

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
24 December 2008 (24.12.2008)

PCT

(10) International Publication Number
WO 2008/155303 A1

(51) International Patent Classification:
F01N 3/20 (2006.01)

(74) Agents: **JACQUES, Philippe** et al.; Rue de Ransbeek, 310, B-1120 Bruxelles (BE).

(21) International Application Number:
PCT/EP2008/057524

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(22) International Filing Date: 16 June 2008 (16.06.2008)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
0755875 20 June 2007 (20.06.2007) FR

(71) Applicant (for all designated States except US): **ENERGY AUTOMOTIVE SYSTEMS RESEARCH** (Société Anonyme) [BE/BE]; Rue de Ransbeek, 310, B-1120 Bruxelles (BE).

(72) Inventor; and

(75) Inventor/Applicant (for US only): **HABUMUREMYI, Jean-Claude** [BE/BE]; Doornstraat 5, B-9450 Haaltert (BE).

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— with international search report

(54) Title: PROCESS FOR STARTING A PUMP

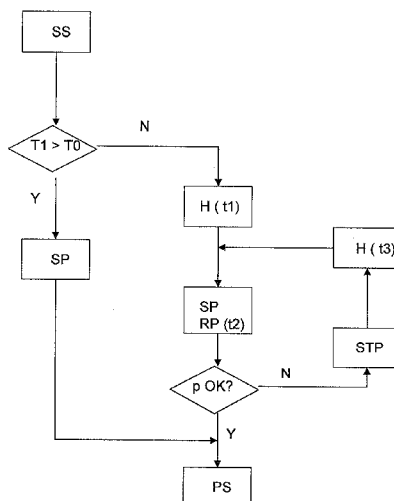


Fig. 1

(57) Abstract: Process for starting a pump intended to pump a liquid contained in a tank and to produce a substantially constant outlet pressure (setpoint pressure), according to which: 1. the temperature (T1) of the liquid held in the tank is determined and compared to a setpoint temperature (T0); 2. if the temperature (T1) is greater than the setpoint temperature (T0), the pump is actuated; 3. if the temperature (T1) is less than or equal to the setpoint temperature (T0), the tank is heated for a time t1; then 4. the pump is actuated for a time t2 during which the pump outlet pressure is measured; 5. if this pressure is stable and in an acceptable margin of the setpoint pressure, the pump is kept going; 6. if this pressure is not stable and/or is not in the acceptable margin of the setpoint pressure, the pump is stopped and the tank is heated for a time t3, at the end of which steps 4 to 6 are repeated.

Process for starting a pump

The present application relates to a process for starting a pump intended to pump a liquid that is capable of freezing or solidifying. It relates, in particular, to starting pumps intended for aqueous urea solutions.

Legislation on vehicle and heavy goods vehicle emissions stipulates, amongst other things, a reduction in the release of nitrogen oxides NO_x into the atmosphere. One known way to achieve this objective is to use the SCR (Selective Catalytic Reduction) process which enables the reduction of nitrogen oxides by injection of a reducing agent, generally ammonia, into the exhaust line. This ammonia may derive from the pyrolytic decomposition of an ammonia precursor solution, whose concentration may be the eutectic concentration. Such an ammonia precursor is generally a urea solution.

With the SCR process the high levels of NO_x produced in the engine during combustion at optimized efficiency are treated in a catalyst on exiting the engine. This treatment requires the use of the reducing agent at a precise concentration and of extreme quality. The solution is thus accurately metered and injected into the exhaust gas stream where it is hydrolysed before converting the nitrogen oxide (NO_x) to nitrogen (N_2) and water (H_2O).

In order to do this, it is necessary to equip the vehicles with a tank containing an additive solution (generally an aqueous urea solution) and also a device for metering the desired amount of additive and injecting it into the exhaust line. Given that the aqueous urea solution generally used for this purpose (eutectic 32.5 wt% urea solution) freezes at -11°C , it is necessary to provide a heating device to liquefy the solution in order to be able to inject it into the exhaust line in the event of starting in freezing conditions. This device should ideally cover at least one part of the storage tank and also the line going from this tank to the injector, and preferably also the devices encountered in this line (filter, pump, etc.).

