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(54) A COMBUSTION CHAMBER FOR A TURBINE-COMPRESSOR UNIT ASSOCIATED WITH AN INTERNAL COMBUSTION ENGINE

(71) We, ETAT FRANCAIS represented by le Délégué Ministériel pour l'Armement, of 4, avenue de la Porte d'Issy, 75996-Paris (France), do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a combustion chamber for a turbine-compressor unit associated with an internal combustion engine such as a Diesel engine, the turbine-compressor unit serving to supercharge the engine, the compressor of the unit delivering fresh air to the engine and the turbine of the unit driving the compressor and being actuated by the exhaust gases from the engine.

The combustion chamber is operable for reheating gases upstream of the turbine of the turbine-compressor unit and is connected to be supplied with fuel, with exhaust gases from the engine and with fresh air taken through a by-pass pipe from the outlet of the compressor.

The combustion chamber thus receives oxygen-poor gas (exhaust gas from the engine) and oxygen-rich gas (fresh air delivered by the compressor), the relative flow-rates of these two gases varying as a function of the rotary speed of the engine; in fact, at high speed the engine absorbs much fresh air and delivers much exhaust gas (the combustion chamber is then supplied by a considerable flow-rate of exhaust gas and by a low flow-rate of fresh air), whilst at reduced speed, e.g. on idling the engine absorbs little fresh air and delivers little exhaust gas (the combustion chamber is supplied by a low flow-rate of exhaust gas and by a considerable flow-rate of fresh air).

This relative variation can reach proportions of 1 to 10 between operation of the engine at full speed and operation of the engine at idling speed.

This relative variation of the flow-rates of the exhaust gas and of fresh air poses problems of combustion stability, especially on acceleration and deceleration of the rotary speed of the engine.

In fact, in these two cases the exhaust gases can contain fuel which has not been burnt in the engine and the carburetted mixture thus constituted risks being exploded on its passage into the combustion chamber, this explosion risking extinction of the flame in the chamber.

It is a principal object of the invention to avoid such occurrences taking place.

According to the invention, there is provided a combustion chamber for a turbine-compressor unit associated with an internal combustion engine, which combustion chamber is operable for reheating gases upstream of the turbine of said turbine-compressor unit and is connected to be supplied with fuel and at the same time with exhaust gases emerging from the engine and with fresh air taken through a by-pass pipe from the outlet of the compressor of said turbine-compressor unit, said combustion chamber comprising tubular means having a closed end and an open end, at least one fuel injector located toward the closed end to the tubular means, a primary air intake conduit arranged to introduce fresh air from said by-pass pipe into a combustion zone in the tubular means in the vicinity of its closed end, an exhaust gas intake conduit arranged to introduce the exhaust gases into a mixing zone in the tubular means located downstream of said combustion zone, the outlet of said exhaust gas intake conduit being oriented to effect said introduction in the direction of the open end of said tubular means, and a secondary air intake conduit arranged to introduce fresh air into the tubular means downstream of the upstream end of said mixing zone in the form of a plurality of jets oriented in a direction transverse to the flow of exhaust gases in said mixing zone.

In a combustion chamber embodying the invention, there is obtained a dilution effect

[Price 33p]

Price 75p

due to the exhaust gases and to the fresh air introduced into the mixing zone, the combination of the two flows thus introduced into the mixing zone resulting in a reduced-pressure zone between the mixing zone and the combustion zone which exerts a suction effect.

This suction effect causes permanent aspiration of fresh air around the combustion zone, which stabilises combustion and avoids extinction of the flame even when explosions are produced due to the presence of unburnt materials in the exhaust gases.

According to a preferred feature of the invention, said primary air intake conduit defines a primary space surrounding the closed end of the tubular means, said tubular means having a plurality of orifices distributed regularly over its circumference for admitting primary air from said primary space into said combustion zone.

Preferably, said exhaust gas intake conduit defines a space of annular shape intermediate said primary space and said secondary air intake conduit and wherein the outlet of the exhaust gas intake conduit is connected to the tubular means downstream of the primary space.

Preferably, the secondary air intake conduit defines a secondary space surrounding at least a portion of said exhaust gas intake conduit, and the outlet of said secondary air let orifices arranged in the downstream portion of said exhaust gas intake conduit and angularly located so that the secondary air is introduced into said mixing zone in the form of a circumferentially distributed array of jets directed into the flow of exhaust gases in said mixing zone in a direction which is substantially radial with respect to the axis of said tubular means.

