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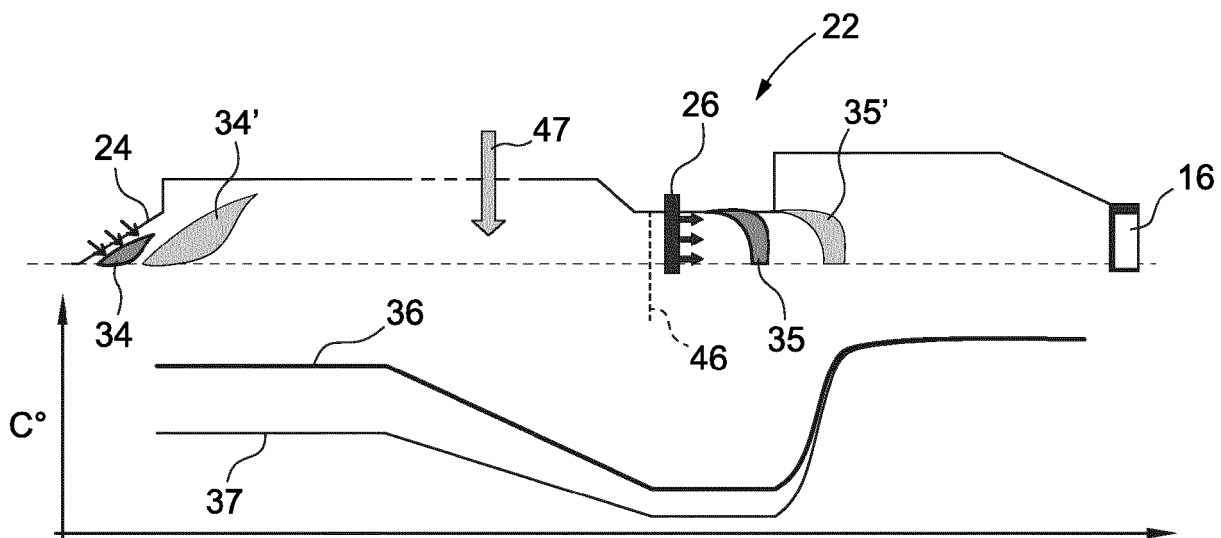
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(54) **SEQUENTIAL COMBUSTOR FOR A GAS TURBINE, METHOD FOR OPERATING THIS SEQUENTIAL COMBUSTOR AND METHOD FOR REFURBISHMENT A SEQUENTIAL COMBUSTOR OF A GAS TURBINE**

(57) A sequential combustor for a gas turbine ; the sequential combustor comprising:

- a first combustor provided with a plurality of first burners fed by compressed air and configured for injecting fuel in the compressed air in a diffusion mode and in a premix mode, each first burners comprises at least a gas fuel nozzle fed by a gas fuel line and at least a liquid fuel nozzle fed by a liquid fuel line;

- a second combustor provided with a plurality of second burners fed by hot gas leaving the first combustor and configured for injecting fuel in the hot gas; wherein the combustor moreover comprises a fluidly connection configured for selectively connecting the gas fuel line and the liquid fuel line for allowing part of gas fuel running in the gas fuel line to enter in the liquid fuel line and to be injected by the liquid fuel nozzle.

**FIG. 3****EP 3 702 670 A1**

Description

Field of the Invention

[0001] The present invention relates to the technical filed of the gas turbine assemblies for power plants. In particular, the present invention relates to a method for operating a sequential combustor of a gas turbine. This sequential combustor comprises an first combustor (or upstream combustor) configured for receiving the compressed air and mixing this air with fuel and a downstream second combustor (or reheat combustor) configured for receiving the hot gas leaving the first combustor and adding fuel into this hot gas for performing a self/spontaneous ignition. More in detail the present invention refers also to a method for refurbishment the above first combustor in order to allow a current first combustor to be fed by a highly reactive fuel, for instance H₂-based fuel.

Description of prior art

[0002] As known, a gas turbine assembly for power plants (in the following only gas turbine) comprises a rotor provided with a compressor unit, a combustor unit and at least a turbine unit. The compressor is configured for compressing air supplied at a compressor inlet. The compressed air leaving the compressor flows into a plenum and from there into a combustor. The combustor comprises a plurality of burners configured for injecting fuel in the compressed air. The mixture of fuel and compressed air flows into a combustion chamber where this mixture is combusted. The resulting hot gas leaves the combustion chamber and is expanded in the turbine performing work on the rotor. As known, the turbine comprises a plurality of stages, or rows, of rotor blades that are interposed by a plurality of stages, or rows, of stator vanes. The rotor blades are connected to the rotor whereas the stator vanes are connected to a vane carrier that is a concentric casing surrounding the turbine unit.