In motor vehicles, the temperature margin in which the systems must operate generally lies between -40°C and 80°C (depending on the countries/regions). It is therefore necessary to ensure that the pump can start in the low-temperature ranges, knowing that the aforementioned solutions have a tendency to crystallize starting from -8°C .

- 2 -

Determination of the actuation time of the "cold" pump (i.e. the time that it is necessary to wait in order to have melted a minimum of liquid and to enable the pump to be started) may be based on experimental data obtained at various temperatures over a given system.

5 The tests that generate this data are generally carried out in a cold room and the effects of wind, vehicle vibrations, changes in the initial temperature conditions, etc. are not taken into account. There are therefore situations where the pump will not be actuated since the starting time has been underestimated (in the case of changing situations, for example). These situations may furthermore lead
10 to irreversible pump damage. Conversely, the actuation time may have been overestimated (which is furthermore generally the case for safety reasons) and the pollution-control system is then not optimal.

 It should be noted that the starting time could also be calculated based on thermodynamic and thermal data, but the results obtained would again not take
15 into account practical parameters of variability.

 Although some documents briefly describe the cold starting of SCR systems (see, for example, documents US 5,884,475 and US 2002/0088220), none of these documents addresses the problem of the optimal determination of the pump actuation time.

20 The present invention aims to solve this problem by providing a process which makes it possible to optimize the pump starting time without damaging this pump.

 For this purpose, the present application relates to a process for starting a pump intended to pump a liquid contained in a tank and to produce a substantially
25 constant outlet pressure (setpoint pressure), according to which:

1. the temperature (T1) of the liquid held in the tank is determined and compared to a setpoint temperature (T0);
2. if the temperature (T1) is greater than the setpoint temperature (T0), the pump is actuated;
- 30 3. if the temperature (T1) is less than or equal to the setpoint temperature (T0), the tank is heated for a time t1; then
4. the pump is actuated for a time t2 during which the pump outlet pressure is measured;
5. if this pressure is stable and in an acceptable margin of the setpoint pressure,
35 the pump is kept going;

- 3 -

6. if this pressure is not stable and/or is not in the acceptable margin of the setpoint pressure, the pump is stopped and the tank is heated for a time t_3 , at the end of which steps 4 to 6 are repeated.

5 The pump to which the invention applies is a pump of any known type, preferably driven by a motor and the operation of which is controlled by a controller. Preferably, the pump is of the gear pump type. It generally comprises a stator and a rotor and can preferably operate in two opposite rotational directions, one generally corresponding to supplying the feed line with liquid and the other generally corresponding to a purge of the feed line.

10 Any type of rotary electric motor may be suitable. Preferably, the motor is of the BLDC (brushless direct current) motor type. In this case, the pump is driven by a magnetic coupling between the rotor of the pump and a drive shaft of the motor.

15 The controller of this pump is a control module (generally comprising a PID regulator and a motor rotational speed controller) and an electric power supply unit which preferably supplies the motor with the power required to rotate it at the desired speed and which enables its direction of rotation to be reversed, where necessary.

20 Most particularly preferably, an ECM (Electronic Control Module) sends, to the pump controller, a PWM (Pulse Width Modulation) control signal having a duty cycle that varies as a function of the desired operating conditions for the pump and according to which the controller acts on the motor to apply said operating conditions to the pump. This preferred variant is the subject of Application FR 0700358 in the name of the Applicant, the subject of which is
25 incorporated by reference in the present application.

30 As explained previously, the liquid for which the invention is intended is a liquid capable of freezing or solidifying (setting solid) when the temperature reaches a low temperature threshold. These may, for example, be aqueous solutions. One liquid to which the present invention applies particularly well is urea.

