

(19)



(11)

EP 4 202 193 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:
20.11.2024 Bulletin 2024/47

(51) International Patent Classification (IPC):
F01N 3/025 ^(2006.01) **F01N 3/20** ^(2006.01)
F01N 3/36 ^(2006.01) **F01N 3/38** ^(2006.01)

(21) Application number: **22213887.7**

(52) Cooperative Patent Classification (CPC):
F01N 3/025; F01N 3/2033; F01N 3/36; F01N 3/38;
F01N 2240/14; F01N 2610/03; F01N 2610/1453

(22) Date of filing: **15.12.2022**

(54) **HEATING DEVICE FOR AN EXHAUST SYSTEM OF AN INTERNAL COMBUSTION ENGINE AND RELATIVE CONTROL METHOD**

HEIZVORRICHTUNG FÜR EIN ABGASSYSTEM EINES VERBRENNUNGSMOTORS UND ZUGEHÖRIGES STEUERUNGSVERFAHREN

DISPOSITIF DE CHAUFFAGE POUR UN SYSTÈME D'ÉCHAPPEMENT D'UN MOTEUR À COMBUSTION INTERNE ET PROCÉDÉ DE COMMANDE ASSOCIÉ

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL NO PL PT RO RS SE SI SK SM TR

- **DE CESARE, Matteo**
20011 CORBETTA (MI) (IT)
- **GUIDO, Claudio**
20011 CORBETTA (MI) (IT)

(30) Priority: **21.12.2021 IT 202100031979**

(74) Representative: **Studio Torta S.p.A.**
Via Viotti, 9
10121 Torino (IT)

(43) Date of publication of application:
28.06.2023 Bulletin 2023/26

(73) Proprietor: **Marelli Europe S.p.A.**
20011 Corbetta (MI) (IT)

(56) References cited:
EP-A1- 2 151 559 EP-A2- 2 199 678
CN-A- 111 997 715

(72) Inventors:
 • **PAROTTO, Marco**
20011 CORBETTA (MI) (IT)

EP 4 202 193 B1

Note: Within nine months of the publication of the mention of the grant of the European patent in the European Patent Bulletin, any person may give notice to the European Patent Office of opposition to that patent, in accordance with the Implementing Regulations. Notice of opposition shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

Description

TECHNICAL FIELD

[0001] The present invention relates to a heating device for an exhaust system of an internal combustion engine and to a relative control method.

PRIOR ART

[0002] An exhaust system of an internal combustion engine comprises an exhaust duct along which at least one treatment device is installed for treating exhaust gases coming from the internal combustion engine; in particular, a (oxidizing or reducing) catalyser is always provided to which a particulate filter can be added. In order to operate (i.e. in order to produce the catalytic conversion), the catalyser requires to operate at a relatively high operating temperature (a modern catalyser works at temperatures also near 800°C) since the chemical reactions for converting unburnt hydrocarbons, i.e. nitrogen oxides and carbon monoxide into carbon dioxide, water and nitrogen take place only once the working temperature has been reached.

[0003] During a cold starting step (i.e. when the internal combustion engine is started after a prolonged stop by effect of which the temperature of the various components of the internal combustion engine has reached the room temperature), the temperature of the catalyser remains for a relatively long time (also several minutes in winter and during a city route along which the internal combustion engine always or almost always runs at idle) very much below the operating temperature. Consequently, during the cold starting step, i.e. during the period of time in which the catalyser has not yet reached its operating temperature, the pollutant emissions at the outlet are high because the purification effect of the catalyser is null or anyway not very effective.

[0004] In order to quicken the reaching of the operating temperature of the catalyser, patent documents EP0631039A1, WO2012139801A1 and US8006487B2 propose to install along the exhaust duct a heating device which by burning fuel generates a (very) hot air flow which passes through the catalyser. In particular, the heating device comprises a combustion chamber which is connected at the outlet to the exhaust duct (immediately upstream of the catalyser) and is connected at the inlet to a fan which generates an air flow which passes through the combustion chamber; in the combustion chamber a fuel injector is also arranged which injects fuel that mixes with the air and a spark plug is also arranged which cyclically gives off sparks for igniting the air-fuel mixture so as to obtain the combustion which heats the air.

[0005] For the injection of fuel into the combustion chamber it has been proposed to use an electromagnetic injector entirely similar to the electromagnetic injectors currently used for injecting fuel into the internal combustion engines; in this manner, it is possible to use compo-

nents already available on the market having proven efficiency and reliability and it is thus unnecessary to develop new components with evident saving as to costs and time.

[0006] However, the assembly in a heating device of a commercial electromagnetic injector for injecting fuel has turned out to be problematic, since the temperatures that can be reached inside the combustion chamber can be very high (also above 800-900 °C) and can produce an excessive overheating of the electromagnetic injector with a consequent destruction of the electromagnetic injector (in particular of the electric insulations of the wire constituting the coil which is the material most susceptible to heat inside an electromagnetic injector). By way of example, the temperature of the outer shell of an electromagnetic injector currently produced must not exceed 140- 150°C so as to prevent the insulation of the copper conductor which forms the coil of the electromagnet from melting, whereas the nose of an electromagnetic injector currently produced must not exceed approximately 250°C so as to prevent annealing phenomena of the steel which could alter the mechanical features thereof.

[0007] Furthermore, it should be noted that not only is it necessary to ensure a suitable thermal insulation of the electromagnetic injector from the heat produced in the combustion chamber, but it is also necessary to simultaneously ensure an effective disposal of the heat which is inevitably transmitted by conduction and radiation to the electromagnetic injector and of the heat produced by Joule effect by the coil of the electromagnet inside the electromagnetic injector.

[0008] Consequently, assembling directly inside the combustion chamber of the heating device a commercial electromagnetic injector designed for injecting fuel into an internal combustion engine is particularly complex and thus expensive due to the inevitable requirements for the thermal screening of the electromagnetic injector and for the heat dissipation from the electromagnetic injector.

[0009] Patent application CN111997715A describes a burner which lacks an outer air source and is completely arranged inside an exhaust system for heating the exhaust system.

DESCRIPTION OF THE INVENTION

[0010] The object of the present invention is to provide a heating device for an exhaust system of an internal combustion engine and a relative control method, said heating device being easy and cost-effective to manufacture.

[0011] According to the present invention a heating device for an exhaust system of an internal combustion engine and a relative control method are provided, according to what is claimed in the appended claims.

[0012] The claims describe preferred embodiments of the present invention forming integral part of the present description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The present invention will now be described with reference to the accompanying drawings, which illustrate a non-limiting example embodiment thereof, wherein:

- Figure 1 is a schematic and partial view of an exhaust system of an internal combustion engine provided with a heating device manufactured in accordance with the present invention;
- Figure 2 is a schematic side view, with parts removed for clarity, of a passive fuel injector of the heating device of Figure 1;
- Figure 3 is a schematic side view, with parts removed for clarity, of a different embodiment of the passive fuel injector of Figure 2;
- Figure 4 is a schematic side view, with parts removed for clarity, of a further embodiment of the passive fuel injector of Figure 2; and
- Figure 5 is a section according to line V-V of the passive fuel injector of Figure 4.

PREFERRED EMBODIMENTS OF THE INVENTION

[0014] In Figure 1, reference numeral 1 indicates, as a whole, an exhaust system of an internal combustion engine 2.

[0015] The exhaust system 1 comprises an exhaust duct 3 which originates from an exhaust manifold of the internal combustion engine 2 and ends with a silencer 4 from which the exhaust gases are let into the atmosphere. Along the exhaust duct 3 at least one treatment device 5 is installed for treating the exhaust gases coming from the internal combustion engine 2; in particular, a (oxidizing or reducing) catalyser is always provided to which it is possible to add a particulate filter. In order to work (i.e. in order to produce the catalytic conversion), the catalyser requires to operate at a relatively high operating temperature (a modern catalyser works at temperatures also near 800°C) since the chemical reactions for converting unburnt hydrocarbons, nitrogen oxides and carbon monoxide into carbon dioxide, water and nitrogen take place only once the working temperature has been reached.

[0016] In order to quicken the heating of the treatment device, i.e. in order to allow the treatment device 5 to reach more quickly its operating temperature, the exhaust system 1 comprises a heating device 6 which by burning fuel generates a (very) hot air flow which passes through the treatment device 5.