[0003] In order to achieve a high efficiency, a high turbine inlet temperature is required. However, in general this high temperature involves an undesired high NO_x emission level. In order to reduce this emission and to increase operational flexibility without decreasing the efficiency, the so called "sequential" gas turbines is particularly suitable. In general, a sequential gas turbine comprises two combustors or combustion stages in series wherein each combustor is provided with a plurality of burners and with at least a relative combustion chamber. Following the main gas flow direction, usually the upstream or first combustor comprises a plurality of so-called "premix" burners. The term "premix" emphasizes the fact that each burner of the first combustor is configured not only for injecting the fuel directly in the compressed air forming a diffusion flame (for instance by a so called "pilot lance") but also for mixing (with a swirl) the compressed air and the fuel before injecting the mixture into the combustion chamber. Therefore in the fol-

lowing with the terms "premix burner" we mean the burner in the first stage of the sequential combustor wherein each premix burner is configured for receiving the compressed air and injecting fuel in this coming air for realizing a diffusion flame (e.g. by pilot lance without any premix) and/or a premix flame. This kind of premix burner is today widely used because a diffusion flame is useful under some condition (for instance during the cold starting operation) whereas a premix flame allows to reduce the NO_x emissions during the normal operation. The downstream or second combustor is called "reheat" or "sequential" combustor and it is fed by the hot gas leaving the first combustor. Also, the reheat combustor is provided with a plurality of reheat burners configured for injecting fuel in the hot gas coming from the first combustor. Due to the high gas temperature, the operating conditions downstream the reheat burners allow a self/spontaneous ignition of the fuel/air mixture. Also these reheat burners are configured for performing a premix for the hot gas and the fuel before the spontaneous ignition. Therefore in the following with terms reheat burners we mean only the burners at the second stage of combustion in the sequential combustor.

[0004] Today two different kinds of sequential gas turbines are known. According to the first embodiment the premix and reheat combustors are annular shaped and are physically separated by a stage of turbine blades, called high pressure turbine. According to a second embodiment, the gas turbine is not provided with the high pressure turbine and the combustor unit is realized in form of a plurality of can-combustors. In this embodiment each can-combustor comprises a premix (first stage) and the reheat (second stage) combustor arranged directly one downstream the other inside the common can shaped casing. In both embodiments the burners are configured for injecting different kinds of fuel, i.e. liquid (in the following with the terms "oil fuel" it is meant "liquid fuel" in general) and gas fuel, and carrying air, i.e. a little part of the compressed air leaving the compressor. In view of the above, the burners are provided with separated channels or ducts for feeding the gas fuel, liquid fuel and carrying air to relevant burner nozzles.

[0005] Starting from the above mentioned structures of sequential gas turbines, today is present the need of improving the fuel flexibility while keeping low emission and high performance. In particular, a real challenge today is to use a highly reactive fuel, e.g. with high amounts of H₂ or higher hydrocarbons (e.g. ethane, propane). Indeed, the increasing use of renewables for energy production is also accompanied by an increasing need for flexible power production, while aiming at carbon free emissions. The potential solutions of energy storage of excess generation from renewables through hydrogen production and precombustion carbon capture are gaining momentum. Both scenarios require gas turbines capable of operation with hydrogen-based fuels. At the same time, the composition of natural gas considered for use within gas turbines is becoming significantly more

variable due to increased use of liquefied natural gas and a wider range of gas sources and extraction methods. Fuel flexibility, both in terms of the amount of hydrogen and higher hydrocarbons is therefore of utmost importance in modern gas turbine development.

[0006] A change in fuel reactivity implies a change in flame location. In particular, higher fuel reactivity (like H₂) forces the flame to move upstream, increasing NO_x emissions, and potentially overheating the burners. Consequently, when burning highly reactive fuels (e.g. fuels containing large quantities of either higher hydrocarbons or hydrogen) the flame moves upstream compared to the case of natural gas, thus increasing the risk of flashback. Since the position of the flame in the reheat combustor can be effectively controlled by the temperature at the inlet of the reheat combustor (self/spontaneous ignition), by lowering the inlet temperature it is therefore possible to move the flame downstream. Therefore, the negative effect of higher fuel reactivity (flashback) in the reheat combustor can be compensated by lowering the first stage temperature. Moreover, also the premix combustor may be affected by flashback in this condition. According to the prior art practice, in order to mitigate the flashback risks by moving the flame back to its design position in the premix and in the reheat combustor is obtained by simply injecting less fuel in the first stage of combustion. In this way the position of the flame in the premix combustor is moved downstream and the inlet temperature of the second stage is lower.

[0007] According to the current prior art practice, only minor amounts of hydrogen are allowable in premix, non-reheat combustion system, therefore diffusion type combustors are used to generate electricity with particularly high amounts of hydrogen as fuel. However, this prior art practice generates high NO_x emissions and therefore a large amounts of diluents (nitrogen, steam) need to be added in the gas flow and/or selective catalytic reduction devices have to be used to keep the NO_x emissions below the limits. As known these remedies significantly reduce the efficiency of the gas turbine plant.