The term "urea" is understood to mean any, generally aqueous, solution containing urea. The invention gives good results with eutectic water/urea solutions for which there is a standard quality: for example, according to the standard DIN 70070, in the case of the AdBlue[®] solution (commercial solution
35 of urea), the urea content is between 31.8% and 33.2% (by weight) (i.e. 32.5 +/- 0.7 wt%) hence an available amount of ammonia between 18.0% and 18.8%. The

- 4 -

invention may also be applied to the urea/ammonium formate mixtures, also in aqueous solution, sold under the trade name Denoxium™ and of which one of the compositions (Denoxium-30) contains an equivalent amount of ammonia to that of the Adblue® solution. The latter have the advantage of only freezing from -30°C onwards (as opposed to -11°C), but have the disadvantages of corrosion problems linked to the possible release of formic acid and a less available market (whereas urea is widely used and readily available even in fields such as agriculture). The present invention is particularly advantageous in the context of eutectic water/urea solutions.

10 According to the invention, the liquid is held in a tank which may be made from any material, preferably one having good chemical resistance to the liquid in question. In general, this is metal or plastic. Polyolefins, in particular polyethylene (and more particularly HDPE or high-density polyethylene), constitute preferred materials, in particular in the case where the liquid is urea.

15 This tank may be produced by any conversion processes known in the case of hollow bodies. One preferred processing method, in particular when the tank is made of plastic, and in particular HDPE, is the extrusion-blow moulding process. In this case a parison (in one or more parts) is obtained by extrusion, and is then shaped by blow moulding in a mould. One-part moulding of the tank
20 from a single parison gives good results.

This tank is advantageously equipped with a base plate or mounting plate (i.e. a support having substantially the shape of a plate) onto which at least one active accessory of the urea storage system and/or injection system is attached. This base plate generally has a perimeter, closed up on itself, of any shape.

25 Usually, its perimeter has a circular shape.

In a particularly preferred manner, this base plate is a submerged mounting plate, i.e. sealing an opening in the lower wall of the tank. The expression "lower wall" is in fact understood to mean the lower half of the tank (whether or not it is moulded in one piece or from two parison sheets or cut-outs). Preferably, the base
30 plate is located in the lower third of the tank, and more particularly preferably, in the lower quarter, or even squarely in the bottom of this tank. It may be partly in the lower side wall, in which case it is slightly slanted once mounted in the vehicle. The location and/or direction of the base plate especially depends on the location of the tank in the vehicle, and on the space occupied around it

35 (considering the components to be integrated therein).

- 5 -

This base plate therefore incorporates at least one component that is active during storage and/or injection. This is understood to mean that the component is attached to or produced as one part with the base plate. This component may be incorporated inside the tank, or on the outside with, if necessary, a connection
5 (delivery tube) passing through it.

Preferably, the base plate according to this variant of the invention integrates several active storage and/or metering components and, most particularly preferably, it integrates all the active components which are brought to be in contact with the liquid additive found in, leaving from or arriving into the additive
10 tank.

Preferably, the component is chosen from the following elements: a pump; a filter; a level gauge; a temperature sensor; a quality sensor; a pressure sensor and a pressure regulator. It is advantageous for the pump of the process according to the invention to be integrated into such a base plate and for this base plate to integrate
15 other active components (preferably all the active components) as defined above.

Preferably, the base plate also integrates at least one heating element and most particularly preferably this heating element comprises at least one flexible part (as described in Application FR 0755118 in the name of the Applicant, the content of which is incorporated by reference in the present application) which is
20 preferably a flexible heater, i.e. a heater comprising one or more resistive track(s) affixed to a film or placed between two films (i.e. two substantially flat supports, the material and thickness of which are such that they are flexible). This film is preferably made of a plastic (although any other insulating material may be suitable) and, in particular, is based on an elastomer. Most particularly
25 preferably, this flexible heater comprises one or more stainless steel resistive track(s) sandwiched between two silicone resin films, one of which is covered with a network of glass fibres.

