DEVICE FOR FEEDING AN INTERNAL COMBUSTION ENGINE WITH LIQUID EMULSIONS AND COMBUSTIBLE GAS

Abstract: A device for feeding an internal combustion engine with liquid emulsions and with combustible gas includes: - mixing means (2) in flow communication with a source (21) of combustible gas (51) and with the engine (5); - emulsifying means (3) in flow communication with a first tank (57) of the liquid fuel (52), with a second tank (30) of the emulsion liquid (53) and with the engine (5). The mixing means (2) include, in cascade connection, delivering means (22) of the combustible gas (51) of the source (21), regulating means (23) of the flow rate of the combustible gas (51) and they are fit for mixing the comburent air (59) for the engine (5) with a combustible gas (51). The emulsifying means (3) include a diffuser mean (33) connected to the outlet of a dosing mean (32) of the emulsion liquid (53) and of the liquid fuel (52) and they are fit for feeding the engine (5) with an emulsion between the emulsion liquid (53) and the liquid fuel (52).
DEVICE FOR FEEDING AN INTERNAL COMBUSTION ENGINE WITH LIQUID EMULSIONS AND COMBUSTIBLE GAS

TECHNICAL FIELD

The present invention relates to devices for feeding internal combustion engines.

Particularly the invention refers to a device for feeding internal combustion engines, principally diesel engines, with liquid emulsions and combustible gas.

BACKGROUND ART

There are known devices feeding the internal combustion in vehicle Otto engines with liquid fuel in which water is emulsified, eventually with an additive, mainly to improve the combustion and the general engine efficiency.

The main drawback of the known devices consists in that only the expensive liquid fuels provide the energetic contribution.

Other drawback consists in that the combustion of the liquid fuels, at present known, generates polluting substances difficult to be reduced.

There are further known devices, which mix gaseous fuel in the sucked comburent air in the internal combustion engines. In the diesel engines, the gas-air mixture is made detonate by the self-ignition of small quantity of liquid fuel.

The main drawback of said known devices consists in that the detonation temperature is too high and the combustion quality is not optimal, being sometimes not homogeneous and incomplete so causing wear, particularly of the injectors, low efficiency and production of pollutants.

DISCLOSURE OF THE INVENTION

The main object of the present invention is to propose a device for feeding an internal
combustion engine with liquid emulsions and combustible gas in order to provide high efficiency, to use low cost gaseous fuels and to reduce the temperature at least in correspondence of the injectors, so reducing the operation and maintenance costs and the production of pollutants.

Further object is to propose a device, which can be easily installed on preexisting engines even not preset.

Other object is to propose a device fit for feeding also an internal combustion engine with liquid fuel only, pure or emulsified with water and additive. Further object of the present invention is to propose a device having an easy manufacture, a low cost and a high reliability.

The objects above-mentioned are achieved according to the content of the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The characteristics of the invention are underlined in the following with particular reference to the attached drawing, in which the figure shows a general diagram of the device object of the present invention in association with a diesel engine, in which some parts have been removed for better underlining other ones;

BEST MODE OF CARRYING OUT THE INVENTION

With reference to the figure, numeral 1 indicates the device for feeding an internal combustion engine 5.

The device 1 includes mixing means 2 fit to mix the comburent air 59 for the engine 5 with combustible gas 51, emulsifying means 3 fit to emulsify a liquid fuel 52 for the engine 5 with a emulsion liquid 53, control means 4 to define and control the operation conditions of the device 1 and the engine 5.

This latter is a diesel engine, for instance of the type at natural or forced intake, and has a filter 63 for the comburent air 59 entered by an inlet manifold 54 in the thermal group 50 having one or more cylinders. The exhausted gases are evacuated through an outlet manifold.
The thermal group 50 is fed by liquid fuel through speed control means 60 of the engine 5 consisting of, for instance, a high pressure variable displacement injection pump connected to injectors, or consisting of injector pumps or of an injection pump and injectors of a "common rail" type feeding system. The speed control means 60 allow varying the quantity of liquid fuel from a minimum quantity corresponding to the minimum idling rotation speed of the engine, to a maximum quantity corresponding to the maximum speed in presence of load at the shaft of the engine 5.