[0008] Summarizing, in case of highly reactive fuels e.g. hydrogen based fuels, the prior art practice gives the following suggestions:

- in case of generic premix systems it is not possible to use highly reactive fuels because of emission and flashback limits on the premix burners, requiring for major derating with detrimental effects on engine performance
- in sequential combustors, highly reactive fuels can be well used in the reheat combustor inlet temperature but beyond a certain limit the first combustor operation is limited by LBO;
- only in case of diffusion combustors (not premixed) it is possible to use a fuel having a high rate of H₂ (i.e. up to 100%). However, by using this kind of combustor it is not possible to reach the efficiency rate of a premix/reheat sequential combustor. More-

over, this solution is not considered today an acceptable solution in view of the detrimental impact on NO_x generation and because of the limitation of fuel gas pressure requirements.

Disclosure of the invention

[0009] Accordingly, a primary object of the present invention is to provide a sequential combustor for a gas turbine in order to overcome the drawbacks foregoing mentioned of the current prior art practice. In particular, the scope of the present invention is to provide a method for refurbishment a current sequential combustor for a gas turbine in order to allow the sequential combustor to be supplied with a highly reactive fuel, for instance H₂-based fuel having a % of H₂ in vol. from 0% to 100%.

[0010] The starting point of the present invention is an innovative method developed by the Applicant for operating a sequential combustor for a gas turbine when the combustor is fed by a highly reactive fuel. The sequential combustor configured for carrying out this operating method comprises:

- a first combustor provided with a plurality of first burners fed by compressed air and configured for injecting fuel in the compressed air;
- a second combustor provided with a plurality of second burners fed by the hot gas leaving the first combustor and configured for injecting fuel in the hot gas.

[0011] Referring to the first combustor, as known the supplied compressed air is the air leaving a compressor upstream arranged in the gas turbine with respect to the sequential combustor. The combustor operating method does not provide any limitation referring to the shape of the first combustor and in the following description of the drawings two different embodiments of the claimed first combustor will be described. Each burner of this first combustor may be a particular kind of burner, namely a so-called "premix" burner. It is clear for a skill person in the field of the gas turbines that the definition "premix" burner means a burner configured for mixing the coming air and the injected fuel before the inlet of the combustion chamber. For instance, in order to generate this mixing the premix burner may comprise an outer conical casing configured for generating a swirl in the air flow wherein this conical casing is also provided with fuel injecting nozzles. In this way the air flow leaving the burner and entering the combustion chamber is already mixed with the injected fuel. Moreover, as known, a "premix" burner may comprises also a pilot configured for injecting fuel directly in the air flow in the combustion chamber without any preliminary mixing feature. For instance, this pilot may be realized in form of a lance axially extending along the outer conical casing. Therefore, a premix burner is a burner configured for generating to different kinds of flame in the combustion chamber, a so-called diffusion flame, for instance generated by the fuel injected by the

pilot, and a premix flame, for instance generated by the swirled mixture air/fuel. As known a premix burner may be operated to generate only a diffusion flame, only a premix flame or a combination of a diffusion and a premix flame with different rate of fuel supplied in the premix circuit and in the diffusion circuit. During normal operation the premix flame is preferable due to a less NO_x generation.

[0012] The combustor operating method developed by the Applicant does not provide any limitation also referring to the shape of the second combustor. Each second burner is a burner configured for injecting fuel in the hot gas flow leaving the first combustor. Due to the high temperature of the hot gas leaving the first combustor, the second burner is not provided with a spark igniter or any forced igniter device and the combustion is based on a self/spontaneous ignition. This second burner is also called "reheat" burner and the present invention does not require any structural modification of current reheat burners.

[0013] As mentioned in the chapter referring to the prior art, today there is the need to provide a new operation mode for a sequential combustor when the supplied fuel is a highly reactive fuel. With the terms "highly reactive fuel" we mean a fuel having higher reactivity compared with natural gas. An example of high reactive fuel is a hydrogen-based fuel. When the sequential combustor is fed by a high reactive fuel the method for operating this sequential combustor developed by the Applicant comprises the following steps:

- switching off at least one of the first burners;
- operating the remaining active first burners for generating hybrid flames as combination of diffusion mode and premix mode combustion. In other words, the above operating method requires a high diffusion fuel rate wherein some burners may be operated only in diffusion configuration.

[0014] Starting from the above, the present invention solves the problem to how safely perform the above operating step of feeding the burner with a high diffusion fuel rate. Indeed, a high diffusion fuel rate during the normal operation would require a high fuel pressure drop (more than 10 bar) and this high fuel pressure drop requires in turn a very high pressure inside the gas fuel line feeding the diffusion nozzles. This high pressure may damage the combustion system. Furthermore the engine would require fuel gas pressure levels not always available in the fuel gas lines.

[0015] The solution proposed by the present invention is to use in parallel another fuel supply line already present in the burner for feeding to the diffusion nozzles at least part of the fuel running in the gas fuel line. In particular, according to the invention the fuel supply line used for feeding to the diffusion nozzles at least part of the fuel running in the gas fuel line is the oil fuel line. In other words, the solution proposed by the present inven-

tion is feeding part of the high reactive gas fuel running in the gas fuel line into the oil (liquid) fuel line; oil fuel line that are usually used only for oil fuel feeding. In order to allow this parallel feeding of the high reactive gas fuel not only inside the gas line but also inside the oil line a connection is provided between the pilot gas fuel line and the oil fuel line. This connection is provided with a valve configured for selectively allowing the flow of part of the high hydrogen gas fuel running in the gas line into the oil line.