[0017] The heating device 6 comprises a combustion chamber 7 which is connected at the outlet to the exhaust duct 3 (immediately upstream of the treatment device 5) and is connected at the inlet to a fan 8 (i.e. to an air pump) which generates an air flow which passes through the combustion chamber 7; in the combustion chamber 7 a fuel injector 9 is also provided which injects fuel that mix-

es with the air and a spark plug 10 is also provided which cyclically gives off sparks for igniting the air-fuel mixture so as to obtain the combustion which heats the air. The combustion chamber 7 of the heating device 6 ends with an outlet duct 11 which engages in the exhaust duct 3 (immediately upstream of the treatment device 5).

[0018] The heating device 6 comprises a tubular body 12 (for example with a cylindrical shape and having a circular or elliptical cross-section) in which the fuel injector 9 and the spark plug 10 are assembled; through the tubular body 12 (at least) an inlet opening 13 is obtained which is connected to the fan 8 by means of an inlet duct 14 for receiving an air flow which is directed into the combustion chamber 7 and is mixed with the fuel injected by the fuel injector 9.

[0019] According to a possible embodiment illustrated in Figure 1, the heating device 6 comprises a temperature sensor 15 which is arranged along the outlet duct 11 for measuring the temperature of the hot air that flows through the outlet duct 11; alternatively, the temperature sensor 15 could be arranged along the exhaust duct 3 downstream of the engaging point of the outlet duct 11 (and upstream of the treatment device 5) for measuring the temperature of the mixture of exhaust gas and hot air that flows through the exhaust duct 3.

[0020] The heating device 6 comprises a tank 16 containing the fuel and a low-pressure pump 17 which draws from the tank 16 for supplying the fuel under pressure towards the fuel injector 9 through a supply duct 18. According to a preferred embodiment, the tank 16 is not exclusively dedicated to the heating device 6 but is (mainly) dedicated to the internal combustion engine 2; i.e. the heating device 6 uses for its operation a (small) part of the fuel contained in the tank 16 and destined to the operation of the internal combustion engine 2. Consequently, also a high-pressure pump 19 is provided which receives the fuel from the low-pressure pump 17 and supplies the fuel to a fuel injection system of the internal combustion engine 2.

[0021] The fuel injector 9 is designed to inject the atomized fuel into the combustion chamber 7 and is fixed to a bottom wall of the tubular body 12. Furthermore, the fuel injector 9 is of passive type, i.e. it totally lacks actuators that can be controlled and capable of generating movement and is controlled only under pressure: when the pressure of the fuel entering the fuel injector 9 is smaller than a predetermined pressure threshold value the fuel injector 9 remains closed, whereas when the pressure of the fuel entering the fuel injector 9 is greater than the pressure threshold value the fuel injector 9 opens spontaneously exploiting the hydraulic thrust generated by the fuel under pressure.

[0022] According to what is illustrated in Figures 2-5, the fuel injector 9 is of passive type, i.e. lacks actuators that can be controlled, and comprises an injection nozzle 20 (provided with a mechanical atomizer), through which the fuel is injected and atomized inside the combustion chamber 7. Furthermore, the passive fuel injector 9 com-

prises a shutter 21 assembled movable so as to move between a closing position, in which the shutter 21 prevents fuel from flowing through the injection nozzle 20, and an opening position, in which the shutter 21 allows fuel to flow through the injection nozzle 20. Finally, the passive fuel injector 9 comprises an elastic body 22 which presses against the shutter 21 in order to hold the shutter 21 in its closing position with a predetermined force. The passive fuel injector 9 is manufactured so that the pressure of the fuel present inside the passive fuel injector 9 tends to press the shutter 21 in the opening position against the action of the elastic body 22. Consequently, when the pressure of the fuel is sufficiently high (i.e. greater than the pressure threshold value) it manages to overcome the elastic force generated by the elastic body 22 and thus moves the shutter 21 in the opening position; similarly, when the pressure of the fuel decreases (i.e. goes below the pressure threshold value) the elastic force generated by the elastic body 22 prevails and thus the shutter 21 is pressed in the closing position.

[0023] In other words, the passive fuel injector 9 is pressure-controlled, since when the pressure of the fuel supplied to the passive fuel injector 9 is greater than the pressure threshold value, the passive fuel injector 9 carries out the injection of fuel into the combustion chamber 7, whereas when the pressure of the fuel supplied to the passive fuel injector 9 is smaller than the pressure threshold value, the passive fuel injector 9 does not carry out the injection of fuel into the combustion chamber 7.

[0024] Being the passive fuel injector 9 of passive type, i.e. lacking actuators that can be controlled and in particular lacking electric conductors insulated with plastic materials or the like, the passive fuel injector 9 is only made of metal components (in particular steels) which are particularly resistant to heat and can bear particularly high temperatures (also above 250°-300° C) without damage. Furthermore, being the fuel injector 9 of passive type, i.e. lacking actuators that can be controlled, inside the passive fuel injector 9 there is no heat generation and thus it is not necessary to provide for any disposal of the heat generated inside the passive fuel injector 9. Finally, the internal structure of the passive fuel injector 9 is simple and only composed of mechanical pieces having a relatively large dimension (unlike a traditional electromagnetic injector) which can tolerate without any problems an also very high heating; in this manner, the passive fuel injector 9 is capable of tolerating particularly high temperatures (also above 250°-300° C).

[0025] According to what is illustrated in Figure 1, the heating device 6 further comprises a shut-off solenoid valve 23, which can be electrically controlled and is arranged along the supply duct 18 between the low-pressure pump 17 and the passive fuel injector 9; in use, the shut-off solenoid valve 23 is controlled in order to control the supply of fuel under pressure from the low-pressure pump 17 to the passive fuel injector 9 and thus to control when to carry out the injection of fuel into the combustion chamber 7. The shut-off solenoid valve 23 is arranged

at a suitable distance from the passive fuel injector 9 (and thus from the combustion chamber 7 and from the exhaust duct 3) so as to be naturally screened from the heat present in the exhaust duct 3 and in the combustion chamber 7 and thus so as not to be subject to an excessive heating by effect of the heat present in the exhaust duct 3 and in the combustion chamber 7.

[0026] The heating device 6 comprises a control unit 24 (schematically illustrated in Figure 1) which is configured to control the entire operation of the heating device 6, i.e. to control the fan 8, the injector 9 (through the shut-off solenoid valve 23), and the spark plug 10 in a coordinated manner in order to reach in the most efficient and effective manner possible the target objective (i.e. to quickly heat the treatment device 5 without damaging due to excess of temperature the treatment device 5 and minimizing the production of pollutant substances). The control unit 24 could exploit the reading of the temperature sensor 15 in order to control (possibly in feedback) the combustion in the combustion chamber 7 so as to quickly heat the treatment device 5 without damaging due to excess of temperature the treatment device 5.

[0027] The control unit 24 is also connected to a pressure sensor 25 which measures the fuel pressure P along the supply duct 18 downstream of the low-pressure pump 17 and upstream of the shut-off solenoid valve 23 (i.e. between the low-pressure pump 17 and the shut-off solenoid valve 23). The pressure sensor 25 is generally already present since it is an essential component of the supply system of the fuel to the internal combustion engine 2. The control unit 24 could also be connected to a pressure sensor 26 (in addition to the pressure sensor 25) which measures the fuel pressure P along the supply duct 18 downstream of the shut-off solenoid valve 23 and upstream of the passive fuel injector 9 (i.e. between the shut-off solenoid valve 23 and the passive fuel injector 9); the pressure sensor 26 is exclusively dedicated to the heating device 6 and could thus not be present so as to reduce the costs of the heating device 6.

[0028] In use, the control unit 24 receives (for example through a BUS of the vehicle in which the exhaust system 1 is installed) the request to carry out a use cycle of the heating device 6 for pre-heating the treatment device 5.