Preferably, the heating element extends inside the tank, and is therefore submerged (partially or completely) in the liquid when the tank is full. Most
30 particularly preferably, the heating element predominantly consists of a flexible heater. Preferably, there is also a heating element (wire or flexible heater) present around the urea feed line up to the injector and the return line, where appropriate. Specifically, in one preferred variant of the invention, the pump intentionally meters too great an amount (pressure) of liquid, the excess of which is returned
35 to the tank, for example using a line equipped with a calibrated valve. When the urea is injected into the exhaust gases of an engine, this variant makes it possible

- 6 -

to cool the injector but it should however be noted that the non-return lines are more advantageous, economically speaking.

Preferably, the element heating these lines is also a flexible heater.

5 In one advantageous variant of the invention, the feed line is purged after each use of the pump (just before it is stopped) in order to reduce the starting time of the system and avoid prematurely damaging the lines (as the urea solutions expand when it freezes). The purge may be carried out, for example, by reversing the rotational direction of the pump just for the time necessary to convey the liquid contained in the feed line back to the tank.

10 As regards the return line, if present, it generally has a relatively low volume and therefore, if it is heated, it should not be purged while the pump is stopped. Therefore, to prevent the liquid from going round in circles in the loop determined by the feed line and the return line during the purge when this is carried out by reversing the rotational direction of the pump, it is advantageous
15 to equip the return line with a non-return valve.

According to the invention, before starting the pump, the temperature (T1) of the liquid held in the tank is determined and compared to a setpoint temperature (T0) (step 1 of the process). Generally, this measurement is carried out using a temperature sensor which is advantageously integrated into a base plate as
20 described previously. The setpoint temperature (T0) is generally that at which the liquid begins to solidify. When it is a question of a liquid capable of freezing or crystallizing, this temperature is generally that of the start of said crystallization (namely around -8°C for eutectic water/urea solutions).

If the temperature measured is greater than T0, the pump is actuated, for
25 example by sending a PWM signal corresponding to the setpoint pressure to the ECM.

If the temperature measured is less than or equal to T0, the tank is heated for a time t1. This time is a function of the temperature measured and is generally the minimum time required to obtain a volume of liquid equal to the volume of the
30 injection line and the return line, where appropriate (including the internal volume of the accessories placed in this line, such as filter, pump, etc.). As explained previously, this time may be deduced from experimental data and/or theoretical calculations.

In practice, the ECM may send a signal to a heating element integrated into
35 the tank (preferably into a submerged base plate as explained previously), so that this tank is heated at a given power for the time t1.

At the end of this time, the pump is actuated (with a suitable command depending on the setpoint pressure) for a time t_2 during which the pump outlet pressure is measured (step 4 of the process, if necessary). Again, this may be carried out using the ECM which sends a signal to the pump controller instructing it to actuate the pump under the conditions required to reach the setpoint pressure, for a time t_2 , and to effectively measure this pressure. Measurement of the pressure over this period is carried out at very precise times, which is generally possible via the use of a real-time operating system (for example, every 50 ms).

In one advantageous variant, the controller is connected to a pressure sensor and it compares, in a loop, the pressure setpoint value with the value measured by the sensor and consequently acts on the rotational speed of the motor in order to attempt to stabilize the pressure at the setpoint value.

Generally, this is done using a pressure regulator which carries out the comparison between the setpoint pressure and the pressure measured and generates an error signal for the motor rotational speed controller.

In this variant, the regulator may be of any known type, but it is preferably of PID (Proportional-Integral-Derivative) type. As regards the pressure sensor, it is preferably integrated with the pump, that is to say that it may be attached to the pump by any known attachment means.

The time t_2 , during which the stability of the pressure is verified, is preferably short enough so that the pump does not risk being damaged if it operates when empty and long enough so that the stability of the outlet pressure can be verified. Generally, a time of the order of seconds (even tens of seconds) is suitable.

If, during the period t_2 , the pressure was effectively stable and in an acceptable margin of the setpoint value (see later on) the controller keeps the pump going and signals to the ECM of the system that the pump has started correctly.

