(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 288 576 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
05.03.2003 Bulletin 2003/10

(51) Int Cl.[7]: **F23R 3/28**, F23D 14/74, F23D 14/78

(21) Application number: **02016027.1**

(22) Date of filing: **18.07.2002**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR IE IT LI LU MC NL PT SE SK TR
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **24.08.2001 JP 2001254360**

(71) Applicant: **Mitsubishi Heavy Industries, Ltd.**
Tokyo (JP)

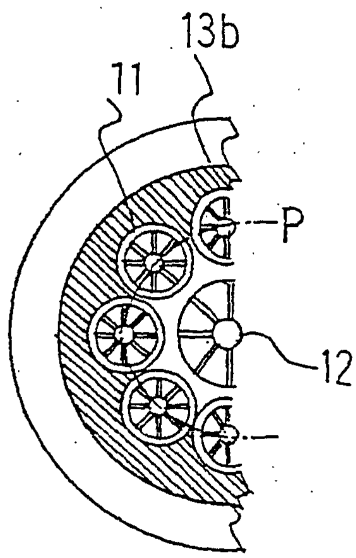
(72) Inventors:
- **Mandai, Shigemi,**
Mitsubishi Heavy Industries, Ltd.
Takasago-shi, Hyogo-ken (JP)
- **Saitoh, Keijirou,**
Mitsubishi Heavy Industries, Ltd
Takasago-shi, Hyogo-ken (JP)
- **Tanaka, Katsunori,**
c/o Mitsubishi Heavy Industries
Takasago-shi, Hyogo-ken (JP)
- **Akizuki, Wataru, c/o Mitsubishi Heavy Industries**
Takasago-shi, Hyogo-ken (JP)

(74) Representative: **Henkel, Feiler, Hänzel**
Möhlstrasse 37
81675 München (DE)

(54) **Gas turbine combustor**

(57) A gas turbine combustor comprising a pilot nozzle (12) arranged on a central axis of said combustor and a plurality of pre-mixing nozzles (11) arranged around the pilot nozzle (12). A diameter of a combustion zone of the combustor is set such that, where an area is taken on a radial directional plane of the combustor, the area inside of the combustion zone and outside of a pitch circle (P) that is defined as a circle on which all central axes of the plurality of pre-mixing nozzles (11) are arranged, less the area taken by the plurality of pre-mixing nozzles (11) outside of the pitch circle (P), is a half or more of the area of all of the plurality of pre-mixing nozzles (11). With this structure, the flame holding ability of the combustor can be enhanced, the pilot fuel quantity can be reduced and a very low NOx generation can be realized.

Fig. 3



EP 1 288 576 A2

Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to a gas turbine combustor that realizes a low NOx combustion.

Description of the Prior Art

[0002] Figs. 4(a) and (b) schematically show a prior art gas turbine combustor, wherein Fig. 4(a) is a longitudinal cross sectional view showing an interior of the combustor and Fig. 4(b) is a front view of a half portion of the combustor. In Figs. 4(a) and (b), main fuel 40 flows into eight pre-mixing nozzles 31, that are arranged within a combustor body 36 around a central axis thereof, and is pre-mixed with air, as will be described next, to form a main pre-mixture to be supplied into a combustion zone of a combustor 33. The air is supplied from a compressor (not shown) to be fed into the combustor 33 flowing through an inner peripheral space portion of the combustor body 36, as shown by arrows 50 in Fig. 4(a). On the other hand, pilot fuel 41 flows into a pilot nozzle 32, that is arranged on the central axis of the combustor body 36, to be jetted into the combustor 33. Thus, the pilot fuel 41 burns with the main pre-mixture there to effect a combustion. A flame holding cone 34 is provided on the pilot nozzle 32 and flame of the pilot fuel 41 is maintained by a high temperature gas circulating flow 35, that is formed by the flame holding cone 34. Such a combustor having the pre-mixing nozzles and being constructed as described above is generally known as a low NOx combustor.

[0003] In the above described pre-mixed flame type low NOx combustor in the prior art, the flame of the pilot nozzle 32 is maintained by a diffused flame, that is, the high temperature gas circulating flow 35, formed by the flame holding cone 34 and NOx quantity generated by the pre-mixing nozzles 31 is reduced. However, NOx quantity generated by the diffused flame of the pilot nozzle 32 cannot be suppressed and realization of a low NOx generation as a whole is limited by that extent.