[0029] During the use cycle of the heating device 6, the control unit 24 actuates the fan 8 for supplying air into the combustion chamber 7, actuates the solenoid valve 23 which activates (opens) the passive fuel injector 9 so as to inject fuel into the combustion chamber 7, and cyclically activates the spark plug 10 so as to give off sparks which determine the hitting of the air-fuel mixture present in the combustion chamber 7. In particular, the control unit 24 establishes a target air flow rate which has to be supplied by the fan 8, establishes a target mixture ratio (i.e. a ratio between air and fuel), and determines a target fuel flow rate depending on the target air flow rate and on the target mixture ratio (and thus controls the solenoid valve 23 which activates the passive fuel injector 9 so as to inject the target fuel flow rate).

[0030] Depending on the target fuel flow rate and depending on the fuel pressure P in the supply duct 18 (measured by the pressure sensor 25), the control unit 24 generally determines the target duty cycle of the passive fuel injector 9 (i.e. of the shut-off solenoid valve 23 which controls the passive fuel injector 9), i.e. the control unit 24 determines the fraction of time for which the passive fuel injector 9 has to remain open in proportion to the total time considered. Therefore, the control unit 24 actuates the target duty cycle controlling the shut-off solenoid valve 23 by means of a Pulse Width Modulation (PWM).

[0031] The control in Pulse Width Modulation of the shut-off solenoid valve 23 (which provides for a cyclic opening and closing of the shut-off solenoid valve 23) is preferable when the internal combustion engine 2 is running and thus the low-pressure pump 17 has to be controlled in order to satisfy (also and especially) the needs of the internal combustion engine 2; by way of example, the control frequency F of the shut-off solenoid valve 23 could be comprised between 50 and 150 Hz and the opening time of the shut-off solenoid valve 23 at each period could be comprised between 2 and 20 ms. Whereas, when the internal combustion engine 2 is not running, the low-pressure pump 17 is used only by the heating device 6 and thus it is simpler to keep the shut-off solenoid valve 23 always open varying the fuel pressure P in the supply duct 18 acting on the control of the low-pressure pump 17.

[0032] In other words, when the internal combustion engine 2 is running, the fuel pressure P in the supply duct 18 is at least in part set by the internal combustion engine 2 and thus the target fuel flow rate of the passive fuel injector 9 is preferably obtained by modulating the opening and the closing of the shut-off solenoid valve 23; instead, when the internal combustion engine 2 is not running, it is also possible to obtain the target fuel flow rate of the passive fuel injector 9 by keeping the shut-off solenoid valve 23 always open and by modulating (acting on the low pressure pump 17) the fuel pressure P in the supply duct 18. By way of example, when the internal combustion engine 2 is running, the fuel pressure P in the supply duct 18 can vary between 4 and 7 bar (in order to prevent malfunctions of the high-pressure pump 19) whereas when the internal combustion engine 2 is not running, the fuel pressure P in the supply duct 18 can change between 2 and 7 bar.

[0033] In use, the control unit 24 can use the reading of the fuel pressure P along the supply duct 18 (upstream of the shut-off solenoid valve 23 and thus read by the pressure sensor 25 or downstream of the shut-off solenoid valve 23 and thus read by the pressure sensor 26) in order to determine (diagnose) a possible malfunction of the shut-off solenoid valve 23 and/or of the passive fuel injector 9. Obviously, a malfunction of the shut-off solenoid valve 23 is more likely as it is an active component (i.e. provided with an electric actuator which produces a movement) with respect to a malfunction of the

passive fuel injector 9 as it is a passive component and thus with many less parts which can be subject to breakdowns (however, also the passive fuel injector 9 can break or get stuck and thus its malfunction, although less likely, is not anyway totally excluded a priori).

[0034] The control unit 24 uses the fuel pressure P measured by the pressure sensor 25 or 26 for carrying out a diagnosis of the correct operation of the shut-off solenoid valve 23 and of the passive fuel injector 9 (which in the absence of malfunctions follows with a small time delay the corresponding opening/closing of the shut-off solenoid valve 23). In particular, when the shut-off solenoid valve 23 and the passive fuel injector 9 open/close regularly with a certain control frequency F (as said in the foregoing comprised between 50 and 150 Hz), they generate an oscillation in the fuel pressure P measured by the pressure sensor 25 or 26 and such oscillation can be searched by the control unit 24 as proof of the regular opening/closing of the shut-off solenoid valve 23 and of the passive fuel injector 9.

[0035] In other words, when the shut-off solenoid valve 23 is controlled to open (consequently causing the opening of the passive fuel injector 9) the fuel pressure between the shut-off solenoid valve 23 and the passive fuel injector 9 has to change if the shut-off solenoid valve 23 and the passive fuel injector 9 open in sequence and subsequently close in sequence (first the shut-off solenoid valve 23 opens and closes and then with a small time delay the passive fuel injector 9 opens and closes); therefore, by observing the fuel pressure P read by the pressure sensor 25 or 26 it is possible to realize if such fuel pressure P has oscillations at the control frequency F of the shut-off solenoid valve 23.

[0036] The diagnosis of the operation of the assembly composed of the shut-off solenoid valve 23 and of the passive fuel injector 9 is simpler by using the reading of the fuel pressure P along the supply duct 18 downstream of the shut-off solenoid valve 23 and thus carried out by the pressure sensor 26, since the oscillation at the control frequency F in the fuel pressure P measured by the pressure sensor 26 is greater (more evident) than the oscillation in the fuel pressure P measured by the pressure sensor 25; in fact, the fuel pressure P measured by the pressure sensor 26 is directly and essentially influenced by the openings of the shut-off solenoid valve 23 and of the fuel injector 9 whereas the fuel pressure P measured by the pressure sensor 25 is significantly influenced also by the actuations of the high pressure pump 19.

[0037] According to a preferred embodiment, the control unit 24 analyses the harmonic content of the fuel pressure P read by the pressure sensor 25 or 26 and thus carries out an FFT (Fast Fourier Transform) or another type of transformation (for example a DFT - Discrete Fourier Transform) for determining the harmonic content of the fuel pressure P read by the pressure sensor 25 or 26. According to the invention the control unit 24 determines the amplitude A of the harmonic content of the fuel pressure P (read by the pressure sensor 25 or 26) at the

control frequency F of the shut-off solenoid valve 23 and compares such amplitude A of the harmonic component with thresholds TH1 and TH2 (the threshold TH2 is smaller than the threshold TH1).

[0038] When the amplitude A of the harmonic component of the fuel pressure P (read by the pressure sensor 25 or 26) at the control frequency F of the shut-off solenoid valve 23 is greater than the threshold TH1, the control unit 24 establishes that the shut-off solenoid valve 23 and the passive fuel injector 9 open/close regularly.

[0039] When the amplitude A of the harmonic component of the fuel pressure P (read by the pressure sensor 25 or 26) at the control frequency F of the shut-off solenoid valve 23 is smaller than the first threshold TH1 but greater than the threshold TH2 (i.e. when the amplitude A of the harmonic component is comprised between the two thresholds TH1 and TH2), the control unit 24 establishes that the shut-off solenoid valve 23 opens/closes regularly, whereas the passive fuel injector 9 is stuck in a closing position.

[0040] When the amplitude A of the harmonic component of the fuel pressure P (read by the pressure sensor 25 or 26) at the control frequency F of the shut-off solenoid valve 23 is greater than the threshold TH2 (and thus also at the threshold TH1 which is greater than the threshold TH2), the control unit 24 establishes that the shut-off solenoid valve 23 is stuck in an opening position or in a closing position. From the analysis of the harmonic content of the fuel pressure P read by the pressure sensor 25 or 26 it is not possible to distinguish the cases in which the shut-off solenoid valve 23 remains stuck open from the cases in which the shut-off solenoid valve 23 remains stuck closed; in the case in which the problem is of electric nature, a distinction could be made through electric tests (for example a check of the continuity or of the short circuit of the electric circuit of a control coil of the shut-off solenoid valve 23).

[0041] From the analysis of the harmonic content of the fuel pressure P read by the pressure sensor 25 or 26 it is not possible to diagnose the case of the passive fuel injector 9 stuck in an opening position and it is not possible to diagnose the presence of a fuel loss along the supply duct 18.