The speed control means 60 are adjusted by a speed control 47 of the engine 5, for instance consisting of the accelerator pedal of the engine installed on a vehicle, or of a lever of the engine in static installation, through driving means 61. These latter, for instance, consist of transmissions or actuators of mechanical hydraulic, pneumatic or electric type connected to the injection pump or to the injectors.

The speed control means 60 are fed by means of a fuel circuit 55 of the engine 5, connected to a tank 57 of the liquid fuel 52. The duct 55 may include pumps and filters of the engine 5.

The mixing means 2 are fit to mix the comburent air 59 for the engine 5 with combustible gas 51 and they include, in cascade connection: a source 21 for the combustible gas 51; delivering means 22 and regulating means 23 of the flow rate of the combustible gas 51. The regulating means 23, for instance having a parallelepiped shape, are interposed between the filter 63 for the air and the inlet manifold 54 and they are fit for mixing to the combustible gas 51 with the comburent air 59.

The delivering means 22 control the pressure of the combustible gas 51, for instance reducing and/or stabilizing said pressure at a predetermined value.

The source 21, for instance, consists of gas cylinders or tanks, in case of mobile or static installations, or consists of a connection to gas pipe network, in case of static installations.

The regulating means 23 include, in cascade connection, an on-off valve 26 for the combustible gas 51, a flow rate regulating mean 25 and a throttle valve 24, for instance approximately rectangular shaped, for the optimal mixing of the gaseous mixture and for choking this latter.
The throttle valve 24 can be operated directly by the speed control 47 or by an actuator, known and not shown, controlled by the control means 4.

The emulsifying means 3 are fit to emulsify the liquid fuel 52 for the engine 5 with an emulsion liquid 53 and they include a second tank 30 of the emulsion liquid 53. A dosing mean 32 has an outlet and two inlets respectively connected to the second tank 30 of the emulsion liquid 53 and a first tank 57 of the liquid fuel 52.

The dosing mean 32 is fit for providing at the outlet, in adjustable proportions, the emulsion liquid 53 and the liquid fuel 52. The dosing mean 32 feeds a diffuser mean 33 with amount of emulsion liquid 53 ranging between 5% and 40% of the liquid fuel 52.

The diffuser mean 33, for instance of the coaxial inverse flow turbine type, is fit to carry out an emulsion 37 of the emulsion liquid 53 with the liquid fuel 52.

The emulsion 37 may consist of a so-called microemulsion with drops of around 0,5 microns having high stability.

The emulsifying means 3 may also include a containment mean 34 of the emulsion 37 fed from the diffuser mean 33 and connected to a filter emulsion 35 interposed between the containment mean 34 and an emulsion pump mean 36.

The second tank 30 of the emulsion liquid 53, can be pressurized at negative pressure or can have known and not shown means fit for filling the volume of said second tank 30, not filled with the emulsion liquid 53 with inert gas, for instance nitrogen for the optimal maintenance of a degassed emulsion liquid 53, particularly without of dissolved oxygen. In contrary case, said oxygen liberates during the combustion in the engine 5 causing an excessive reduction of the primer mixture and an excess of emission of nitric oxides.

The inlet of the diffuser mean 33 is also connected, through a valve 45 for instance a three ways type, to a return circuit 46 of the liquid fuel from the speed control means 60.

The circuit of the fuel 55 of the engine 5 has a couple of interconnecting valve means 44, for instance of the three ways type, connected to the emulsifying means 3 to insert these latter in the circuit of the fuel 55.
The interconnecting valve means 44 can be positioned downstream and upstream the pump and the filter of the duct 55 to exclude them in correspondence of the operation of the emulsifying means 3. It is also provided that that both the interconnecting valve means 44 can be positioned upstream the pump and the filter of the duct 55, particularly when the emulsifying means 3 are without the emulsion filter 35 and the emulsion pump mean 36.

One of the valve means 44 is fit to connect the dosing mean 32 to the first tank 57 while the other one, downstream the first one, is fit to connect the outlet of the emulsifying means 3 to the speed control means 60 of the engine 5 through a portion of the duct 55.

The control means 4 are, for instance, of programmable electronic type with microprocessor and have a plurality of inlet 41, outlets 42 and a user interface 43. This latter, for instance consisting of a plurality of buttons and pilot lights, is fit to define operation conditions of the control means 4 and therefore of the device 1 and the engine 5.