In order that the invention may be readily understood, an embodiment thereof will now be described, by way of example, with reference to the accompanying drawing.

The single Figure of the drawing is a diagrammatic view in section illustrating a preferred embodiment of a combustion chamber according to the invention.

The illustrated combustion chamber 1 is intended to form part of an installation comprising an internal combustion engine 2 (such as for example a Diesel engine) supercharged by a turbine-compressor unit 3. The turbine-compressor unit 3 comprises at least one compressor 4 delivering compressed air to the engine 2, and at least one turbine 5, driving said compressor 4, and actuated by the exhaust gases from the engine 2. The chamber 1 is operable to provide reheating of gases upstream of the turbine.

The combustion chamber 1 is connected upstream of the turbine 5 and is supplied

with fuel through a passage 6, and at the same time, with the exhaust gases coming from the engine 2 through an exhaust pipe 7 and with fresh air taken from the outlet of the compressor 4 through a by-pass pipe 8.

The combustion chamber 1 comprises:

tubular means 9 consisting of two axially spaced coaxial elements and having a closed end 10 and an open end 11,

at least one fuel injector 12 situated towards the closed end 10 of the tubular means 9 and receiving fuel through the passage 6,

a primary air intake conduit 13 arranged for introducing fresh air from the by-pass pipe 8 into a combustion zone 14 in the tubular means 9 in the vicinity of its closed end 10,

an exhaust gas intake conduit 15 arranged to introduce the exhaust gases into a mixing zone 16 in the tubular means 9 downstream of the combustion zone 14, the outlet of the conduit 15 being oriented to introduce the exhaust gases in a direction slightly inclined with respect to the axis XX of the tubular means 9 and in the direction of its open end 11,

and a secondary air intake conduit 17 arranged to introduce fresh air into the mixing zone 16 in the tubular means 9 downstream of the upstream end of the mixing zone, this introduction of secondary air being effected at right angles (approximately at least) to the flow of exhaust gases introduced into the mixing zone and so that the flow of secondary air is opposed by the flow of the exhaust gases.

The interaction of the two flows thus introduced into the mixing zone 16 generates a suction zone 18 between the mixing zone 16 and the combustion zone 14.

The primary air intake conduit 13 defines a primary space 19 surrounding the closed end 10 of the tubular means 9 which is provided with a plurality of orifices 20, distributed regularly over its circumference for admitting primary air from the primary space 19 into the combustion zone.

The exhaust gas intake conduit 15 defines a space 21 of annular shape intermediate the primary space 19 and the secondary air conduit 17, the outlet of the conduit 15 being connected to the tubular means 9 at an annular orifice 22 downstream of the primary space 19.

The secondary air intake conduit 17 defines a secondary space 23 surrounding the intermediate space 21 and comprises outlet orifices 24 arranged in the downstream portion of the exhaust gas intake conduit 15 and arranged so that the secondary air is introduced into the mixing zone in the form of a circumferentially distributed array of jets directed into the flow of exhaust gases in the mixing zone in a direction which

is substantially radial with respect to the axis of the tubular means 9.

The intermediate space 21 is connected directly to the exhaust pipe 7, and the secondary space 23 is connected directly to the by-pass pipe 8.

To enable the supply of fresh air to the primary space 19, passages 25 traversing the intermediate space 21 are provided to connect the secondary space 23 to the primary space 19.

In the Figure, the circulation of the exhaust gases is shown by arrows in heavy line and the circulation of fresh air is shown by arrows in thin line.

Preferably, the primary space 19 has a streamlined shape around which are arranged an upstream portion of the intermediate space 21 and an upstream portion of the secondary space 23, these upstream portions hence having a continuous shape leading to portions adapted to be connected respectively to the exhaust pipe 7 and to the by-pass pipe 8.

A downstream portion of the exhaust gas intake conduit 15 is connected to the tubular means 9 so as to facilitate the introduction of exhaust gases in the direction of the open end 11 of the tubular means 9; this downstream portion hence having a convergent frustoconical shape towards the open end 11.