If, on the other hand, this pressure was not stable and/or was not in an acceptable margin with respect to the setpoint pressure, the pump is stopped (generally via a specific PWM signal sent by the ECM) and the tank is heated for a time t_3 before restarting the pump and again verifying the stability of the outlet pressure over a period t_2 in an iterative manner until a stable setpoint pressure is reached and this information is sent to the ECM, or information is sent to the ECM, according to which information the pump has not been able to

be started if, for example, after a limited number (for example, 4) of attempts at starting, a stable pressure has not been able to be obtained.

To verify the stability of the pressure and the accuracy of its value (i.e. the fact that it is or is not in an acceptable margin with respect to the setpoint pressure), the controller applies a given mathematical criterion to the pressure measurements and to the setpoint pressure. A criterion based on the variance gives good results. According to this, over the interval t_2 , the average distance of n successive pressure measurements carried out over this interval is evaluated relative to the reference pressure (i.e. for each of the n measurements, the square of the difference between the pressure measured and the setpoint pressure is calculated, the n values of the squares thus obtained are added together and this sum is divided by n). Therefore, the average variance of the pressure over the period t_2 is in fact calculated and it is compared with the maximum variance of the pump specifications.

Generally, an acceptable margin is defined as being a few % deviation with respect to the setpoint pressure. In practice, this value should often not exceed 2% of the setpoint pressure after the transient control phase. In this case, the pressure over the period t_2 will be stable if the average variance defined above and calculated over the period t_2 is less than $(0.02)^2$ multiplied by the square of the pressure. If this is the case, the criterion of variance is judged to be satisfied and the controller keeps the pump going (for example by applying a voltage to it that corresponds to the setpoint pressure).

If this is not the case, the controller stops the pump (generally by means of a suitable command) or if the pump is blocked, a pump diagnostics manager (if one exists) may short-circuit the voltage (by earthing it).

The signal that the controller sends to the ECM in order to signal to it if the pump has started correctly may consist of precisely this voltage.

In practice, the time to measure a pressure and calculate the average variance over the latter combined pressure measurements is of the order of tens of ms (milliseconds) which makes it possible, for a time t_2 of the order of seconds, to carry out several tens of separate determinations of the variance.

The process according to the invention has been successfully tested in a MATLAB/SIMULINK[®] simulation environment and a computer controlling an SCR system.

The present invention is illustrated, non-limitingly, by appended Figures 1 and 2.

Figure 1 consists of a block diagram of one preferred variant of the process according to the invention applied to a system for the injection of urea into the exhaust gases of an internal combustion engine (or SCR system) and Figure 2 illustrates one preferred variant of such a system.

5 From the start up of the urea system or SS (Start System), the system controller verifies whether the temperature is above the low temperature threshold ($T1 > T0$) in the tank in order to be able to start the pump without risk of damaging it.

10 If this is the case (Y or YES), it effectively starts the pump (SP) and sends a corresponding signal (PS or Pump Started) to an ECM.

If this is not the case (N or NO), it heats the tank and the lines (urea feed and return lines, where appropriate) of the system for a time $t1$ ($H(t1)$). Next, it starts the pump (SP) and over a time $t2$, it regularly measures the pressure at the pump outlet and calculates the change in its variance ($RP(t2)$). At the end of $t2$, it
15 compares the average variance of the pressure (or its covariance) and compares it to a setpoint value (p OK?).

If this is below the setpoint value (Y), the controller keeps the pump going and signals to the ECM that the pump has indeed started (PS).

20 If the covariance is above the desired value (N), the controller stops the pump (STP or Stop Pump). Next, it again heats the tank and the lines for a time $t3$ ($H(t3)$) before restarting it (SP) and reverifying the stability of the pressure over a period $t2$ ($RP(t2)$), etc. This continues until a stable setpoint pressure is reached, the pump is kept going and the ECM is informed of that, or is informed that the pump has a problem if, at the end of 4 iterations, a stable pressure has
25 not been reached.