SUMMARY OF THE INVENTION

[0004] It is, therefore, an object of the present invention to provide a gas turbine combustor that is constructed so as to improve a flame holding ability by the high temperature gas circulating flow as well as to improve cooling of the pre-mixing nozzles to thereby reduce pilot fuel quantity as well as to reduce NOx quantity generated of the pilot fuel.

[0005] In order to achieve the mentioned object, the present invention provides means of the following (1) to (4):

(1) A gas turbine combustor comprising a pilot nozzle arranged on a central axis of the combustor and a plurality of pre-mixing nozzles arranged around the pilot nozzle, characterized in that a diameter of a combustion zone of the combustor is set such that, where an area is taken on a radial directional plane of the combustor, the area inside of the combustion zone and outside of a pitch circle that is defined as a circle on which all central axes of the plurality of pre-mixing nozzles are arranged, less the area taken by the plurality of pre-mixing nozzles outside of the pitch circle, is a half or more of the area of all of the plurality of pre-mixing nozzles.

(2) A gas turbine combustor as mentioned in the means (1) above, characterized in that each of the plurality of pre-mixing nozzles has its front end projected beyond a base plate that supports the pre-mixing nozzle and a projecting distance of such projected front end is set to one third or more of an outer diameter of the pre-mixing nozzle.

(3) A gas turbine combustor as mentioned in the means (1) above, characterized in that each of the plurality of pre-mixing nozzles has its front portion made in a double structure having inner and outer members with a predetermined gap being maintained between the inner and outer members and air is flowable in the gap.

(4) A gas turbine combustor as mentioned in the means (1) above, characterized in that a combustor body as an outer casing of the combustor comprises therein an inner cylindrical member and an outer cylindrical member, the inner cylindrical member is arranged surrounding the plurality of pre-mixing nozzles and the outer cylindrical member has its inner diameter made larger than an outer diameter of the inner cylindrical member and is arranged surrounding a front end portion of the inner cylindrical member and extending downstream of the inner cylindrical member so as to cover the combustion zone to thereby enable to enlarge the diameter of the combustion zone beyond an inner diameter of the inner cylindrical member.

[0006] In the means (1) of the present invention, the diameter of the combustion zone in which a high temperature combustion gas is generated is set such that the cross sectional area inside of the combustion zone and outside of the pitch circle, less the cross sectional area of the pre-mixing nozzles outside of the pitch circle, is a half or more of the cross sectional area of all the pre-mixing nozzles. By this structure, the outer peripheral space portion of the combustion zone is enlarged and a gas stagnation area is formed in this space portion, that is, in the outer peripheral space portion in front of the pre-mixing nozzles. An outer circulating flow of the high temperature gas generated by combustion of the pre-mixture coming from the pre-mixing nozzles is formed in this gas stagnation area. Also, an inner circulating flow of a high temperature gas generated of the pilot fuel is formed in the central space portion of the combustion zone in front of the pilot nozzle by a flame holding cone. Thus, by the inner and outer circulating flows of the high temperature gas, the flame holding ability of the combustor can be greatly enhanced. Thereby, the pilot fuel quantity, as so far necessitated for the flame holding, can be reduced, the NOx quantity generated by combustion of the pilot fuel can be reduced and a very low NOx generation can be realized as a whole.

[0007] In the means (2) of the present invention, each of the pre-mixing nozzles has its front end projected beyond the base plate so that the base plate may not be directly exposed to the high temperature gas circulating flows. Thereby, the base plate is prevented from being overheated and the effect of the means (1) of the present invention can be realized more securely.

[0008] In the means (3) of the present invention, each of the pre-mixing nozzles has its front portion made in the double structure having the predetermined gap therein and air is flowable in the gap for cooling the pre-mixing nozzle. Thus, the pre-mixing nozzle is prevented from being overheated and the effect of the means (1) of the present invention is further ensured.