[0042] Instead, the case of the passive fuel injector 9 stuck in an opening position and the presence of a fuel loss along the supply duct 18 can be diagnosed by the control unit 24 by observing the fuel pressure P read by the pressure sensor 26 when the shut-off solenoid valve 23 is closed: in this situation and in the absence of problems, the fuel pressure P read by the pressure sensor 26 should remain approximately constant (since the hydraulic system should be sealed and thus totally static). If, when the shut-off solenoid valve 23 is closed, the fuel pressure P read by the pressure sensor 26 goes below a threshold TH3, the control unit 24 diagnoses the presence of a (undesired) fuel loss which can be due to the presence of a fuel loss along the supply duct 18 or to the fact that the passive fuel injector 9 is stuck in an opening

position. Generally, the threshold TH3 (for example 1.5 bars) is less than half of a typical working pressure value (for example 3-5 bars).

[0043] Alternatively or additionally, the control unit 24 could consider not the fuel pressure P read by the pressure sensor 26, but the gradient (i.e. the derivative first in time) of the fuel pressure P read by the pressure sensor 26: if, when the shut-off solenoid valve 23 is closed, the gradient (i.e. the first derivative in time) of the fuel pressure P read by the pressure sensor 26 is greater (in absolute value) than a threshold TH4, then the control unit 24 diagnoses the presence of a (undesired) fuel loss which can be due to the presence of a fuel loss along the supply duct 18 or to the fact that the passive fuel injector 9 is stuck in an opening position.

[0044] In any case, it is not possible to discriminate between the case in which a fuel loss is present along the supply duct 18 and the case in which the passive fuel injector 9 is stuck in an opening position.

[0045] According to a possible embodiment, the control frequency F of the shut-off solenoid valve 23 and the physical features of the supply duct 18 (length and diameter) could be chosen (dimensioned) so as to trigger hydraulic resonance phenomena when the shut-off solenoid valve 23 and the passive fuel injector 9 cyclically open and close so as to amplify (i.e. make more easily identifiable) the alteration in the harmonic content of the fuel pressure read by the pressure sensor 25 caused by the cyclic opening of the shut-off solenoid valve 23 and of the passive fuel injector 9. In other words, the physical characteristics of the supply duct 18 are chosen (dimensioned) so that it has its own resonance frequencies that are substantially equal to the control frequency F of the shut-off solenoid valve 23.

[0046] It is important to highlight that the fuel contained in the tank 16 and which is thus used both by the internal combustion engine 2, and by the heating device 6 can be liquid (petrol, diesel, ethanol...) or also gaseous (LPG, methane, hydrogen...).

[0047] The embodiments described herein can be combined to one another without departing from the scope of protection of the appended claims.

[0048] The above-described heating device 6 has numerous advantages.

[0049] Firstly, the above-described heating device 6 is simple and cost-effective to manufacture as regards the component destined to provide the injection of fuel into the combustion chamber 7. In fact, the passive fuel injector 9 is, by its nature, capable of bearing high temperatures and does not generate inside it any heat and thus it does not require neither a particular thermal insulation from the combustion chamber 7, nor a heat dissipation; furthermore, the shut-off solenoid valve 23 (much more sensible to the heat of the passive fuel injector 9) is arranged at a suitable distance from the combustion chamber 7 and thus does not require any particular thermal protection requirements.

[0050] Furthermore, the above-described heating de-

vice 6 allows carrying out a diagnosis, which is effective (i.e. without false negatives) and efficient (i.e. without false positives), of the correct functioning of the injection of fuel inside the combustion chamber 7 also using only the reading of the pressure sensor 25 which is already present (i.e. is not added in combination with the heating device 6) since it is necessary for the correct functioning of the injection plant of the fuel into the internal combustion engine 2.

LIST OF THE REFERENCE NUMERAL OF THE FIGURES

[0051]

1	exhaust system
2	internal combustion engine
3	exhaust duct
4	silencer
5	treatment device
6	heating device
7	combustion chamber
8	fan
9	fuel injector
10	spark plug
11	outlet duct
12	tubular body
13	inlet opening
14	inlet duct
15	temperature sensor
16	tank
17	low pressure pump
18	supply duct
19	high pressure pump
20	injection nozzle
21	shutter
22	elastic body
23	shut-off solenoid valve
24	control unit
25	pressure sensor
26	pressure sensor

Claims

1. A heating device (6) for an exhaust system (1) of an internal combustion engine (2); the heating device (6) comprises:

a tubular body (12), which contains a combustion chamber (7) ending with an outlet duct (11) configured to engage in an exhaust duct (3) of the exhaust system (1) upstream of a treatment device (5);

a fuel injector (9), which is coupled to the tubular body (12) in order to inject, into the combustion chamber (7), fuel to be mixed with air, is passive, namely it lacks actuators that can be electrically

controlled to generate a movement, and has a movable shutter (21), which is pressure-controlled in order to inject fuel only when the fuel pressure inside the injector (9) is greater than a predetermined pressure threshold value;

a supply duct (18), which is designed to connect the injector (9) to a pump (17), which is configured to supply fuel under pressure;

a shut-off solenoid valve (23), which can be electrically controlled and is arranged along the supply duct (18) between the pump (17) and the passive injector (9);

a control unit (24) configured to electrically control the opening and the closing of the shut-off solenoid valve (23), thus consequently determining the opening and the closing of the passive injector (9); and

a spark plug (10) coupled to the tubular body (12) so as to trigger the combustion of a mixture of air and fuel;

the heating device (6) is **characterized in that:**

the tubular body (12) has at least one inlet opening (13), which can be connected to a fan (8) in order to receive an air flow;

it is provided at least one pressure sensor (25, 26) arranged along the supply duct (18) upstream of the passive injector (9); and

the control unit (24) is configured to diagnose the correct operation of the shut-off solenoid valve (23) and/or of the passive injector (9) depending on a fuel pressure (P) in the supply duct (18) read by the pressure sensor (25, 26) .

2. The heating device (6) according to claim 1, wherein the control unit (24) is configured to obtain a target fuel flow rate through the passive injector (9) by controlling the shut-off solenoid valve (23) by means of a cyclic opening and closing and by applying a pulse width modulation.

3. The heating device (6) according to claim 1, wherein the control unit (24) is configured to obtain a target fuel flow rate through the passive injector (9) by keeping the shut-off solenoid valve (23) always open and by controlling the pump (17) so as to change a fuel pressure in the supply duct (18).

4. The heating device (6) according to claim 1, 2 or 3, wherein the pressure sensor (25) is arranged along the supply duct (18) upstream of the shut-off solenoid valve (23).

5. The heating device (6) according to claim 1, 2 or 3, wherein the pressure sensor (26) is arranged along the supply duct (18) between the shut-off solenoid valve (23) and the passive injector (9).