As mentioned above, Figure 2 illustrates an SCR system to which the block diagram from Figure 1 applies and which comprises the following components (previously described in the description):

- 1: urea tank;
- 30 2: gauge (level sensor);
- 3: flexible heater;
- 4: filter;
- 5: temperature sensor;
- 6: current sensor for the flexible heater;
- 35 7: pump;
- 8: speed sensor;

- 10 -

- 9: heating filament for the lines and pump heating cartridge;
- 10: pressure sensor;
- 11: current sensor for the line heater;
- 12: injector;
- 5 13: non-return valve that prevents the liquid from going round in circles (in the loop created by the feed line and that for return to the tank) during the purge (when the pump rotates in reverse);
- 14: calibrated orifice (restriction) - used to set the flow rate and to add resistance in order to increase the pressure (by increasing pressure drops in the return
- 10 line);
- 15: (BLDC) motor for driving the pump;
- 16: non-return valve that enables the pressure at the pump outlet to be regulated.

CLAIMS

1. Process for starting a pump intended to pump a liquid contained in a tank and to produce a substantially constant outlet pressure (setpoint pressure), according to which:

- 5 1. the temperature (T1) of the liquid held in the tank is determined and compared to a setpoint temperature (T0);
2. if the temperature (T1) is greater than the setpoint temperature (T0), the pump is actuated;
3. if the temperature (T1) is less than or equal to the setpoint temperature (T0), the
10 tank is heated for a time t1; then
4. the pump is actuated for a time t2 during which the pump outlet pressure is measured;
5. if this pressure is stable and in an acceptable margin of the setpoint pressure, the pump is kept going;
- 15 6. if this pressure is not stable and/or is not in the acceptable margin of the setpoint pressure, the pump is stopped and the tank is heated for a time t3, at the end of which steps 4 to 6 are repeated.

2. Process according to the preceding claim, in which the pump is driven by a motor and is controlled by a controller and in which an ECM (Electronic
20 Control Module) sends, to the controller, a PWM (Pulse Width Modulation) control signal having a duty cycle that varies as a function of the desired operating conditions for the pump, the controller acting on the motor to apply said operating conditions to the pump.

3. Process according to any one of the preceding claims, in which the
25 liquid is an aqueous urea solution.

4. Process according to any one of the preceding claims, in which the pump is integrated into a base plate submerged in the tank which also integrates other active components of the tank.

- 12 -

5. Process according to the preceding claim, in which the base plate integrates a heating element.

6. Process according to the preceding claim, in which a liquid feed line comes out of the tank and a liquid return line arrives at the tank and in which
5 these lines are also equipped with a heating element.

7. Process according to the preceding claim, in which the pump is a rotary pump and in which the lines are purged after each use of the pump (just before it is stopped) by reversing its direction of rotation for the time necessary to convey the liquid contained in the feed and return lines back to the tank.

