectively. The direction and magnitude of the swirl imparted to the air passed through fuel injection unit 36 is similar to that imparted by the vanes 34 to the primary air flow into the burner chamber 14. It is noted, however, that the swirl of the air through fuel injection unit 36 may be greater than an angle of about 52° relative to the axis of the burner chamber 14, though the relative angle may not be less than about 42°.

The secondary flow of air into the burner chamber 14 is passed through the apertures 60 and 62 adjacent the third passageway 30. The two series of apertures 60 and 62 divide the burner chamber 14 into three functionally distinct, axially adjacent areas, namely, a primary area I between apertures 60 and the injection end 16 that enabled mixing and expansion of the air-fuel mixture, a secondary area II adjacent the primary area I and lying between apertures 60 and apertures 62 that allows further mixing and combustion of the air-fuel mixture, and a tertiary area III adjacent the secondary area II and downstream of apertures 62 that allows dilution of the air-fuel mixture. The air not used in the combustion process is added to lower the gas temperature to the desired temperature for entering the turbine within the dilution zone. The weight ratio of fuel to air mixture in the primary area I is about 9.5%, whereas the ratio corresponding to the secondary area II is about 5.5% at design operation conditions. The primary area I defined by the axial position of the series of apertures 60 has a length of not less than 60% and not more than 120% of the burner diameter. The axial position of the series of apertures 62 is not less than 30% the burner diameter downstream of apertures 60. The resultant axial velocity of hot gases within the burner chamber 14 is between about 125 to 175 feet per second and preferably about 150 feet per second. The relatively low axial velocity of the hot gas, in conjunction with the secondary flow of air through the apertures 60 and 62, allows rapid and efficient mixing of the primary and secondary flows of air. Hence, only a relatively short burner chamber is required.

It will be apparent to those skilled in the art that modifications and variations can be made to the gas turbine burner apparatus and method of this invention. The invention in its broader aspects is, therefore, not limited to the specific details or their representative methods and apparatus. Thus, it is intended that all matter contained in the foregoing description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

WHAT IS CLAIMED IS:

1. A burner apparatus for combusting fuel and for supplying hot combustion gases to a turbine component, the apparatus comprising:

a burner chamber having an injection end, an exit end, and a burner wall extending axially therebetween;

means for conveying said combustion air from said exit end along said burner wall for convectively cooling said wall prior to admission of said combustion air into the interior of said burner chamber, said conveying means including ducting means for decreasing the temperature, and increasing the mass flow rate, of the combustion air used to convectively cool the portion of the burner wall adjacent the injection end of the burner chamber, said ducting means including a longitudinal member concentrically surrounding said burner wall and sealingly attached at one end thereof to said burner wall at a location between said exit end and said injection end, said longitudinal member being spaced from said burner wall from the location of said sealing attachment to said injection end, the flow of said compressed air used for cooling being in the direction toward said injection end over the burner wall portion between said exit end and said attachment location, and in the direction away from said injection end for the burner wall portion between said attachment location and said injection end; and fuel injection means located at said burner chamber injection end for mixing fuel with a portion of the conveyed combustion air.

2. The gas turbine burner apparatus as in claim 1, wherein said conveying means includes an outer casing concentrically surrounding said burner wall and said longitudinal member, said longitudinal member being sized to provide an air velocity between said longitudinal member and said burner wall about equal to the velocity of air between said burner wall and said outer casing.

3. The gas turbine burner apparatus as in claim 1, wherein the air passed within said conveying means is conveyed along the external periphery of said burner wall at a velocity between about 100 to about 200 feet per second.

4. The gas turbine burner apparatus as in claim 1, further including means for directing air from the space between said longitudinal member and said burner wall into said burner chamber to provide secondary air flow, said directing means including two series of apertures, said series being axially spaced from one another and from said injection end and dividing said burner chamber into three functionally distinct areas, namely, a primary area proximate said injection end providing for diffusion and expansion of said air-fuel mixture, a secondary area axially adjacent said primary area for mixing said air-fuel mixture with a part of the air from said secondary air of said air-fuel mixture, and a tertiary area axially adjacent said secondary area for diluting combustion gases formed in said secondary area with another part of the air from said secondary air flow.

5. The gas turbine burner apparatus as in claim 4, wherein said primary area and said secondary area contain a weight ratio of fuel to air of about 9.5% and about 5.5%, respectively.

6. The gas turbine burner apparatus as in claim 1, wherein said combustion gases flow along the axis of said burner chamber between about 125 to about 175 feet per second.

7. The convectively cooled gas turbine burner apparatus as in claim 4, wherein said burner chamber includes a diffusion zone between said injection end and the proximate one of said two series of apertures, said diffusion zone having an axial length of about 60% to about 120% of the diameter of said burner chamber.