6. The heating device (6) according to one of the claims from 1 to 5, wherein the control unit (24) is configured to:
- control the shut-off solenoid valve (23) so as to cyclically open and close the shut-off solenoid valve (23) with a predetermined control frequency (F);
- analyse a harmonic content of the fuel pressure (P) read by the pressure sensor (25, 26) in order to determine an amplitude (A) of the harmonic component of the fuel pressure (P) at the control frequency (F) of the shut-off solenoid valve (23); and
- compare the amplitude (A) of the harmonic component with at least one threshold (TH1, TH2).
7. The heating device (6) according to claim 6, wherein, when the amplitude (A) of the harmonic component is greater than a first threshold (TH1), the control unit (24) establishes that the shut-off solenoid valve (23) and the passive fuel injector (9) open and close regularly.
8. The heating device (6) according to claim 7, wherein:
- when the amplitude (A) of the harmonic component is smaller than the first threshold (TH1) and greater than a second threshold (TH2), the control unit (24) establishes that the shut-off solenoid valve (23) opens/closes regularly, whereas the passive fuel injector (9) is stuck in a closing position; and
- when the amplitude (A) of the harmonic component is smaller than the second threshold (TH2), the control unit (24) establishes that the shut-off solenoid valve (23) is stuck in an opening position or in a closing position.
9. The heating device (6) according to claim 6, 7 or 8, wherein a control frequency (F) of the shut-off solenoid valve (23) and the physical features of the supply duct (18) are chosen so as to favour hydraulic resonance phenomena when the shut-off solenoid valve (23) and the passive injector (9) cyclically open and close at the control frequency (F).
10. The heating device (6) according to one of the claims from 1 to 9, wherein the control unit (24) is configured to establish that the passive fuel injector (9) is stuck in an opening position or there is a fuel leak along the supply duct (18), if the fuel pressure (P) read by the pressure sensor (26) arranged downstream of the shut-off solenoid valve (23) decreases when the shut-off solenoid valve (23) is closed.
11. A method to control the heating device (6) according to one of the claims from 1 to 10; the control method comprises the steps of:
- measuring a fuel pressure (P) in the supply duct (18) by means of a pressure sensor (25, 26); and
- diagnosing the correct operation of the shut-off solenoid valve (23) and/or of the passive fuel injector (9) depending on the fuel pressure read by the pressure sensor (25, 26).
12. The control method according to claim 11 and comprising the steps of:
- controlling the shut-off solenoid valve (23) so as to cyclically open and close the shut-off solenoid valve (23) with a predetermined control frequency (F);
- analysing a harmonic content of the fuel pressure (P) read by the pressure sensor (25, 26) in order to determine an amplitude (A) of the harmonic component of the fuel pressure (P) at the control frequency (F) of the shut-off solenoid valve (23); and
- comparing the amplitude (A) of the harmonic component with thresholds (TH1, TH2).
13. The control method according to claim 12 and comprising the further step of establishing that the shut-off solenoid valve (23) and the passive fuel injector (9) open/close regularly, when the amplitude (A) of the harmonic component is greater than a first threshold (TH1).
14. The control method according to claim 13 and comprising the further steps of:
- establishing that the shut-off solenoid valve (23) opens/closes regularly, whereas the passive fuel injector (9) is stuck in a closing position, when the amplitude (A) of the harmonic component is smaller than the first threshold (TH1) and greater than a second threshold (TH2); and
- establishing that the shut-off solenoid valve (23) is stuck in an opening position or in a closing position, when the amplitude (A) of the harmonic component is smaller than the second threshold (TH2).
15. The control method according to claim 12, 13 or 14, wherein a control frequency (F) of the shut-off solenoid valve (23) and the physical features of the supply duct (18) are chosen so as to favour hydraulic resonance phenomena when the shut-off solenoid valve (23) and the passive injector (9) cyclically open and close at the control frequency (F).
16. The control method according to one of the claims from 11 to 15 and comprising the further step of establishing that the passive fuel injector (9) is stuck in

an opening position or there is a fuel leak along the supply duct (18), if the fuel pressure (P) read by the pressure sensor (26) arranged downstream of the shut-off solenoid valve (23) decreases when the shut-off solenoid valve (23) is closed.

5

Patentansprüche

1. Heizvorrichtung (6) für ein Abgassystem (1) eines Verbrennungsmotors (2); die Heizvorrichtung (6) umfasst:

einen röhrenförmigen Körper (12), der eine Brennkammer (7) enthält, die mit einem Auslasskanal (11) endet, der dazu konfiguriert ist, in einen Abgaskanal (3) des Abgassystems (1) stromaufwärts einer Behandlungsvorrichtung (5) einzugreifen;

eine Kraftstoffeinspritzdüse (9), die mit dem rohrförmigen Körper (12) gekoppelt ist, um in die Brennkammer (7) mit Luft zu vermischenden Kraftstoff einzuspritzen, und die passiv ist, d.h. keine Aktoren aufweist, die elektrisch gesteuert werden können, um eine Bewegung zu erzeugen, und die eine bewegliche Klappe (21) aufweist, die druckgesteuert ist, um Kraftstoff nur dann einzuspritzen, wenn der Kraftstoffdruck innerhalb der Einspritzdüse (9) größer als ein vorbestimmter Druckschwellenwert ist;

einen Zuführungskanal (18), der dazu ausgelegt ist, die Einspritzdüse (9) mit einer Pumpe (17) zu verbinden, die dazu konfiguriert ist, Kraftstoff unter Druck zuzuführen;

ein elektrisches Absperrmagnetventil (23), das entlang des Zuführungskanals (18) zwischen der Pumpe (17) und der passiven Einspritzdüse (9) angeordnet ist und elektrisch gesteuert werden kann;

eine Steuereinheit (24), die dazu konfiguriert ist, das Öffnen und Schließen des Absperrmagnetventils (23) elektrisch zu steuern und somit das Öffnen und Schließen der passiven Einspritzdüse (9) zu bestimmen; und

eine Zündkerze (10), die mit dem rohrförmigen Körper (12) gekoppelt ist, um die Verbrennung eines Gemischs aus Luft und Kraftstoff auszulösen;

wobei die Heizvorrichtung (6) **dadurch gekennzeichnet ist, dass:**

der rohrförmige Körper (12) wenigstens eine Einlassöffnung (13) aufweist, die mit einem Gebläse (8) verbunden sein kann, um einen Luftstrom aufzunehmen;
wenigstens ein Drucksensor (25, 26) vorgesehen ist, der entlang des Zuführungskanals (18) stromaufwärts von der passiven

- 10 2. Heizvorrichtung (6) nach Anspruch 1, wobei die Steuereinheit (24) dazu konfiguriert ist, einen Soll-Kraftstoffdurchsatz durch die passive Einspritzdüse (9) zu erhalten, indem das Absperrmagnetventil (23) mittels eines zyklischen Öffnens und Schließens und durch Anwendung einer Pulsweitenmodulation gesteuert wird.

- 15 3. Heizvorrichtung (6) nach Anspruch 1, wobei die Steuereinheit (24) dazu konfiguriert ist, einen Soll-Kraftstoffdurchsatz durch die passive Einspritzdüse (9) zu erhalten, indem das Absperrmagnetventil (23) stets offen gehalten wird und die Pumpe (17) so gesteuert wird, dass ein Kraftstoffdruck im Zuführungskanal (18) verändert wird.

- 20 4. Heizvorrichtung (6) nach Anspruch 1, 2 oder 3, wobei der Drucksensor (25) entlang des Zuführungskanals (18) stromaufwärts des Absperrmagnetventils (23) angeordnet ist.

- 25 5. Heizvorrichtung (6) nach Anspruch 1, 2 oder 3, wobei der Drucksensor (26) entlang des Zuführungskanals (18) zwischen dem Absperrmagnetventil (23) und der passiven Einspritzdüse (9) angeordnet ist.

- 30 6. Heizvorrichtung (6) nach einem der Ansprüche 1 bis 5, wobei die Steuereinheit (24) so konfiguriert ist, dass sie:

das Absperrmagnetventil (23) so steuert, dass das Absperrmagnetventil (23) mit einer vorbestimmten Steuerfrequenz (F) zyklisch geöffnet und geschlossen wird;

einen vom Drucksensor (25, 26) gemessenen Oberwellengehalt des Kraftstoffdrucks (P) analysiert, um eine Amplitude (A) der Oberwellenkomponente des Kraftstoffdrucks (P) bei der Steuerfrequenz (F) des Absperrmagnetventils (23) zu bestimmen; und

die Amplitude (A) der Oberwellenkomponente mit wenigstens einem Schwellenwert (TH1, TH2) vergleicht.

- 35 7. Heizvorrichtung (6) nach Anspruch 6, wobei dann, wenn die Amplitude (A) der Oberwellenkomponente größer als ein erster Schwellenwert (TH1) ist, die Steuereinheit (24) feststellt, dass das Absperrmagnetventil (23) und die passive Einspritzdüse (9) re-

regelmäßig öffnen und schließen.

8. Heizvorrichtung (6) nach Anspruch 7, wobei: wenn die Amplitude (A) der Oberwellenkomponente kleiner als der erste Schwellenwert (TH1) und größer als ein zweiter Schwellenwert (TH2) ist, die Steuereinheit (24) feststellt, dass das Absperrmagnetventil (23) regelmäßig öffnet/schließt, während die passive Einspritzdüse (9) in einer Schließstellung festsetzt; und wenn die Amplitude (A) der Oberwellenkomponente kleiner ist als der zweite Schwellenwert (TH2), die Steuereinheit (24) feststellt, dass das Absperrmagnetventil (23) in einer Öffnungsposition oder in einer Schließposition festsetzt.

9. Heizvorrichtung (6) nach Anspruch 6, 7 oder 8, wobei eine Steuerfrequenz (F) des Absperrmagnetventils (23) und die physikalischen Eigenschaften des Zuführungskanals (18) so gewählt sind, dass sie hydraulische Resonanzerscheinungen begünstigen, wenn das Absperrmagnetventil (23) und die passive Einspritzdüse (9) zyklisch mit der Steuerfrequenz (F) öffnen und schließen.