The outlets 42 of the control means 4 are connected to the driving means 61, the dosing means 32, the diffuser mean 33, the emulsion pump mean 36, the interconnecting valve means 44, the valve 45, the regulating means 23 and to the on-off valve 26.

The inlets 41 of the control means 4 are connected to the speed control 47 having eventually a related position sensor, known and not shown.

The device 1 also includes blow-by means 56 interposed between the outlet and inlet manifolds of the engine 5 and eventually controlled by the control means 4.

The blow-by means 56, besides reducing the polluting emissions, allow reducing the oxygen percentage of the primer load, contributing to avoid that this latter is too lean.

It is provided that the device 1 uses a combustible gas 51, consisting of at least one among GPL, methane, hydrogen, their mixtures and uses a liquid fuel 52 consisting of at least one among gas-oil, naphtha, kerosene, gasoline, hydrocarbons generally, alcohols and their mixtures.

The emulsion liquid 53 consists of water or, preferably, water including an additive, which can include antifreeze and/or lubricant.
The operation of the device 1 provides, for instance, that the consumer defines, by means of the user interface, one of the operation conditions programmed in the control means 4 and therefore which can be operated in the device 1 and in the engine 5.

It is provided at least the operation conditions:
- operation with liquid fuel 52, in correspondence of which the control means 4 exclude and disable the mixing means 2 and the emulsifying means 3;
- operation with emulsion 37, in correspondence of which the control means 4 disable the mixing means 2 and enable the emulsifying means 3;
- operation with emulsion 37 and combustible gas 51, in correspondence of which the control means 4 enable the mixing means 2 and the emulsifying means 3.

Furthermore it is provided the operation with liquid fuel 52 and combustible gas 51, in correspondence of which the control means 4 enable the mixing means 2 and disable the emulsifying means 3.

The control means 4 enable the emulsifying means 3 by operating the diffuser mean 33 and the emulsion pump mean 36 and regulating the dosing means 32 so that they provide the emulsion liquid 53 and the liquid fuel 52 in the ratios defined in the program relating to the operation condition selected by the user. Almost at the same time, the control means 4 operate the valve means 44 in order to insert the emulsifying means 3 in the circuit of the fuel 55.

When enabled the emulsifying means 3, the control means 4 operate the valve 45 so that the return circuit of the fuel 46 flows into the inlet of the diffuser mean 33, instead of flowing into the first tank 57.

The control means 4 enable the mixing means 2 opening the on-off valve 26 for the combustible gas 51 and regulating the driving means 61 of the speed control means 60 in order to provide the engine 5 with a quantity of emulsion 37 included between 5% and 25% of the maximum rate of the speed control means 60. The control means 4 operate the regulating means 23 proportionally to the position of the speed control 47 up to predefined maximum flow rate value of the gas 51 corresponding to the maximum nominal power of the engine 5.

In correspondence of the operation condition with emulsion 37 the control means 4 control the
dosing mean 32 to mix the emulsion liquid 53 in a percentage included between 5% and 25% of
the liquid fuel 52.

In correspondence of the operation condition with emulsion 37 and combustible gas 51, the
control means 4 control the dosing mean 32 to mix the emulsion liquid 53 in a percentage
included between 5% and over 50% of the liquid fuel 52.

In correspondence of this last condition, the thermal group 50 sucks a gaseous mixture of air 59
and combustible gas 51, mixed and choked by the throttle valve 24, and compressed between
piston and head in the combustion chamber of each cylinder. The ignition of the gaseous
mixture, which provides the most of energetic contribution, happens in correspondence of the
injection of the emulsion 37 in the combustion chamber.

The presence and the vaporization of the emulsion liquid 53, having high specific heat, cools at
least the injectors and increases the combustion vortexes improving the combustion.

The figure also shows variants of the device 1 in which the regulating means 23 are injection
type. A duct connected downstream to the on-off valve 26 feed, with the combustible gas 51, an
injector 62, flowing into the inlet manifold 54 of the engine 5, carrying out a so-called “single
point” injection, or said duct feeds a plurality of injectors 62, each one flowing into the inlet
manifold 54 in proximity of each combustion chamber of the engine 5, carrying out a so-called
“multi point” injection. The duct can also feed with the gas 51 injectors 62 flowing directly into
the combustion chambers of the engine 5; these last injectors 62 are able to feed gas and to
nebulize the emulsified liquid fuel. The injectors 62 are controlled by the control means 4.

