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(54) **DEVICE AND METHOD FOR REGULATING THE INJECTION OF A QUANTITY OF REDUCER IN THE GASEOUS PHASE**

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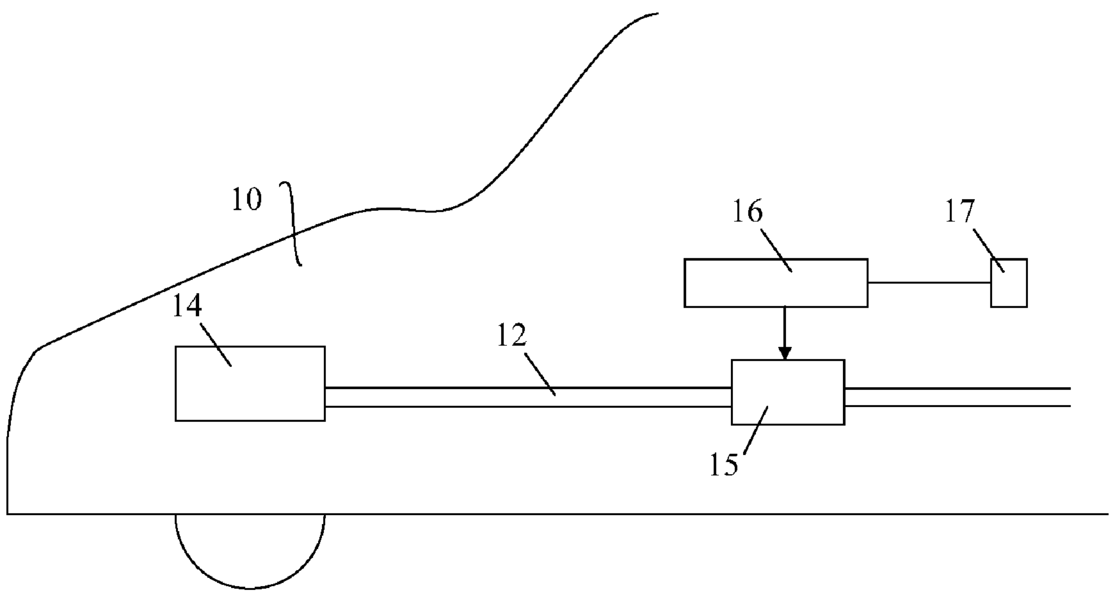
(57) **ABSTRACT**

The invention relates to a device (**16**) for regulating the injection of a quantity of reducer in the gaseous phase, comprising: a reducer supply channel (**18**), a pressure regulator (**20**) for regulating the pressure in the channel, members (**24**) for detecting the pressure downstream of the regulator (**20**), a reducer injector (**22**), and a computer controlling the injector according to the measured pressure.