10. Heizvorrichtung (6) nach einem der Ansprüche 1 bis 9, wobei die Steuereinheit (24) dazu konfiguriert ist, festzustellen, dass die passive Kraftstoffeinspritzdüse (9) in einer Öffnungsposition festsetzt oder ein Kraftstoffleck entlang des Zuführungskanals (18) vorhanden ist, wenn der Kraftstoffdruck (P), der von dem stromabwärts des Absperrmagnetventils (23) angeordneten Drucksensor (26) gemessen wird, abnimmt, wenn das Absperrmagnetventil (23) geschlossen ist.

11. Verfahren zum Steuern der Heizvorrichtung (6) nach einem der Ansprüche 1 bis 10, wobei das Steuerungsverfahren die Schritte umfasst:

Messen eines Kraftstoffdrucks (P) im Zuführungskanal (18) mittels eines Drucksensors (25, 26); und
 Diagnostizieren des korrekten Betriebs des Absperrmagnetventils (23) und/oder der passiven Einspritzdüse (9) in Abhängigkeit von dem durch den Drucksensor (25, 26) gemessenen Kraftstoffdruck.

12. Steuerungsverfahren nach Anspruch 11, das die Schritte umfasst:

Steuern des Absperrmagnetventils (23) so, dass das Absperrmagnetventil (23) mit einer vorbestimmten Steuerfrequenz (F) zyklisch geöffnet und geschlossen wird;
 Analysieren eines Oberwellengehalts des von dem Drucksensor (25, 26) gemessenen Kraft-

stoffdrucks (P), um eine Amplitude (A) der Oberwellenkomponente des Kraftstoffdrucks (P) bei der Steuerfrequenz (F) des Absperrmagnetventils (23) zu bestimmen; und
 Vergleichen der Amplitude (A) der Oberwellenkomponente mit Schwellenwerten (TH1, TH2).

13. Steuerungsverfahren nach Anspruch 12, das ferner den Schritt umfasst, festzustellen, dass das Absperrmagnetventil (23) und die passive Einspritzdüse (9) regelmäßig öffnen/schließen, wenn die Amplitude (A) der Oberwellenkomponente größer als ein erster Schwellenwert (TH1) ist.

14. Steuerungsverfahren nach Anspruch 13, das ferner die weiteren Schritte umfasst:

Feststellen, dass das Absperrmagnetventil (23) regelmäßig öffnet/schließt, während die passive Einspritzdüse (9) in einer Schließposition festsetzt, wenn die Amplitude (A) der Oberwellenkomponente kleiner als der erste Schwellenwert (TH1) und größer als ein zweiter Schwellenwert (TH2) ist; und

Feststellen, dass das Absperrmagnetventil (23) in einer Öffnungsposition oder in einer Schließposition festsetzt, wenn die Amplitude (A) der Oberwellenkomponente kleiner als der zweite Schwellenwert (TH2) ist.

15. Steuerungsverfahren nach Anspruch 12, 13 oder 14, wobei eine Steuerfrequenz (F) des Absperrmagnetventils (23) und die physikalischen Eigenschaften des Zuführungskanals (18) so gewählt werden, dass hydraulische Resonanzerscheinungen begünstigt werden, wenn das Absperrmagnetventil (23) und die passive Einspritzdüse (9) bei der Steuerfrequenz (F) zyklisch öffnen und schließen.

16. Steuerungsverfahren nach einem der Ansprüche 11 bis 15, das ferner den Schritt umfasst, festzustellen, dass die passive Einspritzdüse (9) in einer Öffnungsstellung festsetzt oder ein Kraftstoffleck entlang des Zuführungskanals (18) vorliegt, wenn der Kraftstoffdruck (P), der von dem stromabwärts des Absperrmagnetventils (23) angeordneten Drucksensor (26) gemessen wird, abnimmt, wenn das Absperrmagnetventil (23) geschlossen ist.

Revendications

1. Dispositif de chauffage (6) pour un système d'échappement (1) d'un moteur à combustion interne (2) ; le dispositif de chauffage (6) comprend :

un corps tubulaire (12), qui contient une chambre de combustion (7) se terminant par un con-

duit de sortie (11) configuré pour se mettre en prise dans un conduit d'échappement (3) du système d'échappement (1) en amont d'un dispositif de traitement (5) ;

un injecteur de carburant (9), qui est couplé au corps tubulaire (12) afin d'injecter, dans la chambre de combustion (7), le carburant à mélanger avec l'air, est passif, c'est-à-dire qu'il manque des actionneurs qui peuvent être électriquement commandés pour générer un mouvement et a un obturateur mobile (21) qui est commandé par pression afin d'injecter le carburant uniquement lorsque la pression de carburant à l'intérieur de l'injecteur (9) est supérieure à une valeur de seuil de pression prédéterminée ;

un conduit d'alimentation (18), qui est conçu pour raccorder l'injecteur (9) à une pompe (17), qui est configurée pour fournir le carburant sous pression ;

une électrovanne d'arrêt (23) qui peut être électriquement commandée et est agencée le long du conduit d'alimentation (18) entre la pompe (17) et l'injecteur passif (9) ;

une unité de commande (24) configurée pour commander électriquement l'ouverture et la fermeture de l'électrovanne d'arrêt (23), déterminant ainsi par conséquent, l'ouverture et la fermeture de l'injecteur passif (9) ; et

une bougie d'allumage (10) couplée au corps tubulaire (12) afin de déclencher la combustion d'un mélange d'air et de carburant ;

le dispositif de chauffage (6) est **caractérisé en ce que** :

le corps tubulaire (12) a au moins une ouverture d'entrée (13) qui peut être raccordée à un ventilateur (8) afin de recevoir un écoulement d'air ;

on prévoit au moins un capteur de pression (25, 26) agencé le long du conduit d'alimentation (18) en amont de l'injecteur passif (9) ; et

l'unité de commande (24) est configurée pour effectuer le diagnostic du fonctionnement correct de l'électrovanne d'arrêt (23) et/ou de l'injecteur passif (9) en fonction d'une pression de carburant (P) dans le conduit d'alimentation (18) lue par le capteur de pression (25, 26).

2. Dispositif de chauffage (6) selon la revendication 1, dans lequel l'unité de commande (24) est configurée pour obtenir un débit de carburant cible à travers l'injecteur passif (9) en commandant l'électrovanne d'arrêt (23) au moyen d'une ouverture et d'une fermeture cyclique et en appliquant une modulation d'impulsions en durée.

3. Dispositif de chauffage (6) selon la revendication 1, dans lequel l'unité de commande (24) est configurée pour obtenir un débit de carburant cible à travers l'injecteur passif (9) en maintenant l'électrovanne d'arrêt (23) toujours ouverte et en commandant la pompe (17) afin de modifier une pression de carburant dans le conduit d'alimentation (18).

4. Dispositif de chauffage (6) selon la revendication 1, 2 ou 3, dans lequel le capteur de pression (25) est agencé le long du conduit d'alimentation (18) en amont de l'électrovanne d'arrêt (23) .

5. Dispositif de chauffage (6) selon la revendication 1, 2 ou 3, dans lequel le capteur de pression (26) est agencé le long du conduit d'alimentation (18) entre l'électrovanne d'arrêt (23) et l'injecteur passif (9).

6. Dispositif de chauffage (6) selon l'une des revendications 1 à 5, dans lequel l'unité de commande (24) est configurée pour :

commander l'électrovanne d'arrêt (23) afin d'ouvrir et de fermer de manière cyclique l'électrovanne d'arrêt (23) avec une fréquence de commande (F) prédéterminée ;

analyser un contenu harmonique de la pression de carburant (P) lue par le capteur de pression (25, 26) afin de déterminer une amplitude (A) du composant harmonique de la pression de carburant (P) à la fréquence de commande (F) de l'électrovanne d'arrêt (23) ; et

comparer l'amplitude (A) du composant harmonique avec au moins un seuil (TH1, TH2).