[0016] Advantageously, this solution allows to reduce the pressure present in the gas fuel line without any detrimental impact on combustion. Indeed the NO_x generation level remains the same with and without the high hydrogen gas fuel passing through the oil fuel line.

[0017] According to a first embodiment, the valve connecting the gas line and the oil line is an on/off valve. According to a second embodiment, the valve connecting the gas line and the oil line is a mass flow controller.

[0018] Moreover, the present invention refers to a method for refurbishment a current sequential combustor for a gas turbine comprising a premix burner and a reheat burner, wherein:

- each premix burner is configured for injecting fuel in the compressed air in a diffusion mode by a pilot and in a premix mode; and
- each premix burner comprises at least a gas fuel nozzle fed by a gas fuel line and at least a oil gas nozzle fed by a oil fuel line.

[0019] The method of the present invention comprises the step of adding a connection between the gas fuel line and the oil fuel line wherein this connection is configured for selectively allowing part of gas fuel running in the gas fuel line to enter in the oil fuel line. Once fed inside the oil fuel line the spilled part gas fuel is injected by the oil nozzles in the combustion chamber. The method may comprise the step of providing the above connection with a valve, for instance an on/off valve or a mass flow controller.

[0020] It is to be understood that both the foregoing general description and the following detailed description are exemplary, and are intended to provide further explanation of the invention as claimed. Other advantages and features of the invention will be apparent from the following description, drawings and claims.

[0021] The features of the invention believed to be novel are set forth with particularity in the appended claims.

Brief description of drawings

[0022] Further benefits and advantages of the present invention will become apparent after a careful reading of the detailed description with appropriate reference to the accompanying drawings.

[0023] The invention itself, however, may be best understood by reference to the following detailed descrip-

tion of the invention, which describes an exemplary embodiment of the invention, taken in conjunction with the accompanying drawings, in which:

- figure 1 is a schematic view of a first embodiment of a gas turbine comprising a sequential combustor that can be provided with the innovative component according to the present invention;
- figure 2 is a schematic view of a second embodiment of a gas turbine comprising a sequential combustor that can be provided with the innovative component according to the present invention;
- figure 3 is a schematic view of the sequential combustor of the gas turbine disclosed in figure 2 in two different operation conditions;
- figures 4 and 5 are schematic views of a burner of the sequential combustor of figure 3 in two different operation conditions; and
- figure 6 is a schematic view of burner fuel lines according to an embodiment of the present invention.

Detailed description of preferred embodiments of the invention

[0024] In cooperation with the attached drawings, the technical contents and detailed description of the present invention are described thereafter according to preferred embodiments, being not used to limit its executing scope. Any equivalent variation and modification made according to appended claims is all covered by the claims claimed by the present invention.

[0025] Reference will now be made to the drawing figures to describe the present invention in detail.

[0026] Reference is now made to Fig. 1 that is a schematic view of a first example of a gas turbine 1 comprising a sequential combustor wherein the first burner with a pilot can be provided with the pilot fuel lines according to the present invention. In particular, figure 1 discloses a gas turbine with a high pressure and a low pressure turbine. Following the main gas flow 2, the gas turbine 1 of figure 1 comprises a compressor 3, a first combustor 31, a high-pressure turbine 5, a second combustor 32 and a low-pressure turbine 7. The compressor 3 and the two turbines 5, 7 are part of or are connected to a common rotor 8 rotating around an axis 9 and surrounded by a concentric casing 10. The compressor 3 is supplied with air and is provided with rotating blades 18 and stator vanes 19 configured for compressing the air entering the compressor 3. Once left the compressor, the compressed air flows into a plenum 11 and from there into a plurality of first burners 12 of the first combustor 31 arranged as a ring around the axis 9. Each first burner 12 is configured for injecting fuel (supplied by a first fuel supply 13) in the air flow, in particular this first burner 12 may be defined as a "premix" burner because in configured for mixing the air and the injected fuel before the spark point. Figures 4 and 5 (that will be described in the following) disclose an example of a premix burner with a

pilot that can be provided with the pilot fuel lines according to the present invention. Please notice that the invention however is not limited to present of a pilot. The fuel/compressed air mixture flows into a first combustion chamber 4 annularly shaped where this mixture are combusted via a forced ignition, for instance by a spark igniter. The resulting hot gas leaves the first combustor chamber 4 and is partially expanded in the high-pressure turbine 5 performing work on the rotor 8. Downstream of the high-pressure turbine 5 the hot gas partially expanded flows into a second burner 33 where fuel supplied by a fuel lance 14 is injected. The partially expanded gas has a high temperature and contains sufficient oxygen for a further combustion that occurred based on a self-ignition in the second combustion chamber 6 arranged downstream the second burner 33. This second burner 33 is also called "reheat" burner. The reheated hot gas leaves the second combustion chamber 6 and flows in the low-pressure turbine 7 where it is expanded performing work on the rotor 8. The low-pressure turbine 7 comprises a plurality of stages, or rows, of rotor blades 15 arranged in series in the main flow direction. Such stages of blades 15 are interposed by stages of stator vanes 16. The rotor blades 15 are connected to the rotor 8 whereas the stator vanes 16 are connected to a vane carrier 17 that is a concentric casing surrounding the low-pressure turbine 7.