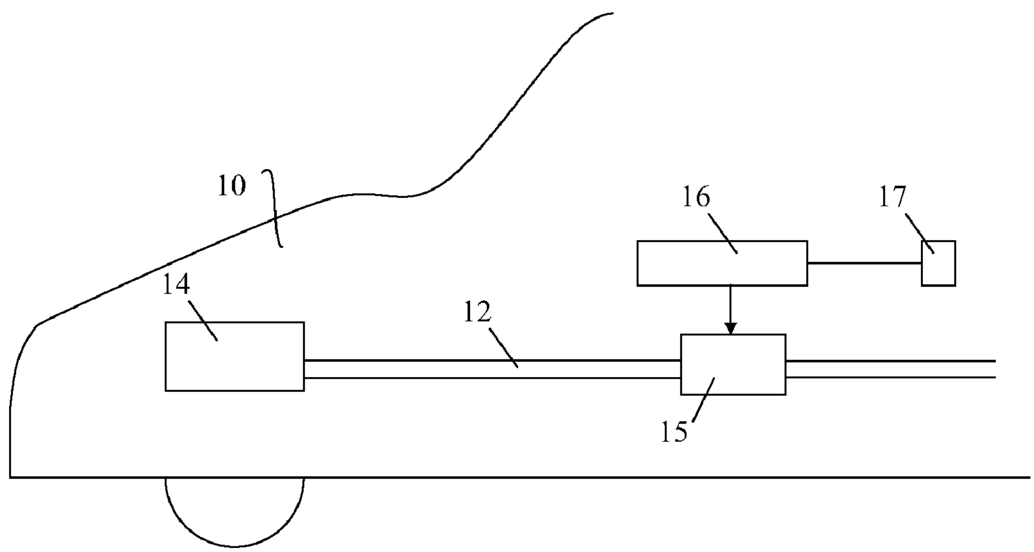


Fig. 1

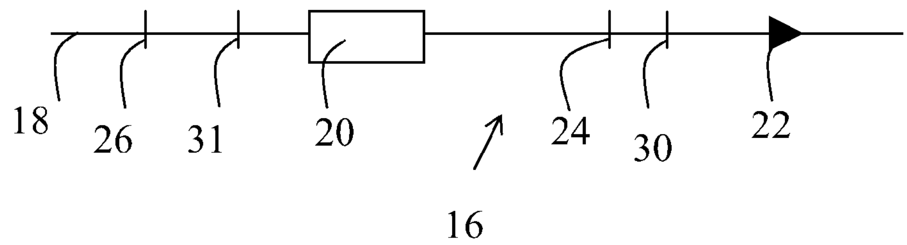


Fig. 2

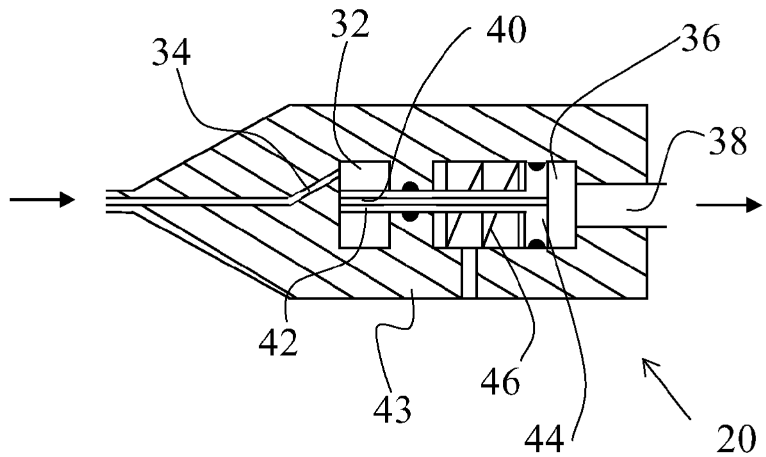


Fig. 3

DEVICE AND METHOD FOR REGULATING THE INJECTION OF A QUANTITY OF REDUCER IN THE GASEOUS PHASE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is the US National stage, under 35 U.S.C. §371, of International App. No. PCT/FR2010/051581 which was filed on Jul. 26, 2010 and claims priority to French Application No. 0956182 which was filed on Sep. 10, 2009, and which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] The present disclosure relates to a device for regulating the injection of a quantity of reducer in gaseous phase. A method is also proposed for implementing this device.

[0003] Nitrogen oxides (NOx) originating from the exhaust gas of internal combustion engines are linked to human health problems and are a key element in the formation of "smog" (pollution clouds) in cities. The legislature is imposing increasingly strict levels for their reduction and/or their elimination from mobile or fixed sources. To this end, a proven effective solution consists of chemical reduction of NOx by addition of a reducing agent such as NH_3 (ammonia) upstream of a catalyst employing a specific selective catalytic reduction (or SCR). This solution enables a diesel engine to comply with increasingly strict emission levels.

[0004] The problem faced by SCR is to bring the ammonia necessary for the NOx reduction in the exhaust. The reducer must be stored on the vehicle. Several concepts were developed to store the ammonia on board: in the form of solid urea, in the form of liquid urea, in aqueous solution, in the form of ammonium carbamate, etc.

[0005] Document FR-A-2 725 245 discloses a device for supplying an internal combustion engine with fuel. The device comprises a pump designed to draw fuel from a reservoir and an element sensitive to the pressure existing in the supply line without bypass, connected to the outlet of the pump and adapted to pilot the start up of the pump. The device comprises furthermore an expansion regulator placed in series in the supply line without bypass, connected to the outlet of the pump, upstream of the location where the fuel is used.

[0006] Document EP-A-1 198 740 describes a device for measuring the flow of a fluid through a pressure regulator, whereby the device comprises pressure sensors upstream and downstream of the regulator.

[0007] Document US-A-2008 022670 discloses a device for injecting liquid urea in an exhaust line. It uses a pressure regulator for the liquid urea and a pressure sensor for the urea. The pressure sensor measures the pressure of the urea supplied to the injector and the regulator regulates the incoming pressure. When said incoming pressure becomes too high, the urea returns to the urea reservoir.

[0008] The disadvantage of storing and using liquid urea or urea in aqueous solution is the requirement for large reservoirs, which creates additional weight for the vehicle. For this reason, the use of a reducing gas is preferred, but here the problem is in developing an architecture for controlling the quantity of injected reducing gas.

