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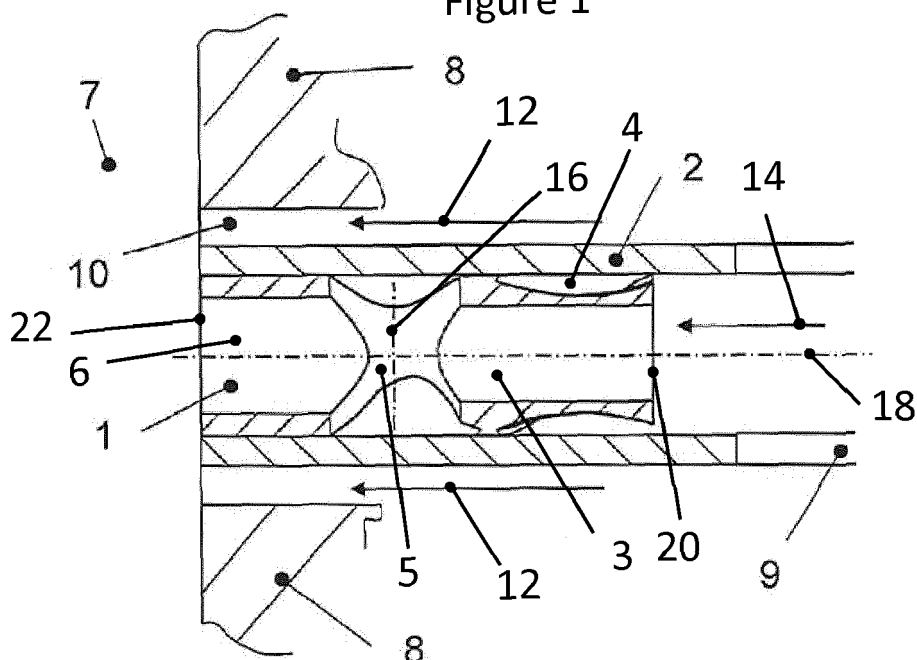
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(54) **NOZZLE FOR A GAS TURBINE COMBUSTOR**

(57) The disclosure concerns a nozzle (1) for a gas turbine combustor, the nozzle (1) comprising an inner channel (3), a swirl channel (4), a mixing zone (5) and an outlet channel (6), wherein the nozzle (1) extends from an inlet (20) to an outlet (22), the swirl channel (4) is disposed around the inner channel (3), the inner channel (3) and the swirl channel (4) extend from the inlet (20) to

the mixing zone (5), the mixing zone (5) extends from the inner channel (3) and the swirl channel (4) to the outlet channel (6), and the outlet channel (6) extends from the mixing zone (5) to the outlet (22). A burner (8) and a gas turbine comprising the nozzle (1) are also described, along with a method of using the nozzle (1).

Figure 1



Description

TECHNICAL FIELD

5 **[0001]** The present disclosure relates to a nozzle for a gas turbine combustor, and particularly to a nozzle for a gas turbine combustor with a swirl channel and an inner channel.

BACKGROUND OF THE INVENTION

10 **[0002]** Today's nozzle systems for gas turbine combustors are mostly designed as plain jet or swirl nozzles. The main differences between these nozzle types are atomising quality, spray cone angle and pressure drop. Swirl nozzles provide good atomising combined with large spray cone angles. Comparatively, plain jets provide a lower fuel pressure drop, but also worse atomising quality and smaller spray cone angles.

15 **[0003]** A plain jet nozzle consists of an axial bore hole, and the corresponding manufacturing costs are low. The plain jet nozzle also requires less space in the combustor compared to a swirl nozzle. Swirl nozzles generally have a geometrically complex swirler combined with a sophisticated nozzle exit shape, and therefore provide better spray quality. The manufacturing costs for swirl nozzles can be a great deal larger than for plain jet nozzles, although as a result of the better spray quality a greater operation range can be available.