The operation of these variants differs from the operation previously described in that the
mixing of the combustible gas 51 with the comburent air 59 is made in the collector 54 or in the
combustion chambers of the engine 5.

It is also provided that the inlets 41 of the control means 4 are connected to a plurality of
combustion and temperature sensors in the thermal group 50, of chemical concentration sensors
in the outlet manifold and of pressure sensors in the mixing means 23 in order to optimize the
ratios of fuel and comburent, through related programs of the control means 4.

It is provided that the second tank 30 includes more separated containers, known and not shown,
each one connected to an inlet of the dosing mean 32, by means of on-off valves operated by the control means 4. This allows the control means 4, by operating said on-off valves, to feed the dosing mean 32 with emulsion liquid 53 of each container, having different percentages of additive.

The control means 4 will determine the container from which to suck the emulsion liquid 53 or the percentage of additive in the emulsion liquid 53, with reference to the operation conditions of the engine 5. In alternative it is provided that the second tank 30 is divided in two separate compartments, known and not shown, one for the water, the other one for the additive, and connected to an inlet of the dosing mean 32 by a varying mixer, known and not shown, controlled by the control means 4, which can consequently adjust the ratio of additive in the emulsion liquid 53 in a progressive way.

The main advantage of the present invention is to provide a device for feeding an internal combustion engine with liquid emulsions and combustible gas in order to provide high efficiency, to use low cost gaseous fuels and to reduce the temperature at least in correspondence of the injectors to reduce the operation costs, the polluting production and the maintenance cost.

Further advantage is to provide a device that can be easily installed on preexisting engine even not preset and fit for feeding the engine also with liquid fuel only, pure or emulsified with water and additive.

Other advantage is to provide a device a device having an easy manufacture, a low cost and a high reliability.
CLAIMS

1) Device for feeding an internal combustion engine with liquid emulsions and combustible gas characterized in that includes:
   - mixing means (2) in flow communication with a source (21) of combustible gas (51) and with the engine (5);
   - emulsifying means (3) in flow communication with a first tank (57) of the liquid fuel (52), with at least a second tank (30) of the emulsion liquid (53) and, at the outlet, with the engine (5);
   - the mixing means (2) being fit for mixing the comburent air (59) for the engine (5) with a combustible gas (51); the emulsifying means (3) being fit for feeding the engine (5) with an emulsion between the emulsion liquid (53) and the liquid fuel (52).

2) Device according to claim 1 characterized in that the mixing means (2) include:
   - delivering means (22) of the combustible gas (51) of the source (21);
   - an on-off valve (26) for the combustible gas (51);
   - regulating means (23) of the flow rate of the combustible gas (51), fit for mixing this latter with the comburent air (59).

3) Device according to claim 2 characterized in that the regulating means (23) include a throttle valve (24) fed by means of a flow rate regulating mean (25) for the combustible gas (51).

4) Device according to claim 2 characterized in that the regulating means (23) include at least an injector (62) of combustible gas (51).

5) Device according to claim 4 characterized in that the injector (62) flows into an inlet manifold (54) of the engine (5).

6) Device according to claim 5 characterized in that the injector (62) flows near to each combustion chamber of the engine (5).

7) Device according to claim 4 characterized in that the injector (62) flows into each combustion chamber of the engine (5).
8) Device according to any of the preceding claims characterized in that the emulsifying means (3) include:
   - a dosing mean (32) having an outlet and at least two inlets connected respectively to the second tank (30) of the emulsion liquid (53) and to the first tank (57) of the liquid fuel (52); said dosing mean (32) being fit for providing at the outlet the emulsion liquid (53) and the liquid fuel (52) in adjustable ratios;
   - a diffuser mean (33) connected to the outlet of the dosing mean (32) and fit to carry out an emulsion (37) of the emulsion liquid (53) with the liquid fuel (52).

9) Device according to claim 8 characterized in that the emulsifying means (3) further includes:
   - a containment mean (34) of the emulsion (37) connected to the diffuser mean (33);
   - an emulsion filter (35);
   - an emulsion pump mean (36).

10) Device according to any of the preceding claims characterized in that the second tank (30) of the emulsion liquid (53), is pressurized at negative pressure.

11) Device according to any of the claims from 1 to 9 characterized in that the volume of the second tank (30) not filled with the emulsion liquid (53) is filled with inert gases.