A downstream portion of the secondary air intake conduit 17 is connected to the tubular means 9 so as to facilitate the radial introduction of fresh air perpendicularly to the axis XX of the tubular element 9; this downstream portion hence having a shape for deflecting secondary air through the orifices 24 in the direction radially inward of the axis XX.

Finally and whatever the embodiment adopted, the combustion chamber according to the invention has a certain number of advantages among which may be mentioned those summarised by the following points:

the risk of extinction of the flame in the chamber is practically eliminated due to permanent aspiration of fresh air around the combustion zone;

the kinetic energy of the exhaust gases ensures the dilution and cooling of the hot gases resulting from combustion;

the exhaust gases experience minimal resistance in their flow towards the turbine; and

the structure of the combustion chamber is simple and enables easy and inexpensive construction.

WHAT WE CLAIM IS:—

1. A combustion chamber for a turbine-compressor unit associated with an internal combustion engine, which combustion chamber is operable for reheating gases upstream of the turbine of said turbine-compressor

unit and is connected to be supplied with fuel and at the same time with exhaust gases emerging from the engine and which fresh air taken through a by-pass pipe from the outlet of the compressor of said turbine-compressor unit, said combustion chamber comprising tubular means having a closed end and an open end, at least one fuel injector located toward the closed end of the tubular means, a primary air intake conduit arranged to introduce fresh air from said by-pass pipe into a combustion zone in the tubular means in the vicinity of its closed end, an exhaust gas intake conduit arranged to introduce the exhaust gases into a mixing zone in the tubular means located downstream of said combustion zone, the outlet of said exhaust gas intake conduit being oriented to effect said introduction in the direction of the open end of said tubular means, and a secondary air intake conduit arranged to introduce fresh air into the tubular means downstream of the upstream end of said mixing zone in the form of a plurality of jets oriented in a direction transverse to the flow of exhaust gases in said mixing zone.

2. A combustion chamber according to Claim 1, wherein said primary air intake conduit defines a primary space surrounding the closed end of the tubular means, said tubular means having a plurality of orifices distributed regularly over its circumference for admitting primary air from said primary space into said combustion zone.

3. A combustion chamber according to Claim 2, wherein said exhaust gas intake conduit defines a space of annular shape intermediate said primary space and said secondary air intake conduit and wherein the outlet of the exhaust gas intake conduit is connected to the tubular means downstream of the primary space.

4. A combustion chamber according to Claim 3, wherein the outlet of the exhaust gas intake conduit comprises an annular orifice.

5. A combustion chamber according to Claim 3, wherein the secondary air intake conduit defines a secondary space surrounding at least a portion of said exhaust gas intake conduit, and the outlet of said secondary air intake conduit comprises a plurality of outlet orifices arranged in the downstream portion of said exhaust gas intake conduit and angularly located so that the secondary air is introduced into said mixing zone in the form of a circumferentially distributed array of jets directed into the flow of exhaust gases in said mixing zone in a direction which is substantially radial with respect to the axis of said tubular means.

6. A combustion chamber according to Claim 5, wherein the intermediate space of said exhaust gas intake conduit is connectable directly to the engine exhaust pipe, and



is substantially radial with respect to the axis of the tubular means 9.

The intermediate space 21 is connected directly to the exhaust pipe 7, and the secondary space 23 is connected directly to the by-pass pipe 8.

To enable the supply of fresh air to the primary space 19, passages 25 traversing the intermediate space 21 are provided to connect the secondary space 23 to the primary space 19.

In the Figure, the circulation of the exhaust gases is shown by arrows in heavy line and the circulation of fresh air is shown by arrows in thin line.

Preferably, the primary space 19 has a streamlined shape around which are arranged an upstream portion of the intermediate space 21 and an upstream portion of the secondary space 23, these upstream portions hence having a continuous shape leading to portions adapted to be connected respectively to the exhaust pipe 7 and to the by-pass pipe 8.

A downstream portion of the exhaust gas intake conduit 15 is connected to the tubular means 9 so as to facilitate the introduction of exhaust gases in the direction of the open end 11 of the tubular means 9; this downstream portion hence having a convergent frustoconical shape towards the open end 11.