7. Dispositif de chauffage (6) selon la revendication 6, dans lequel, lorsque l'amplitude (A) du composant harmonique est supérieure à un premier seuil (TH1), l'unité de commande (24) établit que l'électrovanne d'arrêt (23) et l'injecteur de carburant passif (9) s'ouvrent et se ferment de manière régulière.

8. Dispositif de chauffage (6) selon la revendication 7, dans lequel :

lorsque l'amplitude (A) du composant harmonique est inférieure au premier seuil (TH1) et supérieure à un second seuil (TH2), l'unité de commande (24) établit que l'électrovanne d'arrêt (23) s'ouvre/se ferme de manière régulière, alors que l'injecteur de carburant passif (9) est bloqué dans une position de fermeture ; et lorsque l'amplitude (A) du composant harmonique est inférieure au second seuil (TH2), l'unité de commande (24) établit que l'électrovanne d'arrêt (23) est bloquée dans une position d'ouverture ou dans une position de fermeture.

9. Dispositif de chauffage (6) selon la revendication 6, 7 ou 8, dans lequel une fréquence de commande (F) de l'électrovanne d'arrêt (23) et les caractéristiques physiques du conduit d'alimentation (18) sont choisies afin de favoriser le phénomène de résonance hydraulique lorsque l'électrovanne d'arrêt (23) et l'injecteur passif (9) s'ouvrent et se ferment de manière cyclique à la fréquence de commande (F). 5
10. Dispositif de chauffage (6) selon l'une des revendications 1 à 9, dans lequel l'unité de commande (24) est configurée pour établir que l'injecteur de carburant passif (9) est bloqué dans une position d'ouverture ou bien qu'il y a une fuite de carburant le long du conduit d'alimentation (18), si la pression de carburant (P) lue par le capteur de pression (26) agencé en aval de l'électrovanne d'arrêt (23) diminue lorsque l'électrovanne d'arrêt (23) est fermée. 10
11. Procédé pour commander le dispositif de chauffage (6) selon l'une des revendications 1 à 10 ; le procédé de commande comprenant les étapes suivantes : 20
- mesurer une pression de carburant (P) dans le conduit d'alimentation (18) au moyen d'un capteur de pression (25, 26) ; et 25
- effectuer le diagnostic du bon fonctionnement de l'électrovanne d'arrêt (23) et/ou de l'injecteur de carburant passif (9) en fonction de la pression de carburant lue par le capteur de pression (25, 26). 30
12. Procédé de commande selon la revendication 11 et comprenant les étapes suivantes : 35
- commander l'électrovanne de commande (23) afin d'ouvrir et de fermer, de manière cyclique, l'électrovanne d'arrêt (23) avec une fréquence de commande (F) prédéterminée ; 40
- analyser un contenu harmonique de la pression de carburant (P) lue par le capteur de pression (25, 26) afin de déterminer une amplitude (A) du composant harmonique de la pression de carburant (P) à la fréquence de commande (F) de l'électrovanne d'arrêt (23) ; et 45
- comparer l'amplitude (A) du composant harmonique avec les seuils (TH1, TH2).
13. Procédé de commande selon la revendication 12 et comprenant l'étape supplémentaire pour établir le fait que l'électrovanne d'arrêt (23) et l'injecteur de carburant passif (9) s'ouvrent/se ferment de manière régulière, lorsque l'amplitude (A) du composant harmonique est supérieure à un premier seuil (TH1). 50
14. Procédé de commande selon la revendication 13 et comprenant les étapes supplémentaires suivantes : 55
- établir le fait que l'électrovanne d'arrêt (23) s'ouvre/se ferme de manière régulière, alors que l'injecteur de carburant passif (9) est bloqué dans une position de fermeture, lorsque l'amplitude (A) du composant harmonique est inférieure au premier seuil (TH1) et supérieure à un second seuil (TH2) ; et
- établir le fait que l'électrovanne d'arrêt (23) est bloquée dans une position d'ouverture ou dans une position de fermeture, lorsque l'amplitude (A) du composant harmonique est inférieure au second seuil (TH2).
15. Procédé de commande selon la revendication 12, 13 ou 14, dans lequel une fréquence de commande (F) de l'électrovanne d'arrêt (23) et les caractéristiques physiques du conduit d'alimentation (18) sont choisies afin de favoriser le phénomène de résonance hydraulique lorsque l'électrovanne d'arrêt (23) et l'injecteur passif (9) s'ouvrent et se ferment de manière cyclique à la fréquence de commande (F).
16. Procédé de commande selon l'une des revendications 11 à 15 et comprenant l'étape supplémentaire pour établir le fait que l'injecteur de carburant passif (9) est bloqué dans une position d'ouverture ou bien qu'il y a une fuite de carburant le long du conduit d'alimentation (18), si la pression de carburant (P) lue par le capteur de pression (26) agencé en aval de l'électrovanne d'arrêt (23) diminue lorsque l'électrovanne d'arrêt (23) est fermée.