[0027] Reference is now made to Fig. 2 that is a schematic view of a second example of a gas turbine 20 comprising a sequential combustor wherein the first burner with a pilot can be provided with the pilot fuel lines according to the present invention. In particular, figure 2 discloses a gas turbine 20 provided with a compressor 29, one turbine 21 and a sequential combustor 22. The sequential combustor 22 of figure 2 comprises a plurality of so-called can combustors, i.e. a plurality of cylindrical casings wherein each can combustor houses a plurality of first burners 24, for instance four first burners 24, a first combustion chamber 25, a second burner 26, and a second combustion chamber 27. Upstream the second burner 26 an air mixer (not represented) may be provided configured for adding air in the hot gas leaving the first combustion chamber 25. The sequential combustor arrangement is at least in part housed in an outer casing 28 supporting the plurality of can combustor 22 arranged as a ring around the turbine axis. A first fuel is introduced via a first fuel injector (not shown) into the first burners 24 wherein the fuel is mixed with the compressed gas supplied by the compressor 29. Also each first burner 24 of this embodiment is a "premix" burner configured for generating a premix flame and a diffusion flame. Each first burner 24 of figure 2 and each first burner 12 of figure 1 is independently operable, i.e. each first burner may be switched off independently on the other first burners and each first burner may be operated independently in terms of ratio between the fuel injected in the diffusion mode and the fuel injected in the premix mode. Finally, the hot gas leaving the second combustion chamber 27

expands in the turbine 21 performing work on a rotor 30.

[0028] Reference is now made to Fig. 3 that is a schematic view of a can combustor 22 that may be a combustor of the turbine of figure 2. In particular, figure 3 discloses the combustor in two different operation conditions, i.e. with two different flames positions inside the can combustor 22. Moreover, below figure 3 a diagram is present disclosing how the temperature varies in these two different operation conditions inside the can combustor 22. As known and as foregoing mentioned, the can combustor 22 is today preferable because it has significant advantages in terms of both low emissions and fuel flexibility. The first stage premixed burner 24 utilizes aerodynamic structures to stabilize a propagating premix flame providing excellent flame stability and combustion efficiency over an extensive operational range. This flame having a correct distance from the burner nozzles is represented by the reference 34'. The second burner 26 in contrast is a primarily auto-ignition controlled burner. The flame generated by the second burner 26 is represented by the reference 35'. These two contrasting methods of generating the flames provide a substantial advantage in minimising NOx emissions at base load while maximising the engine's turndown capability. The flexibility of the can combustor 22 can be applied to allow low emission performance for a wide range of fuels. For each fuel type an operational approach through the adjustment of the inlet temperature of the second burner 26 (temperature at ref. 46 after the reference 47 representing the air dilution mixer) can be defined which allows both flame locations to be correctly maintained. For higher reactivity fuels (e.g. high hydrogen or higher hydrocarbon contents) the flames at the first 24 and the second burner 26 move upstream as represented by the references 34 and 35. These movement towards the burners involves some drawbacks, i.e. a high flame residence time (and therefore high NOx generation) and overheating of the burner nozzles. A solution to move downstream the flames 34 35 to a correct position of flames 34' 35' may be reducing the first stage flame temperature (reducing fuel injected in the first stage for passing from line 36 to line 37 in diagram of Figure 3). At the same time it also accounts for the change in auto-ignition delay time and hence flame location of the second stage whose position for the same flame temperature can be controlled. If, for example, instead of natural gas a more reactive fuel, i.e. hydrogen, is burnt, the first stage temperature has to be reduced. As can be seen in Figure 3, reducing the first stage temperature alters the ignition delay time of the second stage in the desired way to keep the flame 35 at its design position 35'. In order to further increase the hydrogen content of the fuel up to 100% a lower second inlet temperature is required. Applicant developed a new solution for allowing the feeding of highly reactive fuels. This solution is to realize hybrid flames obtained by adjusting the distribution of fuel of some active first burners between the diffusion and premixed mode, in particular by providing a high pilot fuel rate. In this way

the lean blow out margin (low temperature) of the first stage is extended without any drawback of the prior art practice. Therefore, the first stage can be operated with highly reactive fuels without injecting diluents while delivering sufficiently lower inlet temperature levels for the second stage combustor. Starting from the above hybrid operating mode, the present invention solves the problem of safely performing the above operating step of feeding the burner with a "high diffusion fuel flow rate". Indeed, a high diffusion fuel flow rate during normal operation requires a high fuel pressure drop (more than 10 bar) and this high fuel pressure drop requires a very high fuel pressure inside the gas fuel line feeding.