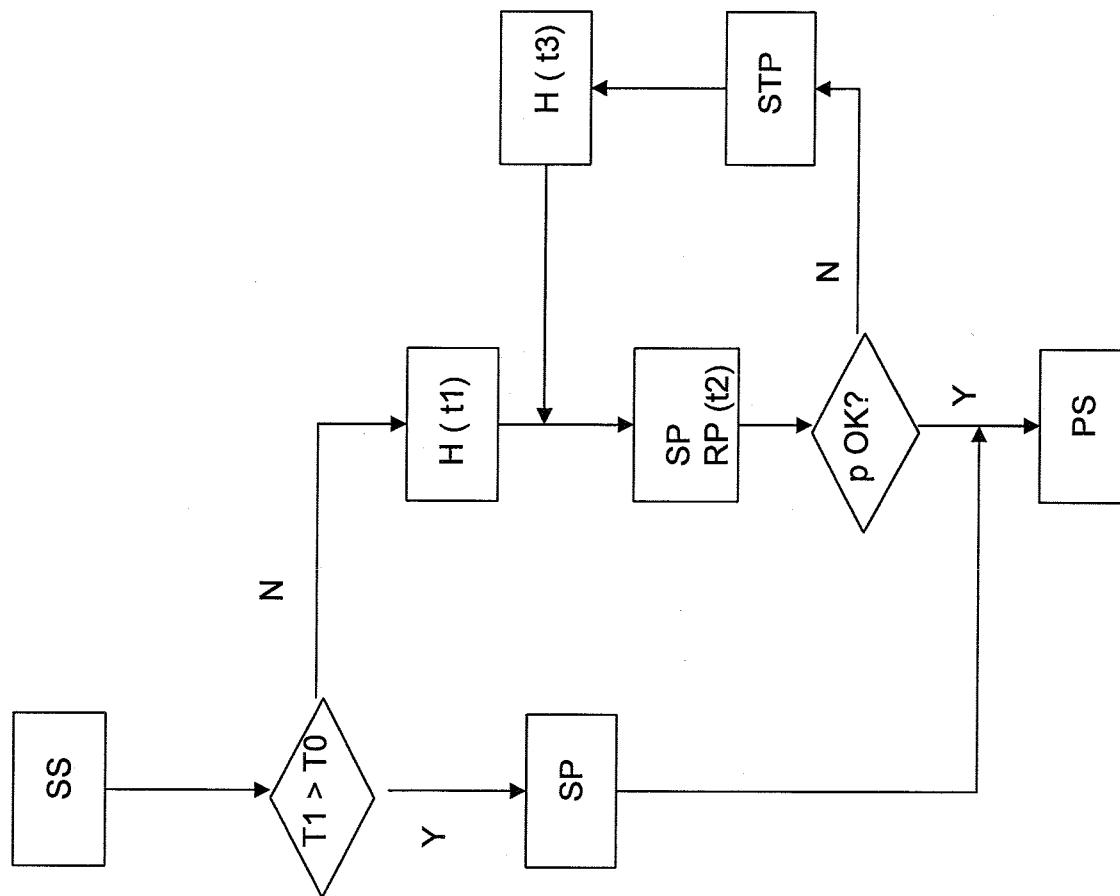
8. Process according to Claim 6 or 7, in which the time t_1 is the minimum
10 time required to obtain a volume of liquid equal to the volume of the injection line, the return line and the components in these lines (pumps, valves, etc.).

9. Process according to Claim 2, in which the controller is connected to a pressure sensor and in which the controller compares, in a loop, the pressure
15 setpoint value with the value measured by the sensor and consequently acts on the rotational speed of the motor in order to attempt to stabilize the pressure at the setpoint value.

10. Process according to the preceding claim, in which during the period t_2 , the pressure is measured periodically and a mathematical criterion based on
20 the variance is applied to the pressure measurements and to the setpoint pressure.

11. Process according to the preceding claim, in which, if the pressure is not stable and/or is not in an acceptable margin with respect to the setpoint pressure at the end of several iterations (repetition of steps 4 to 6), the controller stops the pump and sends information to the ECM, according to which
25 information the pump has not been able to be started.

12. Process according to any one of the preceding claims, characterized in that it has been tested in a MATLAB/SIMULINK[®] simulation environment and/or in that it has been concretely applied to an SCR system.