20 **[0004]** The requirements for fuel nozzles with respect to through flow values are strict, and confined in a narrow range with a specified tolerance band that cannot be exceeded. As a result, a 100% flow rate check of the fuel nozzles is required. Deviations from the specified tolerance band are not acceptable and can require expensive reworking of the nozzles. For complex swirl nozzles in particular, this may be too expensive, and exchangeable additional orifices are applied upstream of the nozzle in order to regulate the throughput. This measure leads to additional pressure loss, increased manufacturing costs and increased space requirements, along with a reduction in fuel injection system reliability with its associated increased commissioning and maintenance costs.

25 **[0005]** As a result of these issues with existing nozzles, it has been appreciated that existing designs could be improved.

SUMMARY OF THE INVENTION

30 **[0006]** The invention is defined in the appended independent claims to which reference should now be made. Advantageous features of the invention are set forth in the dependent claims.

35 **[0007]** A first aspect of the invention provides a nozzle for a gas turbine combustor, the nozzle comprising an inner channel, a swirl channel, a mixing zone and an outlet channel, wherein the nozzle extends from an inlet to an outlet, the swirl channel is disposed around the inner channel, the inner channel and the swirl channel extend from the inlet to the mixing zone, the mixing zone extends from the inner channel and the swirl channel to the outlet channel, and the outlet channel extends from the mixing zone to the outlet.

40 **[0008]** This can result in a fuel spray from the nozzle outlet with an improved spray quality compared to a plain jet nozzle. The nozzle can also provide some of the advantages of a plain jet nozzle and a swirl nozzle within the same nozzle, and can provide an optimised compromise between the two designs. The nozzle can also be made smaller than a swirl nozzle.

[0009] In one embodiment, the nozzle is arranged such that when in use 30 to 75% of a fuel goes through the inner channel. In one embodiment, the nozzle comprises a diffuser attached to the outlet channel and wherein the outlet channel extends from the mixing zone to the diffuser. The diffuser can enhance the spray angle and improve mixing with air to reduce hot spots in the combustion chamber and thereby increase lifetime and reduce emissions.

45 **[0010]** In one embodiment, the diameter of the inner channel is smaller than the diameter of the outlet channel. The flow number of the nozzle can be corrected even when the nozzle is in place in a gas turbine by reaming the inner channel.

[0011] In one embodiment, the nozzle is for use with a liquid fuel such as fuel oil, kerosene, diesel oil, or an emulsion of fuel oil, kerosene or diesel oil with water. Use of an emulsion fuel can reduce the peak burning temperature and reduce emissions, particularly of NO_x. In one embodiment, the outlet channel opens directly into a combustion chamber.

50 **[0012]** A second aspect of the invention provides a burner comprising the nozzle as described above. In one embodiment, the burner comprises at least one shielding fluid hole disposed around the outlet of the nozzle. A shielding fluid such as air provided through the shielding fluid holes can help protect the nozzle and other nearby parts from heat (when the nozzle is not being used), and from the fuel and from coke formation when in use.

55 **[0013]** A third aspect of the invention provides a gas turbine comprising a combustor comprising the nozzle as described above or the burner as described above.

[0014] A fourth aspect of the invention provides a method of using a nozzle for a gas turbine combustor, the nozzle comprising an inner channel, a swirl channel, a mixing zone and an outlet channel and the nozzle having an inlet and an outlet, wherein the swirl channel is disposed around the inner channel, the inner channel and the swirl channel extend

from the inlet to the mixing zone, the mixing zone extends from the inner channel and the swirl channel to the outlet channel, and the outlet channel extends from the mixing zone to the outlet, the method comprising feeding a fuel through the nozzle and combusting the fuel in a combustion chamber. In one embodiment, the fuel is a liquid fuel such as fuel oil, kerosene, diesel oil, or an emulsion of fuel oil, kerosene or diesel oil with water.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] An embodiment of the invention will now be described by way of example only and with reference to the accompanying drawings in which:

Figure 1 shows a cross-section of part of a burner for a gas turbine including a nozzle according to the invention;
Figure 2 shows a side view of a nozzle according to the invention; and
Figure 3 shows a cross-section of the nozzle in Figure 2 along A-A.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0016] Figure 1 shows a nozzle 1 according to the invention in a burner 8 for a gas turbine. The nozzle comprises at least one inner channel 3 (inner axial inlet channel) with at least one swirl channel 4 (outer swirl channel) extending around the outer diameter of the inner channel 3. The inner channel 3 and the swirl channel 4 extend from a nozzle inlet 20 to a mixing zone 5 downstream of the inner channel 3 and swirl channel 4. The mixing zone 5 is a cylindrical hole through the nozzle, with the axis of the mixing zone cylindrical hole 16 being perpendicular to the axis 18 of the nozzle (see also Figure 2).

[0017] An outlet channel 6 is disposed at the other side of the mixing zone from the inner channel 3 and the swirl channel 4 (downstream of the mixing zone 5), with the outlet channel 6 extending from the mixing zone 5 to the outlet 22 of the nozzle.

[0018] A shielding fluid hole 10 (shielding fluid channel) is provided between a nozzle carrier 2 and the burner 8, for providing a shielding fluid such as cooling air. The nozzle carrier 2 is part of a fuel supply line 9.

[0019] Figure 2 shows a side view of the nozzle of Figure 1, with features as described above. Figure 2 includes dashed lines showing the internal extent of the walls of the nozzle. Figure 3 shows a cross-section view of the nozzle in the same direction as Figure 1 but without the surrounding burner. Figure 3 is also a cross-section of the nozzle in Figure 2 along A-A. An optional diffuser 24 is shown in Figure 3, downstream of and attached at the outlet of the nozzle.

[0020] The nozzle and burner described above are for use in a gas turbine. For example, the nozzle could be used in an AEV burner (advanced environmental burner). The nozzle can be used in a liquid fuel burner or as the liquid fuel nozzles in a combined gas and liquid fuel burner with both liquid fuel nozzles and gas nozzles.

[0021] When in use, fuel 14 is fed through the fuel supply line 9 and the nozzle carrier 2 to the inlet 20, where it splits into two flows, a main flow going through the inner channel 3 and a second flow going through the swirl channel 4. After flowing through the inner channel 3 and swirl channel 4 respectively, the main flow and the second flow recombine in the mixing zone 5. From the mixing zone 5, the fuel 14 flows through the outlet channel 6 and into the combustion chamber 7. If a diffuser is provided after the outlet, the fuel flows through the diffuser after leaving the outlet channel before entering the combustor.

[0022] The fuel can be a liquid fuel such as fuel oil, kerosene, diesel oil, or an emulsion of fuel oil, kerosene or diesel oil with water. The fuel oil may be fuel oil number 2, for example (i.e. oil which is primarily made up of hydrocarbon molecules with chain lengths of between 10 and 20 carbon atoms).

[0023] In some embodiments, a majority of the fuel goes through the inner channel, preferably at least 75%, more preferably at least 85% and most preferably at least 95%. The remaining fuel goes through the swirl channel, generally at least 1% or 2%. The maximum fuel flow fraction through the inner channel is therefore generally 98% or 99%. In other embodiments, 30 to 75% of the fuel goes through the inner channel, preferably 40 to 70% and most preferably 55 to 60%. One embodiment has 58% of the fuel going through the inner channel and 42% of the fuel going through the swirl channel, for example. This means that a part of the fuel goes directly through (is fed through) the inner channel, the mixing zone and the outlet channel into the combustor. The remaining fuel takes the same path except that it goes through the swirl channel instead of through the inner channel, generating additional swirl and turbulence in the mixing zone. This can result in a fuel spray from the nozzle outlet with an improved spray quality compared to a plain jet nozzle.