[0009] In the means (4) of the present invention, the combustor body as the outer casing of the combustor comprises therein the inner cylindrical member and the outer cylindrical member. The outer cylindrical member has its inner diameter made larger than the outer diameter of the inner cylindrical member. Thus, the diameter of the combustion zone is enlarged outwardly so that the gas stagnation area is easily formed in the outer peripheral space portion of the combustion zone in front of the pre-mixing nozzles. The outer circulating flow of the high temperature combustion gas generated by combustion of the pre-mixture coming from the pre-mixing nozzles is formed in the gas stagnation area and the flame holding ability is enhanced. Hence, the effect to realize the low NOx generation by the means (1) of the present invention can be further ensured.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010]

Figs. 1(a) and (b) schematically show a gas turbine combustor of an embodiment according to the present invention, wherein Fig. 1(a) is a longitudinal cross sectional view showing an interior of the combustor and Fig. 1(b) is a front view of a half portion of the combustor.

Fig. 2 is an enlarged longitudinal cross sectional view of one of pre-mixing nozzles.

Fig. 3 is the same view as Fig. 1(a) in which a hatched portion is added.

Figs. 4(a) and (b) schematically show a prior art gas turbine combustor, wherein Fig. 4(a) is a longitudinal cross sectional view showing an interior of the combustor and Fig. 4(b) is a front view of a half portion of the combustor.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0011] Herebelow, an embodiment according to the present invention will be described with reference to the appended drawings.

[0012] Figs. 1(a) and (b) schematically show a gas turbine combustor of the embodiment, wherein Fig. 1(a) is a longitudinal cross sectional view showing an interior of the combustor and Fig. 1(b) is a front view of a half portion of the combustor. In Figs. 1(a) and (b), numeral 10 designates a combustor body as an outer casing of the combustor and eight pre-mixing nozzles 11 are provided therein being connected to each other around a central axis of the combustor body 10. The pre-mixing nozzles 11 are constructed so as to have their front ends projected beyond a base plate 17, that will be described later. Numeral 12 designates a pilot nozzle, that is arranged on the central axis of the combustor body 10. Numeral 13 designates a combustor, that includes the combustor body 10 and other components arranged therein. The combustor body 10 comprises therein an inner cylindrical member 13a and an outer cylindrical member 13b. The outer cylindrical member 13b has its inner diameter made larger than an outer diameter of the inner cylindrical member 13a as well as larger than an outer diameter of a cylindrical member of the prior art combustor. The outer cylindrical member 13b is arranged surrounding a front end portion of the inner cylindrical member 13a and extending downstream of the inner cylindrical member 13a so as to cover a combustion zone of the combustor 13. Numeral 14 designates a flame holding cone, that has its front end portion eliminated to be made shorter than the prior art flame holding cone. Numeral 17 designates the base plate, that is a member supporting the eight pre-mixing nozzles 11 to an inner circumferential wall surface of the inner cylindrical member 13a.

[0013] Fig. 2 is an enlarged longitudinal cross sectional view of one of the pre-mixing nozzles 11. The pre-mixing nozzle 11 has its front portion made in a double structure having a pre-mixing nozzle portion 21 of the inner side and an outer sleeve 23 of the outer side. While illustration is omitted, the outer sleeve 23 is supported to the pre-mixing nozzle portion 21 via a plurality of rib members. While the pre-mixing nozzle in the prior art has its front end cut at the position of its base plate without projecting further, the pre-mixing nozzle 11 of the present invention has its front end projected beyond the base plate 17. That is, a front end of the outer sleeve 23 projects frontward beyond the position of the base plate 17. Numeral 14 designates a flame holding cone, that has its front end portion cut by the projection of the outer sleeve 23 to be made shorter. Numeral 22 designates a swirler vane, construction of which is the same as that of the prior art one.

[0014] In the combustor described above with reference to Figs. 1 and 2, main fuel 40 flows into the eight pre-mixing nozzles 11 and is pre-mixed with air to form a pre-mixture for combustion in the combustion zone of the combustor 13. The air is supplied from a compressor (not shown) to be fed into the combustor 13 flowing through an inner peripheral space portion of the combustor body 10, as shown by arrows 50 in Fig. 1(a), and further flowing through the pre-mixing nozzle portion 21 as well as through an outer peripheral space portion of the pre-mixing nozzle portion 21, as shown by arrows 51 in Fig. 2. On the other hand, pilot fuel 41 is supplied into the combustor 13 through the pilot nozzle 12 of the combustor central position and burns there together with the pre-mixture.