BRIEF SUMMARY

[0009] To this end, a device for regulating the injection of a quantity of reducer in gaseous phase comprising a reducer supply line, a pressure regulator in the line, instruments for detecting the pressure downstream of the regulator, a reducer injector, and a processor controlling the injection in function of the measured pressure are provided.

[0010] In a variant, the device further comprises instruments for detecting the pressure upstream of the regulator, whereby the downstream pressure detection instrument, and if necessary the upstream instrument, are for example a pressure sensor or a pressure switch.

[0011] In a variant, the device further comprises a temperature sensor downstream and/or upstream of the pressure regulator.

[0012] In a variant, the regulator comprises a first reducer entry chamber, a second chamber that routes the reducer towards the injector, a passage for the reducer between the first chamber and the second chamber, whereby the passage is obturated above a pressure threshold in the second chamber and the passage is open below this pressure threshold, so that the pressure downstream of the regulator can be increased.

[0013] In a variant, the passage extends through a piston rod that connects the first and second chambers. The rod supports a piston head movable in translation in the second chamber. A spring pushes against the head of the piston and is suitable for opening the passage when the pressure in the second chamber is lower than the threshold and suitable for closing the passage when the pressure in the second chamber is higher than the threshold.

[0014] In a variant, the reducer in gaseous phase comprises ammonia (NH_3), hydrogen (H_2), or hydrocarbons (HC).

[0015] The device also includes a post treatment line for exhaust gas, which comprises one or more storage reservoirs for a reducer in gaseous phase, and wherein the device is connected to the reservoir(s).

[0016] Also disclosed is a method for regulating the injection of a quantity of reducer in gaseous phase in this type of post treatment line for exhaust gas. The method comprises supplying a reducer to the injector, regulating the pressure downstream of the regulator, detecting the pressure downstream of the regulator, and, controlling the opening time of the injector through the processor in function of the measured pressure.

[0017] In a variant, the method further comprises the detection of the pressure upstream of the regulator, and emission of a fault signal when the pressure upstream and/or downstream of the regulator is above or below a threshold.

[0018] In a variant, adapted to controlling a line comprising a plurality of reservoirs, the method further comprises the detection of the pressure upstream of the regulator, and switching the supply of reducer to the line from one reservoir to another when the detected pressure upstream of the regulator is below the threshold.

[0019] In a variant, the method further comprises a step of measuring the temperature downstream and/or upstream of the regulator, by measuring the temperature or by using a model, while the opening time of the injector is also controlled by the processor as a function of the temperature.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0020] Other characteristics and advantages of the invention will become clear by reading the following detailed description of the implementation modes of the invention, provided only as an example and with reference to the drawings which show:

[0021] FIG. **1**, a vehicle equipped with a post treatment line for exhaust gas;

[0022] FIG. **2**, a regulating device for the reducer injection; and

[0023] FIG. **3**, a pressure regulator.

DETAILED DESCRIPTION

[0024] A device and a method for regulating the injection of a quantity of reducer in gaseous phase are disclosed. The device comprises a reducer supply line and a pressure regulator in the line. The device also comprises detection instruments for the pressure downstream of the regulator and a pressure controlled reducer injector. The device also comprises a processor controlling the injector as a function of the measured pressure. The processor allows for precise control of the reducer gas flow. Furthermore, this architecture controls the flow with a reduced number of components, which reduces the cost of the assembly.

[0025] FIG. **1** shows a vehicle **10** comprising a line **12** for post treatment of exhaust gas. Vehicle **10** comprises an engine **14**, for instance a diesel engine, to which line **12** is connected. Line **12** can comprise different exhaust gas treatment sites. For instance, line **12** can comprise a denitrification site **15**. The DeNOx denitrification site **15** comprises a catalyst causing the reduction of NOx by reaction with ammonia injected in line **12**. Other sites can be present in the line but are not shown.

[0026] FIG. **1** also shows a device **16** for regulating the injection of a quantity of reducer in gaseous phase. Device **16** allows for the injection of a reducer in gaseous phase. The reducer is, for instance, hydrogen (H_2) or hydrocarbons (HC). The reducer can also be ammonia (NH_3) used in site **15**. The advantage of injecting a reducer in gaseous phase is that it does not require preliminary transformation of a liquid reducer into a gaseous reducer, since this transformation must take place in very special conditions which can be difficult to create. Furthermore, larger quantities of reducer in gaseous phase can be available on board of the vehicle for a much smaller storage weight. Device **16** is connected to one or more reservoirs **17** which store the reducer. For instance, reservoir **17** can be comprised of storage by absorption of NH_3 in a XCl_2 type salt. The gas is released by adding heat or by lowering the pressure.