[0024] Both the swirl of the fuel exiting the nozzle outlet and the number and position of fuel-rich zones in the fuel flow field in the combustor vary based on the mass flow ratio (between the inner channel and the swirl channel) and on the number of swirl channels. The location of the fuel-rich zones in the fuel flow field is important, and fuel-rich zones should be kept away from other components in the combustor to minimise the thermal load on these components. The orientation of the nozzle can be chosen to optimise the position of the fuel-rich zones and minimise the thermal load.

[0025] In a method of manufacture of a nozzle 1 as described above, the nozzle 1 may be manufactured as an integral

part or as several separate parts. Generally, the nozzle 1 is then attached to the nozzle carrier 2, which is then attached to the fuel supply line 9. The nozzle 1 may be attached to the nozzle carrier 2 by any appropriate method, such as brazing or welding. The join between the nozzle 1 and the nozzle carrier 2 is generally gas-tight. Similarly, the nozzle carrier 2 may be attached to the fuel supply line 9 by any appropriate method, such as brazing or welding.

[0026] Before, during or after insertion of the nozzle into the gas turbine, the inner channel may be reamed to increase its inner diameter; that is, its diameter in a plane perpendicular to the nozzle axis 18. This can be useful if the nozzle is outside of a tolerance band after initial manufacture, or is found subsequently to be outside of a tolerance band. The nozzle may be retrofitted to existing gas turbines.

[0027] The nozzle is generally a cylindrical or substantially cylindrical shape, although other shapes are also possible. As a result, the cross-section of the nozzle in the plane perpendicular to the nozzle axis 18 is generally circular, although again other shapes are possible. The nozzle can be part of a combustor, and can lead fuel directly to a combustion chamber after the outlet of the nozzle. If a diffuser is provided, the fuel exits through the outlet into the diffuser and then into the combustion chamber.

[0028] One, two or more inner channels 3 may be provided. The inner channel may have a smaller diameter than the outlet channel, as can be seen in the Figures. However, the inner channel may alternatively have the same or a larger diameter than the outlet channel. One, two or more swirl channels 4 may be provided. The swirl channel(s) and the inner channel(s) are preferably concentric. The swirl channel may be disposed around the entire circumference (relative to the nozzle axis direction) of the inner channel.

[0029] The mixing zone 5 is shown as a cylindrical hole through the nozzle, but may be other shapes and at other angles, such as a cuboid or ovoid shape or an irregular shape.

[0030] The nozzle carrier 2 is shown in Figure 1 extending around the nozzle and beyond the inlet 20 of the nozzle. Alternatively, the nozzle carrier may extend up to the inlet 20 of the nozzle, or may only extend part of the length of the nozzle (relative to the nozzle axis direction). Beyond the end of the nozzle carrier, the fuel supply line continues as shown in Figure 1. The nozzle carrier 2 (fuel supply line) may extend around the entire circumference (relative to the nozzle axis) of the nozzle. In the region of the nozzle carrier adjacent to the swirl channel 4, the nozzle carrier (or another portion of the fuel supply line) generally provides the outer limit of the swirl channel, as shown in Figure 1. Alternatively, the structure of the nozzle itself may delimit the swirl channel. The nozzle carrier 2 may also be an integral part of the fuel supply line 9. The nozzle axis 18 may also be an axis of the fuel supply line. The nozzle and the fuel supply line (nozzle carrier) may be concentric.

[0031] The shielding fluid hole 10 is optional, and the nozzle carrier 2 may be directly adjacent to the burner. The burner can be attached to the nozzle carrier. The shielding fluid hole may extend around the entire circumference of the nozzle (and nozzle carrier), or alternatively one or more shielding fluid holes may be provided that each only extend part of the way around the entire circumference. Supports may also be provided in the shielding fluid hole between the nozzle carrier and the burner, particularly in embodiments where the shielding fluid hole extends around the entire circumference. The shielding fluid hole is normally further from the nozzle axis 18 than the inner channel 3 and the swirl channel 4. The shielding fluid hole can provide an annulus of air through which the shielded fluid (i.e. the fluid from the inner channel and swirl channel) flows.