[0015] In a front central space portion of the flame holding cone 14 of the pilot nozzle 12, a high temperature gas inner circulating flow 15 is generated by the pilot fuel. Also, in an inner peripheral space portion of the outer cylindrical member 13b in front of the pre-mixing nozzle 11, a high temperature gas outer circulating flow 16 is generated by the pre-mixture coming from the pre-mixing nozzle 11. Thus, by these two circulating flows 15, 16, the flame holding is securely effected. A gas stagnation area is formed in the inner peripheral space portion of the outer cylindrical member 13b in front of the pre-mixing nozzle 11 by the construction of the combustor 13 comprising the inner cylindrical member 13a and the outer cylindrical member 13b and having the inner diameter of the outer cylindrical member 13b made larger. Thus, the high temperature gas outer circulating flow 16 is formed in this gas stagnation area as a circulating flow of a high temperature combustion gas generated by combustion of the main pre-mixture.

[0016] As the flame holding effected by the high temperature gas inner circulating flow 15 generated by the flame holding cone 14 is added, the flame holding ability is greatly enhanced by the construction of the high temperature gas inner and outer circulating flows 15, 16. Thus, the pilot fuel quantity, as so far necessitated for the flame holding, can be reduced and thereby the NOx quantity generated of the pilot fuel can be reduced and a very low NOx combustion can be realized.

[0017] As described with reference to Fig. 2, the pre-mixing nozzle 11 comprises the swirler vane 22, the pre-mixing nozzle portion 21 and the outer sleeve 23. The outer sleeve 23 is arranged with a predetermined gap being maintained from the pre-mixing nozzle portion 21 of the inner side thereof and the air, as shown by the arrows 51, flows into the gap, so that the pre-mixing nozzle portion 21 and the outer sleeve 23 that are heated by the high temperature gas can be sufficiently cooled.

[0018] Moreover, the front end of the pre-mixing nozzle 11, that is formed by the front end of the outer sleeve 23, projects beyond the base plate 17. By this projecting portion, the base plate 17, that is directly exposed to the high temperature gas outer circulating flow 16, is prevented from being overheated. In Fig. 2, where L is a projecting distance of the projecting portion, that is, a distance between a front side surface of the base plate 17 and the front end of the pre-mixing nozzle 11, and D is an outer diameter of the pre-mixing nozzle 11, that is, an outer diameter of the outer sleeve 23, if L is set to D/3 or more ($L \geqq D/3$), then the effect to prevent the overheat of the base plate 17 can be enhanced.

[0019] Fig. 3 is the same view as Fig. 1(b) in which a hatched portion is added. In Fig. 3, letter P is defined as a pitch circle that is a circle on which central axes of all of the pre-mixing nozzles 11 are arranged. An inner diameter of the outer cylindrical member 13b, that corresponds to a diameter of the combustion zone in the combustor, is set such that, where an area is taken on a radial directional plane of the combustor, the area inside of the outer cylindrical member 13b and outside of the pitch circle P, less the area taken by the pre-mixing nozzles 11 outside of the pitch circle P, that is, the area shown by the hatched portion in Fig. 3, is a half or more of the area of all the pre-mixing nozzles 11. By so selecting the diameter of the combustion zone in the combustor, the abovementioned gas stagnation area is effectively formed in the front outer side space portion of the pre-mixing nozzles 11 and the flame holding ability can be greatly enhanced.

[0020] According to the gas turbine combustor constructed as described above, a remarkable NOx reduction effect can be obtained. For example, NOx quantity of 25 PPM in the prior art can be reduced to 10 PPM or less.

[0021] While the preferred form of the present invention has been described, it is to be understood that the invention is not limited to the particular construction and arrangement herein illustrated and described but embraces such modified forms thereof as come within the scope of the appended claims.