[0027] FIG. **2** shows device **16** in more detail. Device **16** comprises a reducer supply line **18**. Line **18** is connected to reservoir **17**. The reducer is routed towards line **12** through line **18** starting from reservoir **17**. Device **16** further comprises a regulator **20** for the pressure inside the line. Regulator **20** controls the pressure of the reducer. Regulator **20** will be better described with reference to FIG. **3**. Injector **22** injects the reducer in line **12**. The injector controls the flow of the reducer. In particular, device **16** controls injector **22** by varying the injection time of the reducer as a function of the reducer pressure in line **18**. This allows for precise control of the reducing gas flow and for the reduction of NOx. Injector **22** is, for instance a needle injector or a membrane injector, both of which are well known.

[0028] Regulator **20** brings the reducer to a pressure suitable for injection in line **12**. Regulator **20** can reduce the pressure based on the status of the line **12**. Indeed, injector **22** functions at fixed pressure, and since the reducer pressure fluctuates significantly because of its gaseous state, the role of regulator **20** is to regulate the pressure upstream of injector **22**. Since the pressure at the outlet of reservoir **17** can vary from 0 to 300 bar, or more generally, from 0.1 bar to 30 bar, the regulator stabilizes the pressure upstream of injector **22**. Therefore, the device uses the regulation of the pressure in conjunction with the opening time of the injector to define the quantity of supplied gas.

[0029] FIG. **3** shows an example of an embodiment of regulator **20**. The regulator is based on a mechanical principle. Regulator **20** increases the pressure downstream of the regulator if the pressure is below a pressure threshold for injection in line **12**. This ensures that the reducer pressure is sufficiently high for a suitable injection, and for a suitable reduction of the toxic substances present in the exhaust gas. The regulator can comprise a first chamber **32** in which the reducer enters through the bias of a channel **34** connected to line **18**.

[0030] Regulator **20** further comprises a second chamber **36** that routes the reducer towards injector **22** through the bias of a channel **38** connected to line **18**. The pressure of the reducer entering the first chamber is high and the pressure of the reducer leaving the second chamber is low.

[0031] The line comprises a reducer passage **40** between the first chamber **32** and the second chamber **36**. Passage **40** is closed when the pressure in the second chamber **36** is above a predetermined threshold. Passage **40** is open when the pressure in the second chamber **36** is below the predetermined threshold. Furthermore, if the pressure in the first chamber becomes higher than the pressure in the second chamber, the reducer will flow towards the second chamber through the bias of passage **40**. This increases the pressure in the second chamber and therefore the pressure upstream of injector **22**.

[0032] In more detailed manner, passage **40** extends through a piston rod **42** that connects the two chambers **32** and **36**. Passage **40** is a routing channel through which the reducer can circulate from one chamber to the other. Rod **42** extends from one chamber to the other through a wall **43** of the regulator separating the two chambers. Rod **42** supports a piston head **44**. The head **44** is movable in translation in the second chamber **36**. A spring **46** pushes against the head of the piston **44** in translation in the second chamber **36**. Spring **46** is for instance held in compression between piston head **44** and wall **43**.

[0033] When the pressure in the second chamber **36** diminishes and the pressure in the second chamber **36** drops below the predetermined threshold, spring **46** pushes the head **44** in the direction of channel **38**. This opens the orifice in the extremity of passage **40**, situated in the first chamber **32**. Since the pressure is now higher in the first chamber **32**, the reducer passes through the orifice in passage **40** and flows through the orifice at the other end of passage **40**, situated in the second chamber **36**. When the pressure in the second chamber **36** is sufficiently high to counteract the force of spring **46**, the pressure in the second chamber **36** pushes the head **44** of the piston in direction of the wall **43** against spring

46. The orifice located at the extremity of passage **40**, situated in the first chamber **32**, is pressed against the body of regulator **20** and is closed. The reducer can then no longer circulate from the first chamber **32** to the second chamber **36**.

[0034] Spring **46** is rated to regulate the pressure upstream of the injector **32** regardless of the pressure upstream of the regulator **20**.

[0035] O-rings ensure sealing between piston head **44** and the regulator body and between piston rod **42** and the regulator body, in particular wall **43**.

[0036] Device **16** further comprises detection instruments **24** for measuring the pressure downstream of regulator **20**. The detection instruments **24** are used to determine whether the pressure upstream of injector **22** is too high or too low relative to the pressure required for injection in line **12**. Consequently, the processor controls the injector as a function of the measured pressure, and in particular the opening time of the injector.