[0029] Reference is now made to figures 4 and 5 that are schematic views of an non limiting example of a first or premix burner suitable for performing the invention in two different operation conditions. According to this example the premix burner 41 is a burner configured for generating a diffusion flame 42 (figure 4) and a premix flame 43 (figure 5). For generating the diffusion flame 42 the fuel is directly injected in the combustion chamber by a pilot lance 44 without any preliminary mixing with the coming compressed air. For generating the premix flame 43, the fuel is mixed with the compressed air before entering the combustion chamber. For instance the mixing may be realized by passing the air in a conical casing 45 configured for generating a swirl wherein this conical casing 45 is also provided with nozzles for injecting fuel in this swirl. According the present invention, when the burner is fed by reactive fuel like H2-based fuel, the method comprises the step switching off at least one of the first burners (for instance at least a burner for each can combustor) and operating the remaining active first burners for generating hybrid flames as combination of diffusion mode and premix mode. Preferably, at least one of active first burners is operated so that a significant amount of fuel is burnt in diffusion mode, in particular at least 5% of the fuel fed to this burner. According to a different embodiment, in a can combustor some burners on the first stage may be operated only in premix configuration and others only in diffusion configuration.

[0030] According to a different embodiment, different burners may be operated simultaneously in premix and in diffusion configuration with different ratios of diffusion/premix mode. The switch-off of some of the first stage burners may be done with a specific pattern in order to optimize the temperature distribution.

[0031] Reference is now made to figure 6 that is a schematic view of fuel lines according to an embodiment of the present invention. The solution proposed is feeding part of the high reactive gas fuel running inside the gas line into the oil line (already present in the burner and usually used only for oil fuel feeding). According to the embodiment of figure 6, the burner is provided with a gas fuel nozzle 48 and an oil fuel nozzle 49. The gas fuel nozzle 48 is fed by a gas fuel line 50 connected at the opposite end to a gas fuel source 51. The oil fuel nozzle 49 is fed by a oil fuel line 52 connected at the opposite

end to an oil fuel source 53. According to the invention the burner is also provided with a connection 54 (i.e. at least a duct) fluidly connecting the gas fuel line 50 with oil fuel line 52. According to the embodiment disclosed in figure 6 the connection 54 is provided with a valve 55 configured for selectively feeding part of the gas fuel running in the gas fuel line 50 inside the oil fuel line 52 so that the pressure present in the gas line may be reduced without any detrimental impact on combustion. Of course the burner may comprise a plurality of gas and oil nozzles fed by a plurality of fuel lines.

[0032] Although the invention has been explained in relation to its preferred embodiment(s) as mentioned above, it is to be understood that many other possible modifications and variations can be made without departing from the scope of the present invention. It is, therefore, contemplated that the appended claim or claims will cover such modifications and variations that fall within the true scope of the invention.

Claims

1. A sequential combustor (22) for a gas turbine (1, 20); the sequential combustor (22) comprising:

- a first combustor provided with a plurality of first burners (12, 24) fed by compressed air and configured for injecting fuel in the compressed air in a diffusion mode (42) and in a premix mode (43), each first burners (12, 24) comprises at least a gas fuel nozzle (48) fed by a gas fuel line (50) and at least a liquid fuel nozzle (49) fed by a liquid fuel line (52);
- a second combustor provided with a plurality of second burners (26, 33) fed by hot gas leaving the first combustor and configured for injecting fuel in the hot gas;

characterized in that the combustor (22) moreover comprises a fluidly connection (54) configured for selectively connecting the gas fuel line (50) and the liquid fuel line (52) for allowing part of gas fuel running in the gas fuel line (50) to enter in the liquid fuel line (52) and to be injected by the liquid fuel nozzle (49).

2. Sequential combustor (22) as claimed in claim 1, wherein, the connection (54) is provided with an on/off valve (55).
3. Sequential combustor (22) as claimed in claim 1, wherein, the connection (54) is provided at a mass flow controller.
4. A method for operating a sequential combustor (22) for a gas turbine (1, 20); the method comprising the steps of:

- a) providing a sequential combustor (22) comprising:

- a first combustor provided with a plurality of first burners (12, 24) fed by compressed air and configured for injecting fuel in the compressed air in a diffusion mode (42) and in a premix mode (43), each first burners (12, 24) comprises at least a gas fuel nozzle (48) fed by a gas fuel line (50) and at least a liquid fuel nozzle (49) fed by a liquid fuel line (52);
- a second combustor provided with a plurality of second burners (26, 33) fed by hot gas leaving the first combustor and configured for injecting fuel in the hot gas;
- a fluidly connection (54) configured for selectively connecting the gas fuel line (50) and liquid fuel line (52) for allowing part of gas fuel running in the gas fuel line (50) to enter in the liquid fuel line (52) and to be injected by the liquid fuel nozzle (49)

- b) feeding the first (12, 24) and second burners (26, 33) with a high reactive fuel;
- c) switching off at least one of the first burners (12, 24);
- d) operating the remaining active first burners so as to generate hybrid flames as combination of diffusion mode and premix mode;
- e) flowing at least part of the gas fuel running inside the gas fuel line (50) into the liquid fuel line (52) through the connection (54);