12) Device according to any of the preceding claims characterized in that further includes control means (4) having a plurality of inlets (41), outlets (42) and an user interface (43) which is fit for defining at least an operation condition among:
   - operation with liquid fuel (52), in correspondence of which the control means (4) disable the mixing means (2) and the emulsifying means (3);
   - operation with emulsion (37), in correspondence of which the control means (4) disable the mixing means (2) and enable the emulsifying means (3);
   - operation with emulsion (37) and combustible gas (51), in correspondence of which the control means (4) enable the mixing means (2) and the emulsifying means (3).
   - operation with liquid fuel (52) and combustible gas (51), in correspondence of which the control means (4) enable the mixing means (2) and disable the emulsifying means (3).

13) Device according to claim 12 characterized in that control means (4) enable the emulsifying
means (3) at least operating these latter and commutating a set of interconnecting valve means (44) in order to activate the emulsifying means (3) in a circuit of the fuel (55) of the engine (5).

14) Device according to one of the claims 12 or 13 characterized in that in correspondence of an operation condition with emulsion (37) or operation with emulsion (37) and combustible gas (51), the control means (4) commute a valve (45) to connect a return circuit (46) of the fuel to the emulsifying means (3).

15) Device according to one of the claims from 12 to 14 and the claim 2 characterized in that the control means (4) enable the mixing means (2) at least opening the on-off valve (26) of the mixing means (2) for the combustible gas (51).

16) Device according to one of the claims from 12 to 15 and the claim 2 characterized in that at least an inlet (41) of the control means (4) is connected to a speed control (47), and two outlets (42) of the control means (4) are respectively connected to driving means (61) of speed control means (60) of the engine (5) and to the regulating means (23) of the mixing means (2).

17) Device according to claim 16 characterized in that in correspondence of an operation condition with emulsion (37) and combustible gas (51) the control means (4) control the means of driving (61) to provide the engine (5) with an amount of emulsion (37) ranging between 5% and 25% of the maximum rate of the speed control means (60), and the control means (4) operate the regulating means (23) proportionally to the position of the speed control (47).

18) Device according to one of the claims from 13 to 17 and the claim 8 characterized in that at least an outlet (42) of the control means (4) is connected to the dosing mean (32) of the emulsifying means (3).

19) Device according to claim 18 characterized in that in correspondence of an operation condition with emulsion (37) the control means (4) control the dosing mean (32) for mixing the emulsion liquid (53) in a percentage ranging between 5% and 25% of the liquid fuel (52).
20) Device according to claim 18 characterized in that in correspondence of an operation condition with emulsion (37) and combustible gas (51), the control means (4) control the dosing mean (32) in order to mix the emulsion liquid (53) in a percentage ranging between 5% and over 50% of the liquid fuel (52).

21) Device according to any of the preceding claims characterized in that said combustible gas (51) consists of at least one among GPL, methane, hydrogen and mixtures thereof.

22) Device according to any of the preceding claims characterized in that said liquid fuel (52) consists of at least one among gas-oil, naphtha, kerosene, alcohol, gasoline and mixtures thereof.

23) Device according to any of the preceding claims characterized in that said liquid emulsion (53) consists of one between water and water with additive.

24) Device according to claim 23 characterized in that said additive includes at least one between antifreeze and lubricating.

25) Device according to any of the preceding claims characterized in that further includes blow-by means (56) interposed between the outlet and the inlet collectors of the engine (5).

26) Device according to any of the preceding claims characterized in that the second tank (30) includes a plurality of separated containers, each one connected to an inlet of the dosing mean (32), through on-off valves operated by the control means (4).

27) Device according to any of the claims from 1 to 25 characterized in that the second tank (30) includes two separate compartments, one for the water, the other one for the additive, and both connected to an inlet of the dosing mean (32) through a varying mixer controlled by the control means (4).
**INTERNATIONAL SEARCH REPORT**

**A. CLASSIFICATION OF SUBJECT MATTER**

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According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

PAJ, EPO-Internal

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

<table>
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  & JP 11 159361 A (TOKYO GAS CO LTD),
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  page 5, line 14 -page 7, line 11; figure 1 |
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Further documents are listed in the continuation of box C. Patent family members are listed in annex.

**Date of the actual completion of the international search**

24 July 2002

**Date of mailing of the international search report**

02/08/2002

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