[0037] Device **16** further comprises detection instruments **26** for measuring the pressure upstream of regulator **20**. The detection instruments **26** can be used to pilot the reservoir(s) **17**. The information of instruments **26** is also supplied to the processor. For instance, if the instruments **26** detect a large increase in pressure on the side of the reservoir(s) **17**, this could indicate that the reservoirs **17** have released too much reducer. Inversely, if the pressure is too low and beyond a certain threshold, this could indicate that the reservoir(s) **17** are about to be exhausted. In case the vehicle comprises several reservoirs **17**, for instance two reservoirs **17**, the processor can command a switch of the reducer supply to the line from one reservoir **17** to another and signal that one of the reservoirs needs to be changed. In this way, several reservoirs can be used automatically.

[0038] Pressure detection instruments **24**, **26** are also used for determining the state of the device, namely whether the device **16** is functional or dysfunctional. In other words, detection instruments **24**, **26** detect the proper functioning of regulator **20**, or an anomaly. For instance, instruments **24** can be used for detecting the proper state of the spring. The information of instruments **24** is delivered to a processor which determines the proper functioning of the regulator, and in particular of spring **46**. The instruments **24** are connected to the processor, in order to supply it with information relative to the pressure upstream of injector **22**. Instruments **26** can detect a malfunction of one or more reservoirs. The processor can send an anomaly signal to inform the driver of the malfunction.

[0039] Instruments **24** and **26** are for instance pressure switches. Pressure switches, such as those disclosed in document FR-A-2 275 245, are used for converting a pressure to an electrical signal, which is sent to the processor. The movements of a membrane in a chamber, as a function of the pressure in the chamber, open or close an electrical contact which sends, or stops sending, the electrical signal. The signal is a binary signal. It can be envisaged that one or two pressures switches are installed for each instrument **24** and **26**. The advantage of two pressure switches is the redundancy in case of failure of one pressure switch. Instruments **24** and **26** can also be pressure sensors. One pressure sensor for each instrument **24**, **26** is sufficient because of its reliability.

[0040] Temperature sensors **30**, **31** can be present upstream and/or downstream of regulator **20**. The processor can then also control the opening time of the injector as a function of the temperature. This provides a refined measurement of the reducer pressure, which varies as a function of the temperature in line **38**. The temperature information can also be obtained by calculation, in particular by means of a model. This method avoids the use of supplementary sensors.

1. A device for regulating the injection of a quantity of reducer in gaseous phase comprising a line supplying the reducer, a pressure regulator in the line, pressure detection instruments downstream of regulator, a reducer injector, and a processor controlling the injector as a function of the measured pressure.

2. The device according to claim **1**, further comprising pressure detection instruments upstream of regulator.

3. The device according to claim **1**, further comprising a temperature sensor downstream and/or upstream of the pressure regulator.

4. The device according to claim **1**, the regulator further comprising a first reducer entry chamber, a second chamber routing the reducer towards the injector, a reducer passage between the first chamber and the second chamber, whereby the reducer passage is blocked above a certain pressure threshold in the second chamber and the reducer passage is open below this pressure threshold.

5. The device according to claim **4**, wherein the reducer passage is in a piston rod that extends between the first and second chambers, the rod supporting a piston head which is movable axially in the second chamber, and a spring that pushes against the piston head and is suitable for opening the reducer passage when the pressure in the second chamber is lower than the threshold pressure and suitable for closing the reducer passage when the pressure in the second chamber is higher than the pressure threshold.

6. The device according to claim **1**, further comprising a post treatment line for exhaust gas, having one or more reservoirs for storing reducer in gaseous phase.

7. A method for regulating the injection of a quantity of reducer in gaseous phase in a line comprising the steps of supplying reducer to an injector, regulating the pressure downstream of a regulator, detecting the pressure downstream of the regulator, and, controlling the opening time of the injector by a processor as a function of the measured pressure.

8. The method according to claim **7**, of further comprising detecting the pressure upstream of the regulator, and emitting an anomaly signal when the pressure upstream and/or downstream of the regulator is above or below a threshold.

9. The method according to claim **7**, whereby a post treatment line comprises a plurality of reservoirs, the method further comprising the step of detecting the pressure upstream of the regulator, and switching the reducer supply to the line from one reservoir to another when the detected pressure upstream of the regulator is beyond a threshold.

10. The method according to claim **7**, further comprising a step of measuring the temperature upstream and/or downstream of the regulator, through measurement of the temperature or through the use of a model, whereby the opening time of an injector is also controlled by a processor as a function of temperature.

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