Claims

1. A gas turbine combustor comprising a pilot nozzle (12) arranged on a central axis of said combustor and a plurality of pre-mixing nozzles (11) arranged around said pilot nozzle (12), **characterized in that** a diameter of a combustion zone of said combustor is set such that, where an area is taken on a radial directional plane of said combustor, the area inside of said combustion zone and outside of a pitch circle (P) that is defined as a circle on which all central axes of said plurality of pre-mixing nozzles (11) are arranged, less the area taken by said plurality of pre-mixing nozzles (11) outside of said pitch circle (P), is a half or more of the area of all of said plurality of pre-mixing nozzles (11).

2. A gas turbine combustor as claimed in Claim 1, **characterized in that** each of said plurality of pre-mixing nozzles (11) has its front end projected be-

yond a base plate (17) that supports said pre-mixing nozzle (11) and a projecting distance (L) of such projected front end is set to one third or more of an outer diameter (D) of said pre-mixing nozzle (11).

3. A gas turbine combustor as claimed in Claim 1, **characterized in that** each of said plurality of premixing nozzles (11) has its front portion made in a double structure having inner and outer members (21, 23) with a predetermined gap being maintained between said inner and outer members (21, 23) and air is flowable in said gap.

4. A gas turbine combustor as claimed in Claim 1, **characterized in that** a combustor body (10) as an outer casing of said combustor comprises therein an inner cylindrical member (13a) and an outer cylindrical member (13b), said inner cylindrical member (13a) is arranged surrounding said plurality of pre-mixing nozzles and said outer cylindrical member (13b) has its inner diameter made larger than an outer diameter of said inner cylindrical member (13a) and is arranged surrounding a front end portion of said inner cylindrical member (13a) and extending downstream of said inner cylindrical member (13a) so as to cover said combustion zone to thereby enable to enlarge the diameter of said combustion zone beyond an inner diameter of said inner cylindrical member (13a).

Fig. 1(b)

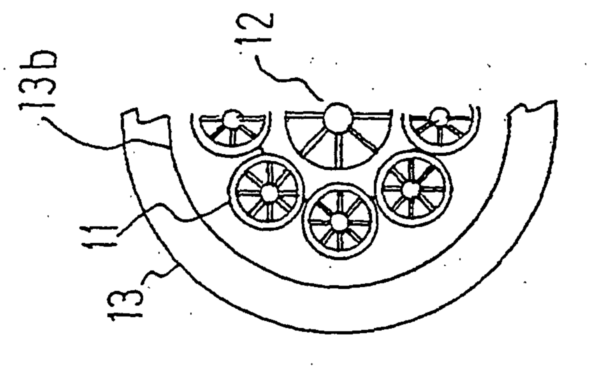


Fig. 1(a)