**Fig. 1**

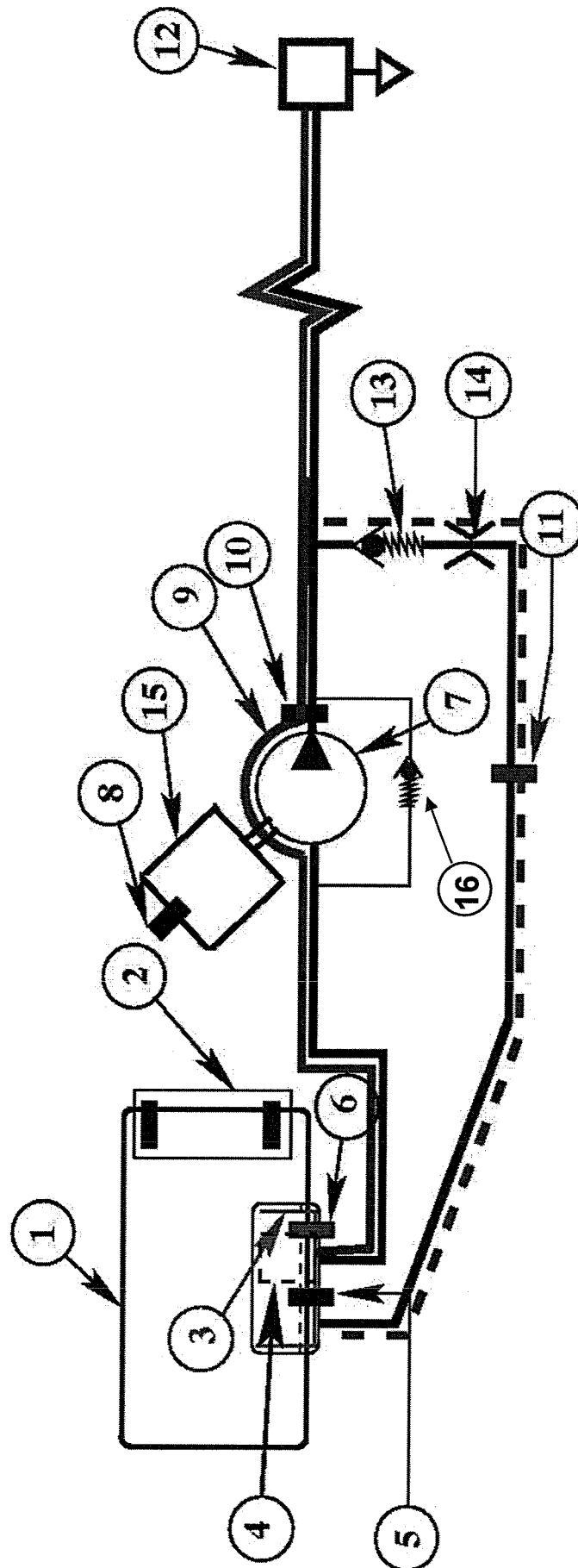


Fig. 2

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2008/057524

A. CLASSIFICATION OF SUBJECT MATTER
INV. F01N3/20

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)

F01N

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)

EPO-Internal, PAJ, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 1 669 567 A (NISSAN DIESEL MOTOR CO [JP]) 14 June 2006 (2006-06-14) paragraphs [0047] - [0058], [0065] - [0080]; figures 4,6	1-12
A	US 2005/207936 A1 (BERRYHILL ROSS C [US] ET AL) 22 September 2005 (2005-09-22) paragraphs [0063] - [0086]; figures 9-11	1-12
A	EP 1 712 754 A (NISSAN DIESEL MOTOR CO [JP]) 18 October 2006 (2006-10-18) the whole document	1-12
A	US 5 884 475 A (HOFMANN LOTHAR [DE] ET AL) 23 March 1999 (1999-03-23) cited in the application the whole document	1-12



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

- *A* document defining the general state of the art which is not considered to be of particular relevance
- *E* earlier document but published on or after the international filing date
- *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- *O* document referring to an oral disclosure, use, exhibition or other means
- *P* document published prior to the international filing date but later than the priority date claimed

T later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

X document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

Y document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

G document member of the same patent family

Date of the actual completion of the international search

22 September 2008

Date of mailing of the international search report

01/10/2008

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Blanc, Sébastien

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2008/057524

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
EP 1669567	A	14-06-2006	WO 2005028826 A1	31-03-2005
			US 2007180816 A1	09-08-2007
US 2005207936	A1	22-09-2005	DE 102005012393 A1	13-10-2005
			JP 2005264933 A	29-09-2005
EP 1712754	A	18-10-2006	WO 2005073527 A1	11-08-2005
			US 2007035832 A1	15-02-2007
US 5884475	A	23-03-1999	AT 187226 T	15-12-1999
			CA 2199737 A1	21-03-1996
			WO 9608639 A1	21-03-1996
			EP 0839264 A1	06-05-1998
			ES 2140700 T3	01-03-2000
			JP 3022601 B2	21-03-2000
			JP 9511807 T	25-11-1997