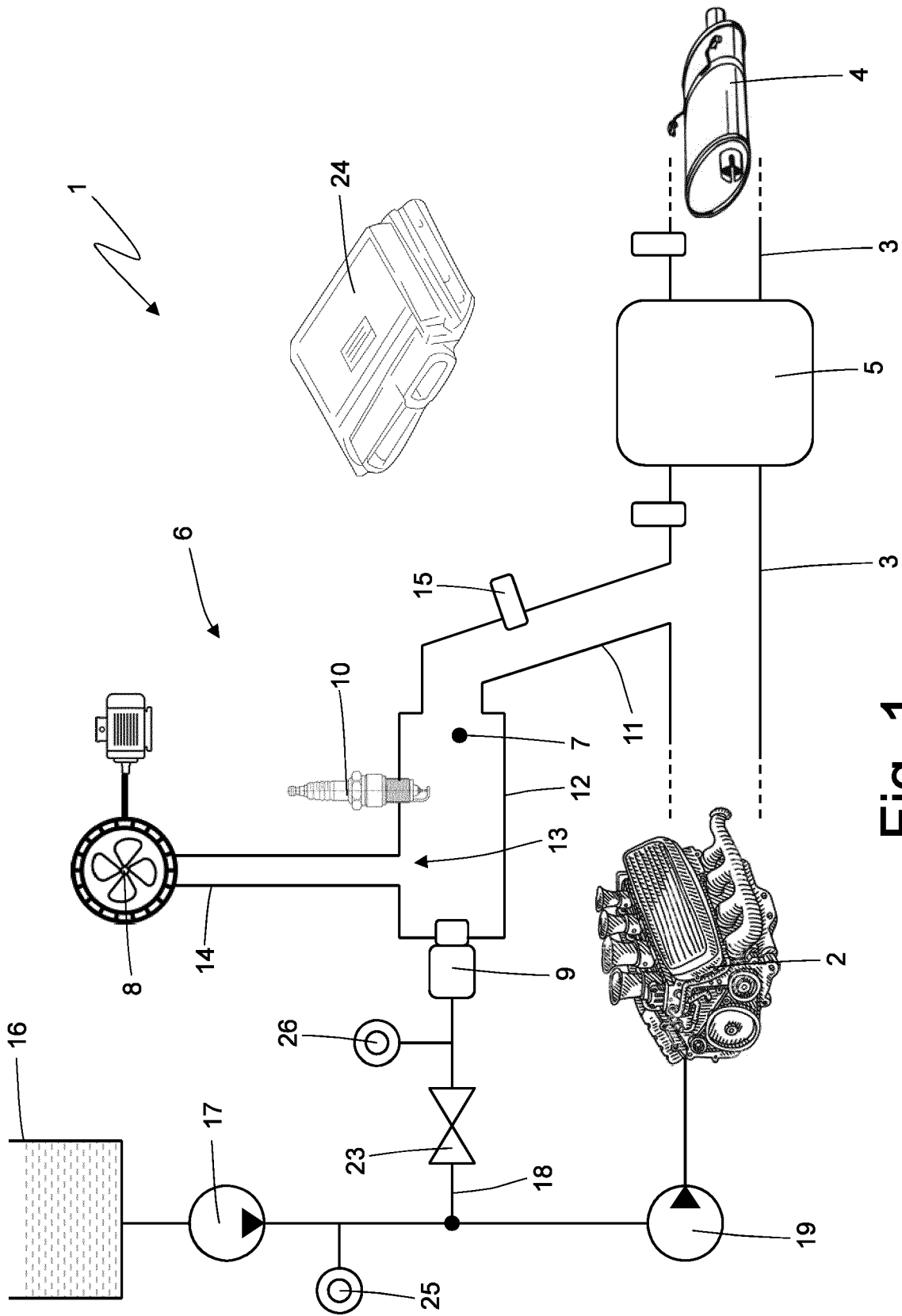


Fig. 1

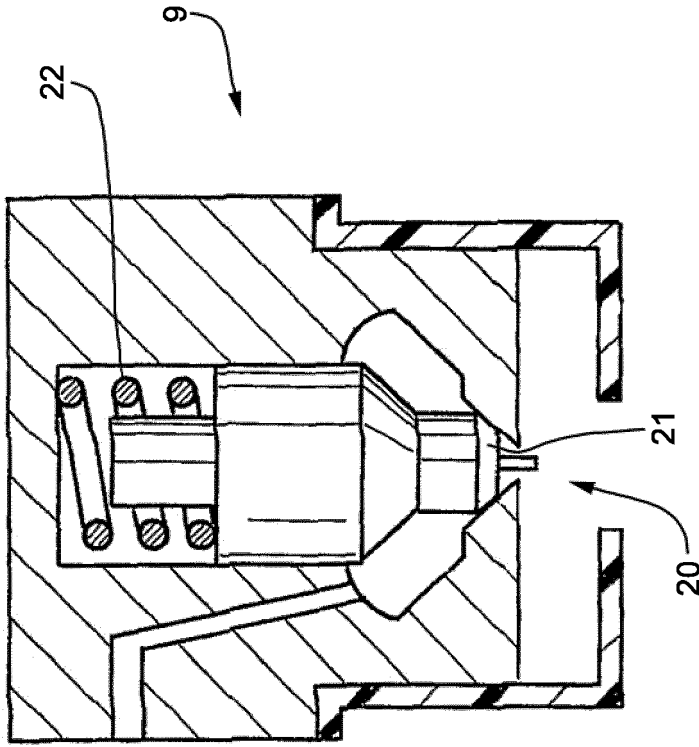


Fig. 3

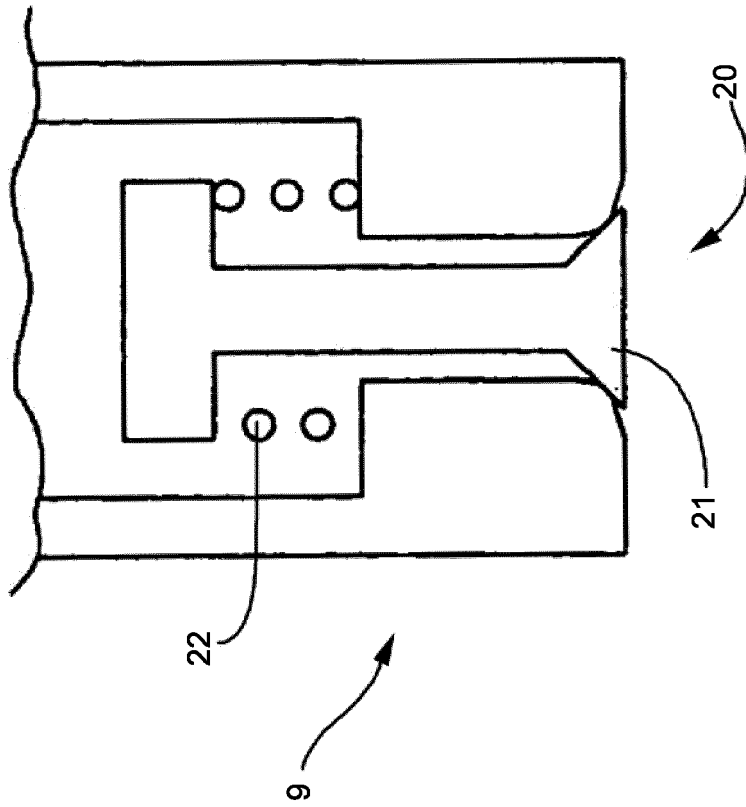


Fig. 2

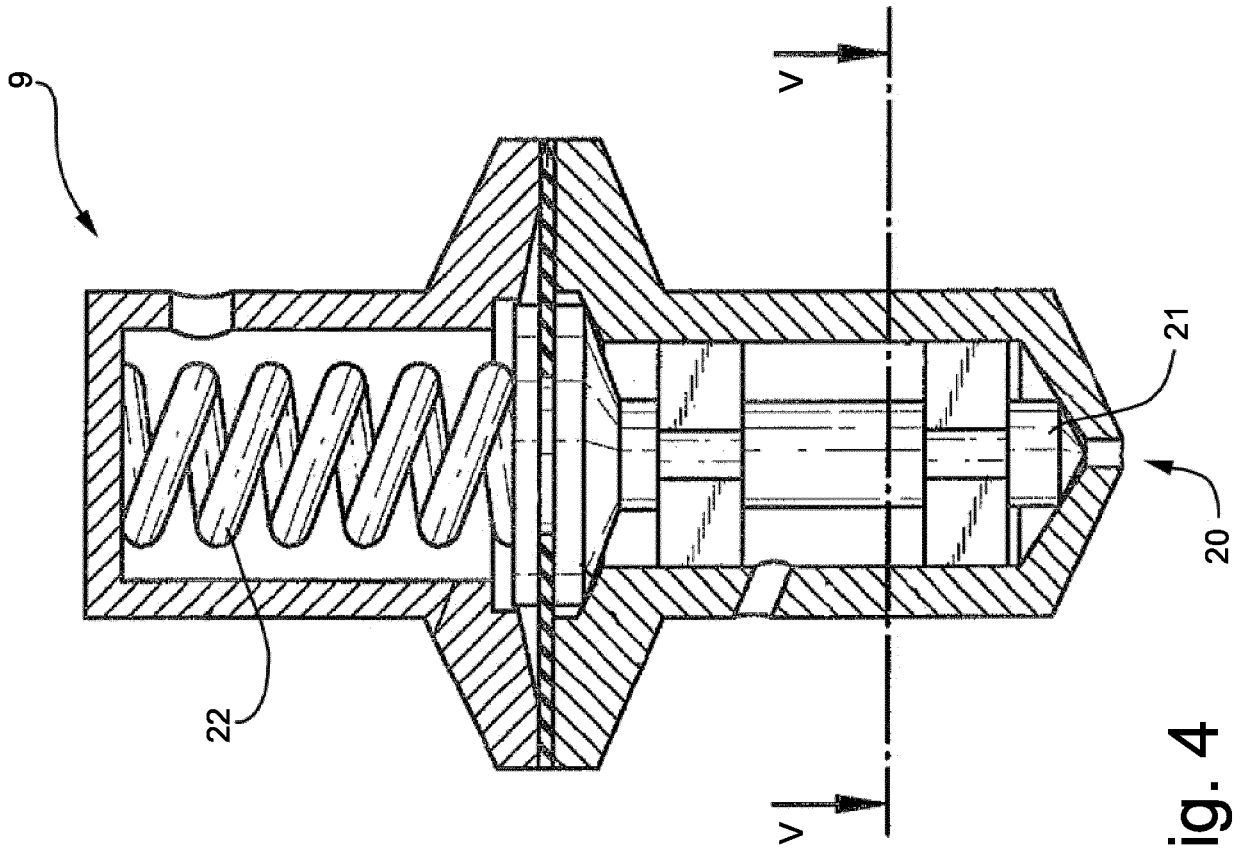


Fig. 4

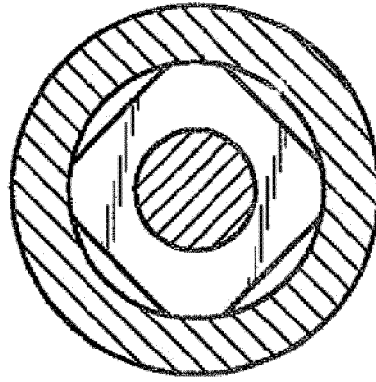


Fig. 5

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- EP 0631039 A1 [0004]
- WO 2012139801 A1 [0004]
- US 8006487 B2 [0004]
- CN 111997715 A [0009]