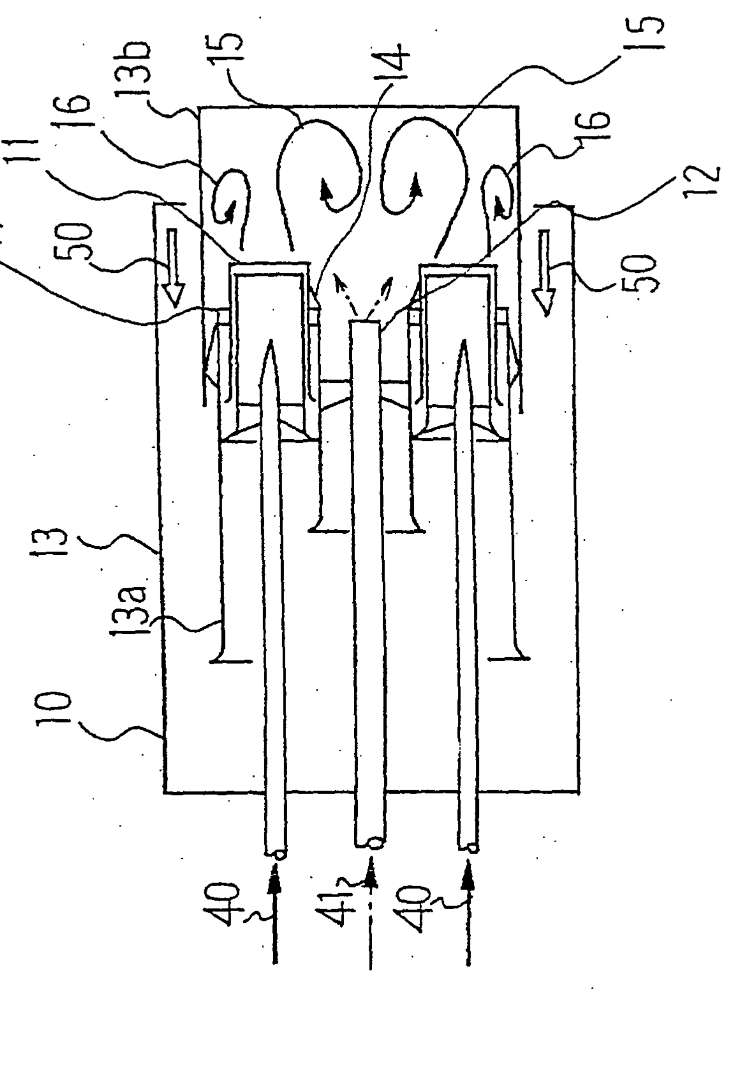


Fig. 2

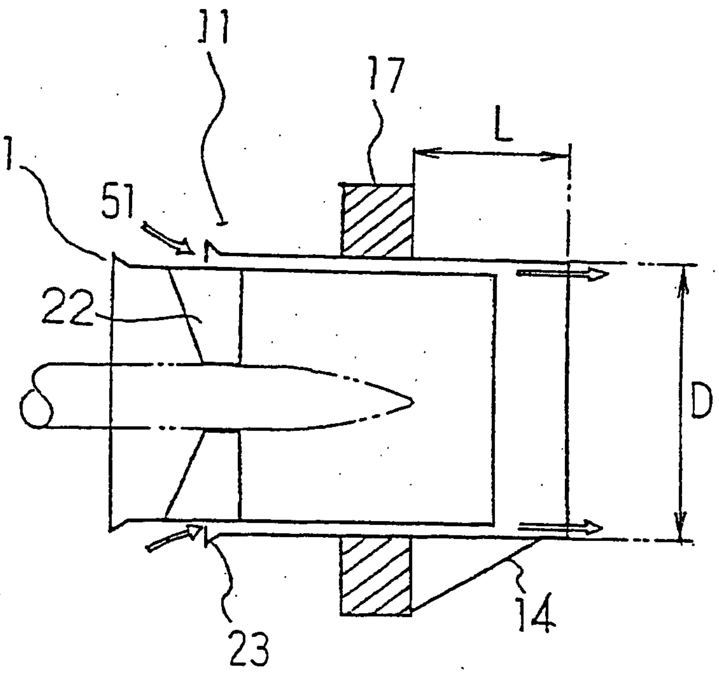


Fig. 3

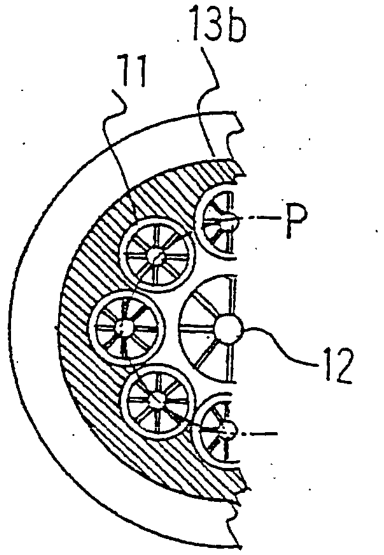


Fig. 4(b)

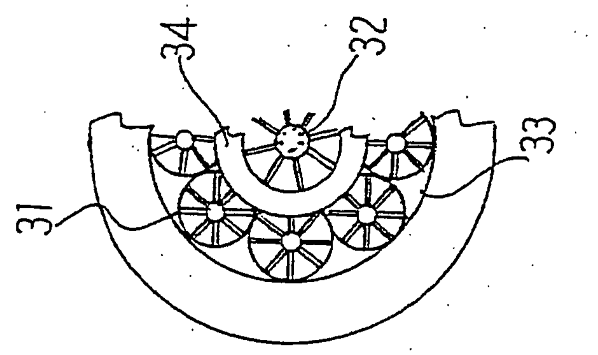


Fig. 4(a)