5. Method as claimed in claim 4, wherein the method comprises the step of providing the connection (54) with a valve (55).
6. Method as claimed in claim 4, wherein the method comprises the step of providing the connection (54) with mass flow controller.
7. Method for refurbishment a sequential combustor for a gas turbine, the method comprising the steps of:

- a) providing a sequential combustor (22) comprising:

- a first combustor provided with a plurality of first burners (12, 24) fed by compressed air and configured for injecting fuel in the compressed air in a diffusion mode (42) and in a premix mode (43), each first burners (12, 24) comprises at least a gas fuel nozzle (48) fed by a gas fuel line (50) and at least a liquid fuel nozzle (49) fed by a liquid fuel line (52);
- a second combustor provided with a plu-

ality of second burners (26, 33) fed by hot gas leaving the first combustor and configured for injecting fuel in the hot gas;

b) adding a connection (54) between the gas fuel line (50) and the liquid fuel line (52) for selectively allowing part of gas fuel running in the gas fuel line (50) to enter in the liquid fuel line (52) and to be injected by the liquid fuel nozzle (49). 5 10

8. Method as claimed in claim 7, wherein the method comprises the step of providing the connection (54) with a valve (55). 15

9. Method as claimed in claim 7, wherein the method comprises the step of providing the connection (54) with mass flow controller. 20

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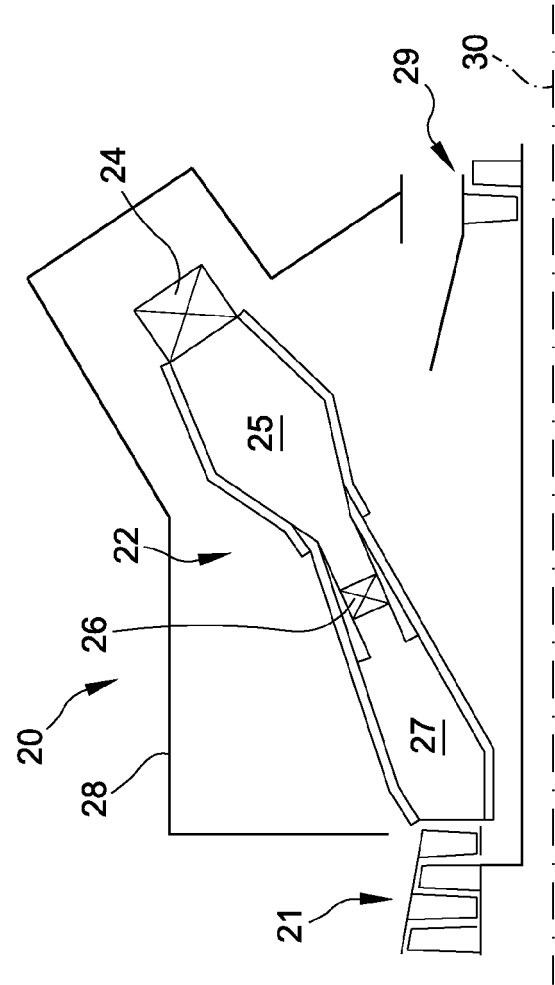
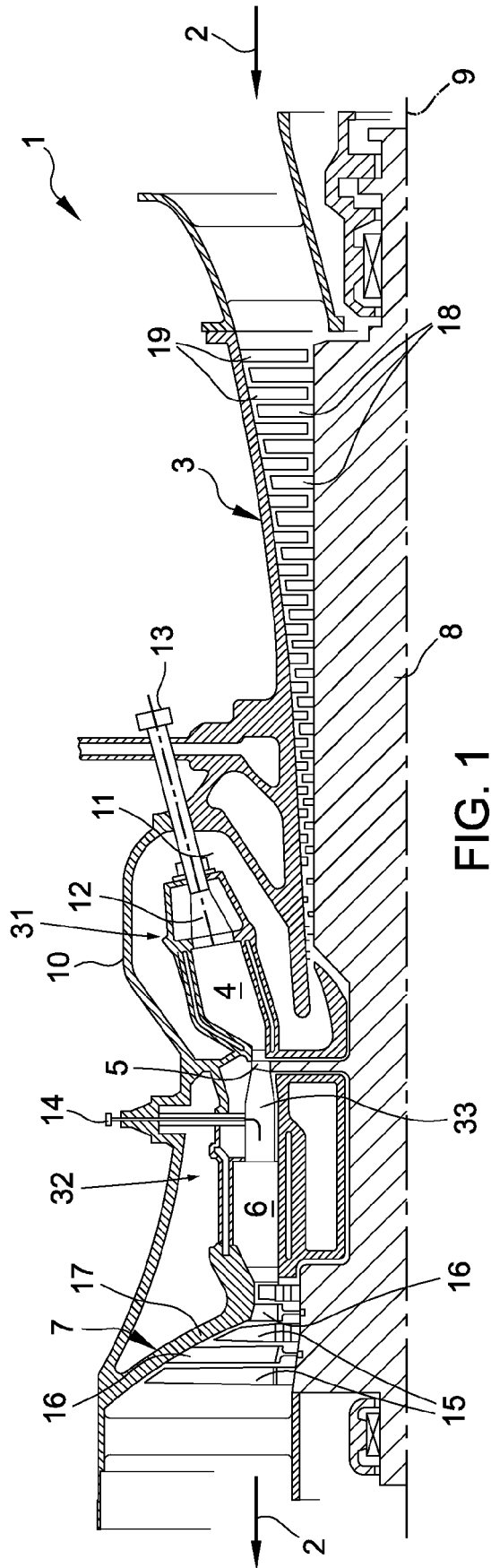
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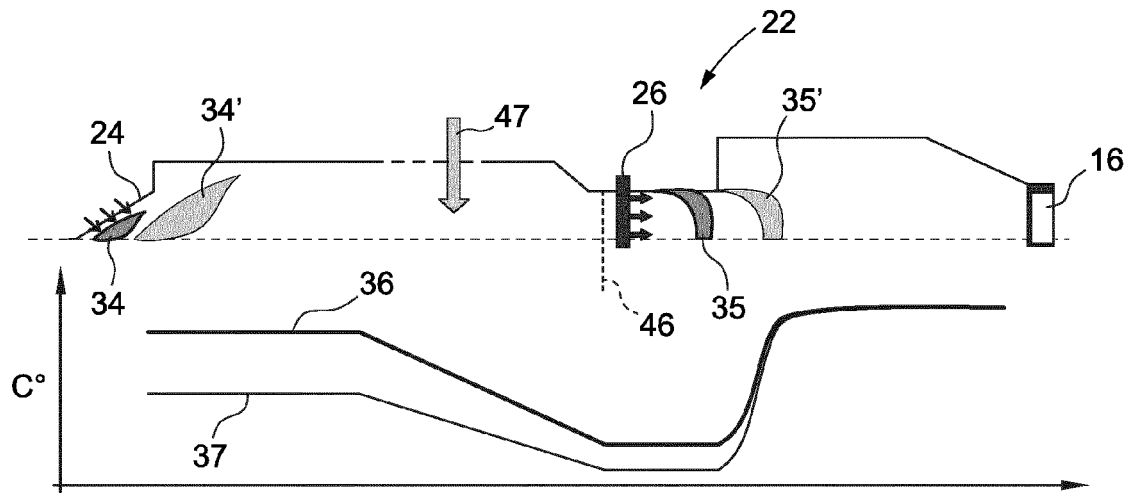