[0032] The diffuser may be a conical shape (conical frustum) or another appropriate shape, such as pyramidal. The diffuser will generally conform to the shape of the outlet of the nozzle.

[0033] Various modifications to the embodiments described are possible and will occur to those skilled in the art without departing from the invention which is defined by the following claims.

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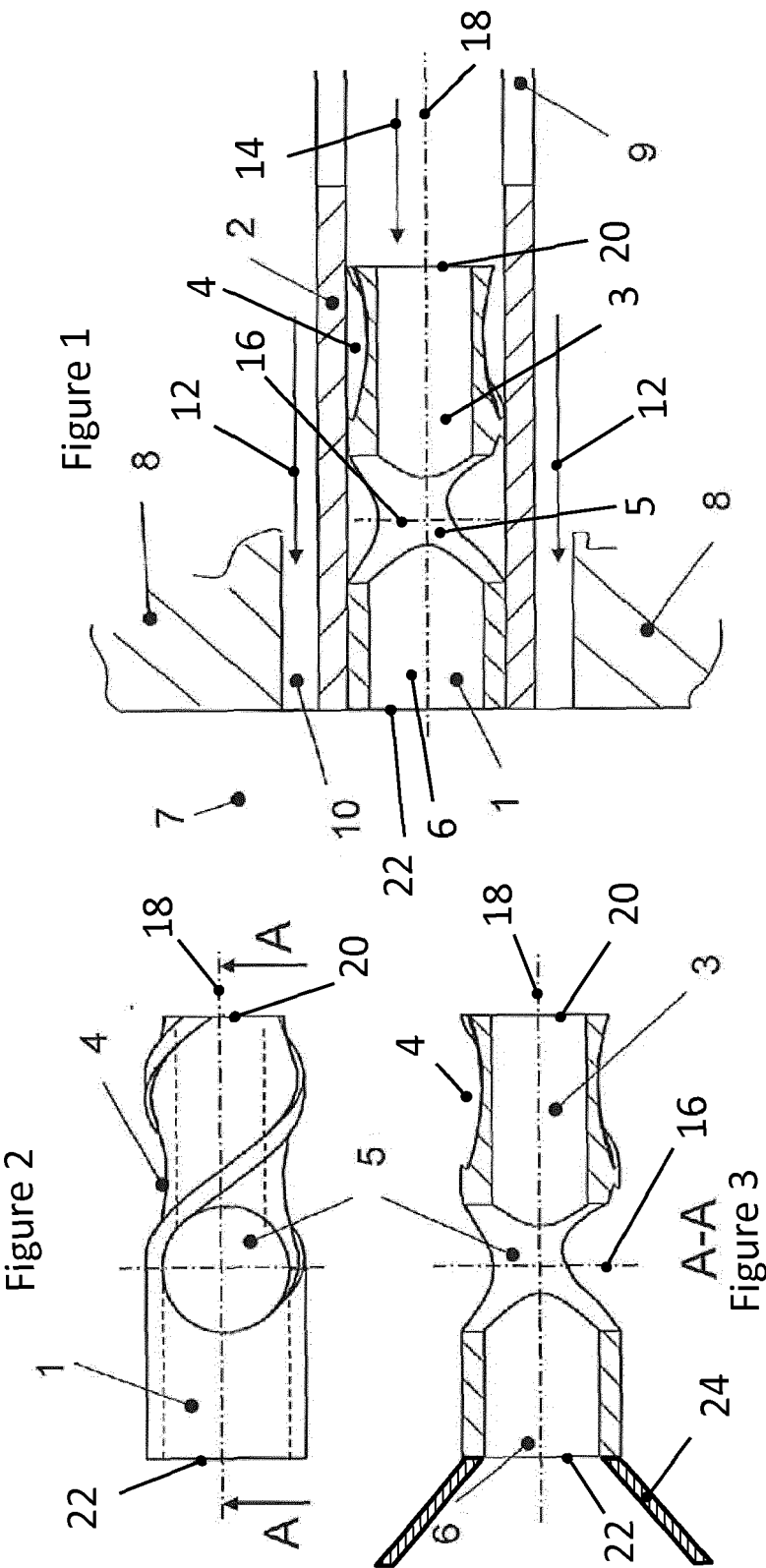
1	nozzle	10	shielding fluid hole
2	nozzle carrier	12	shielding fluid
3	inner channel	14	fuel
4	swirl channel	16	mixing zone axis
5	mixing zone	18	nozzle axis
6	outlet channel	20	inlet
7	combustion chamber	22	outlet
8	burner	24	diffuser
9	fuel supply line		