A downstream portion of the secondary air intake conduit 17 is connected to the tubular means 9 so as to facilitate the radial introduction of fresh air perpendicularly to the axis XX of the tubular element 9; this downstream portion hence having a shape for deflecting secondary air through the orifices 24 in the direction radially inward of the axis XX.

Finally and whatever the embodiment adopted, the combustion chamber according to the invention has a certain number of advantages among which may be mentioned those summarised by the following points:

the risk of extinction of the flame in the chamber is practically eliminated due to permanent aspiration of fresh air around the combustion zone;

the kinetic energy of the exhaust gases ensures the dilution and cooling of the hot gases resulting from combustion;

the exhaust gases experience minimal resistance in their flow towards the turbine; and

the structure of the combustion chamber is simple and enables easy and inexpensive construction.

WHAT WE CLAIM IS:—

1. A combustion chamber for a turbine-compressor unit associated with an internal combustion engine, which combustion chamber is operable for reheating gases upstream of the turbine of said turbine-compressor

unit and is connected to be supplied with fuel and at the same time with exhaust gases emerging from the engine and which fresh air taken through a by-pass pipe from the outlet of the compressor of said turbine-compressor unit, said combustion chamber comprising tubular means having a closed end and an open end, at least one fuel injector located toward the closed end of the tubular means, a primary air intake conduit arranged to introduce fresh air from said by-pass pipe into a combustion zone in the tubular means in the vicinity of its closed end, an exhaust gas intake conduit arranged to introduce the exhaust gases into a mixing zone in the tubular means located downstream of said combustion zone, the outlet of said exhaust gas intake conduit being oriented to effect said introduction in the direction of the open end of said tubular means, and a secondary air intake conduit arranged to introduce fresh air into the tubular means downstream of the upstream end of said mixing zone in the form of a plurality of jets oriented in a direction transverse to the flow of exhaust gases in said mixing zone.

2. A combustion chamber according to Claim 1, wherein said primary air intake conduit defines a primary space surrounding the closed end of the tubular means, said tubular means having a plurality of orifices distributed regularly over its circumference for admitting primary air from said primary space into said combustion zone.

3. A combustion chamber according to Claim 2, wherein said exhaust gas intake conduit defines a space of annular shape intermediate said primary space and said secondary air intake conduit and wherein the outlet of the exhaust gas intake conduit is connected to the tubular means downstream of the primary space.

4. A combustion chamber according to Claim 3, wherein the outlet of the exhaust gas intake conduit comprises an annular orifice.

5. A combustion chamber according to Claim 3, wherein the secondary air intake conduit defines a secondary space surrounding at least a portion of said exhaust gas intake conduit, and the outlet of said secondary air intake conduit comprises a plurality of outlet orifices arranged in the downstream portion of said exhaust gas intake conduit and angularly located so that the secondary air is introduced into said mixing zone in the form of a circumferentially distributed array of jets directed into the flow of exhaust gases in said mixing zone in a direction which is substantially radial with respect to the axis of said tubular means.

6. A combustion chamber according to Claim 5, wherein the intermediate space of said exhaust gas intake conduit is connectable directly to the engine exhaust pipe, and



the secondary space is connectable directly to the by-pass pipe.

7. A combustion chamber according to Claim 6, wherein said secondary air intake conduit is connected to said primary air intake conduit by passages traversing said intermediate space of said exhaust gas intake conduit.

8. A combustion chamber according to Claim 7, wherein said primary air intake conduit has a streamlined shape around which are arranged an upstream portion of said exhaust gas intake conduit and an upstream portion of said secondary air intake conduit, said upstream conduit portions having a continuous shape leading to portions adapted to be connected respectively to the exhaust pipe and to the by-pass pipe.

9. A combustion chamber according to Claim 8, wherein the downstream portion of said exhaust gas intake conduit is connected to the tubular means by a conduit portion of frustoconic shape convergent towards the open end of the tubular means and encircling the outlet of said combustion zone.

10. A combustion chamber according to Claim 9, wherein a downstream portion of said secondary air intake conduit connected to the tubular means has an air deflecting shape for deflecting secondary air into said outlet orifices of secondary air intake conduit in the direction radially inwardly to the axis of the tubular means.

11. A combustion chamber substantially as hereinbefore described with reference to the accompanying drawing.

12. A power unit having an internal combustion engine, particularly a Diesel engine, and a combustion chamber according to any preceding claim.

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