FIG. 3

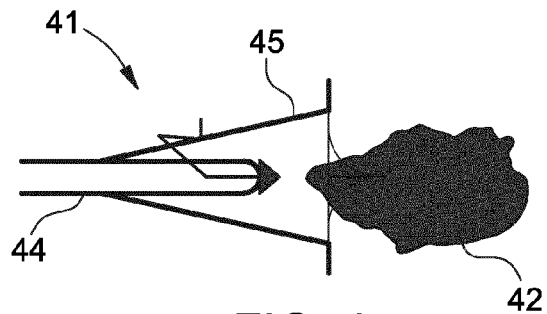


FIG. 4

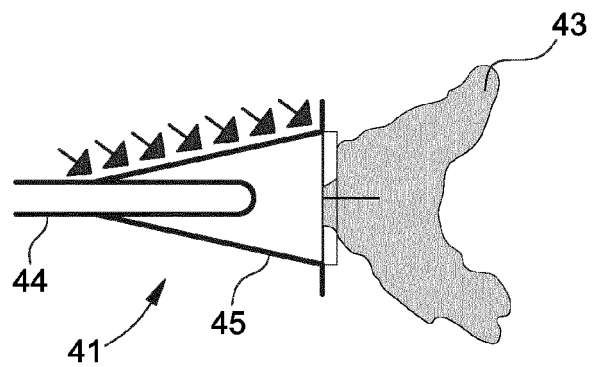


FIG. 5

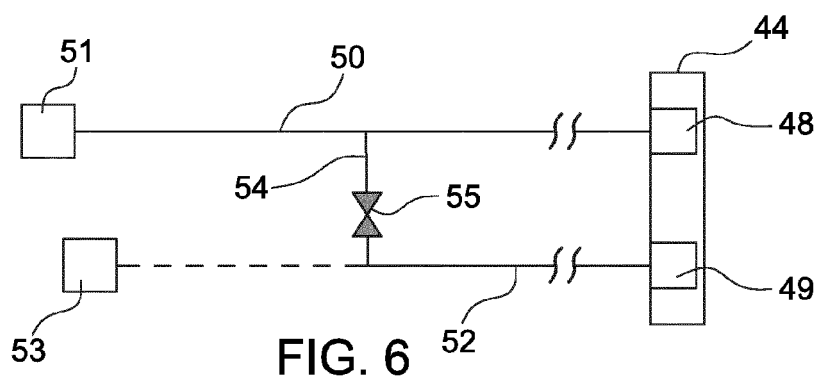


FIG. 6



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