Claims

1. A nozzle (1) for a gas turbine combustor, the nozzle (1) comprising an inner channel (3), a swirl channel (4), a mixing

zone (5) and an outlet channel (6), wherein
the nozzle (1) extends from an inlet (20) to an outlet (22),
the swirl channel (4) is disposed around the inner channel (3),
the inner channel (3) and the swirl channel (4) extend from the inlet (20) to the mixing zone (5),
the mixing zone (5) extends from the inner channel (3) and the swirl channel (4) to the outlet channel (6), and
the outlet channel (6) extends from the mixing zone (5) to the outlet (22).

2. The nozzle (1) of claim 1, arranged such that when in use 30 to 75% of a fuel goes through the inner channel (3).
3. The nozzle (1) of claim 1 or 2, comprising a diffuser (24) attached to the outlet channel (6) and wherein the outlet channel (6) extends from the mixing zone (5) to the diffuser (24).
4. The nozzle (1) of any of claims 1 to 3, wherein the diameter of the inner channel (3) is smaller than the diameter of the outlet channel (6).
5. The nozzle (1) of any of claims 1 to 4, wherein the nozzle (1) is for use with a liquid fuel such as fuel oil, kerosene, diesel oil, or an emulsion of fuel oil, kerosene or diesel oil with water.
6. The nozzle (1) of claim 1 or 2, wherein the outlet channel (6) opens directly into a combustion chamber.
7. A fuel supply line (9) comprising the nozzle (1) of any of claims 1 to 6.
8. A burner (8) comprising the nozzle (1) of any of claims 1 to 6 or the fuel supply line of claim 7.
9. The burner (8) of claim 8, wherein the burner (8) comprises at least one shielding fluid hole disposed around the outlet (22) of the nozzle (1).
10. A gas turbine comprising a combustor comprising the nozzle (1) of any of claims 1 to 6 or the burner (8) of claim 8 or 9.
11. A method of using nozzle (1) for a gas turbine combustor, the nozzle (1) comprising an inner channel (3), a swirl channel (4), a mixing zone (5) and an outlet channel (6), wherein the nozzle (1) extends from an inlet (20) to an outlet (22), the swirl channel (4) is disposed around the inner channel (3), the inner channel (3) and the swirl channel (4) extend from the inlet (20) to the mixing zone (5), the mixing zone (5) extends from the inner channel (3) and the swirl channel (4) to the outlet channel (6), and the outlet channel (6) extends from the mixing zone (5) to the outlet (22), the method comprising feeding a fuel through the nozzle (1) and combusting the fuel in a combustion chamber.
12. The method of claim 11, wherein the fuel is a liquid fuel such as fuel oil, kerosene, diesel oil, or an emulsion of fuel oil, kerosene or diesel oil with water.





EUROPEAN SEARCH REPORT

 Application Number
 EP 16 16 5158

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Place of search The Hague		Date of completion of the search 19 September 2016	Examiner Mootz, Frank
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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