8. The convectively cooled gas turbine burner apparatus as in claim 4, wherein said burner chamber includes a mixing and combustion zone between said two series of apertures, said mixing and combustion zone having an axial length of about 30% of the diameter of said burner chamber.

9. A method for convectively cooling an axially compact gas turbine burner having a longitudinal burner wall with an injection end, an exit end, the combustion gas flow direction being generally from the injection end axially toward the exit end, and the burner having a source of combustion air proximate the exit end, the method of comprising the steps of:

flowing the combustion air along the burner wall in a direction counter to the combustion gas flow direction, from the exit end to a point intermediate the exit and the injection end;

directing the combustion air away from the burner wall and toward the injection end; and

flowing at least part of the combustion air back along the burner wall in a direction concurrent with the combustion gases, from the injection end to said intermediate point.

10. The method as in claim 9 including the further step of directing the concurrent combustion air flow through the burner wall for use as secondary air.

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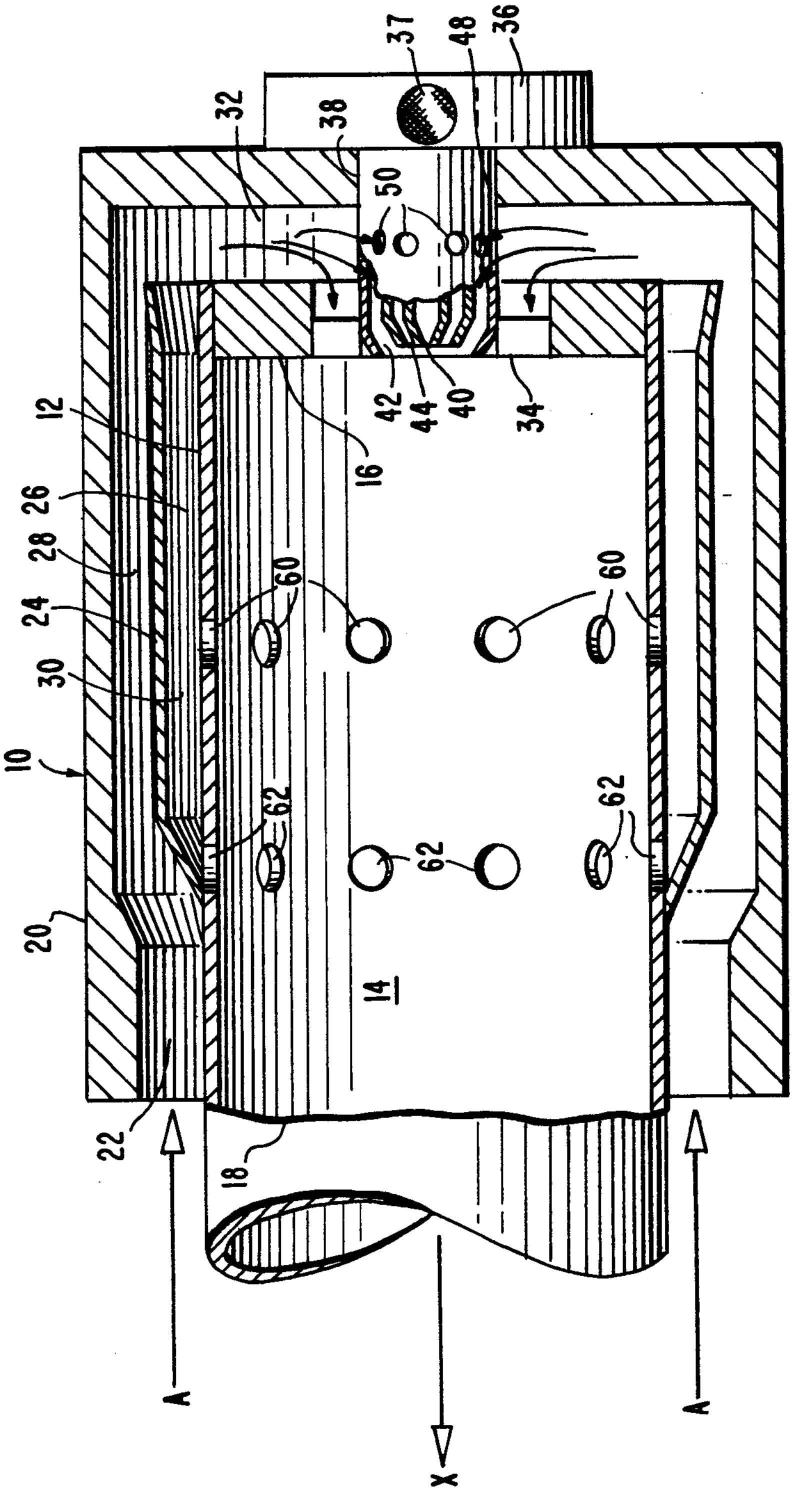

FIG. 1.