Improved Pump Unit for an Injection Apparatus of an Internal Combustion Engine

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(54) **IMPROVED PUMP UNIT FOR AN INJECTION APPARATUS OF AN INTERNAL COMBUSTION ENGINE**

VERBESSERTE PUMPENEINHEIT FÜR EINE EINSPRITZVORRICHTUNG EINES VERBRENNUNGSMOTORS

UNITÉ DE POMPE AMÉLIORÉE POUR DISPOSITIF D'INJECTION DE MOTEUR À COMBUSTION INTERNE

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(56) References cited:
EP-A2- 0 990 792
WO-A1-02/079635
WO-A1-02/084105
WO-A2-2008/115462
US-A1- 2002 017 278

- **BOSCH ED - ISENBURG R: 'Elektronische Speichereinspritzung Common Rail', 01 January 1998, DIESEL-SPEICHEREINSPRITZSYSTEM COMMON RAIL. AUSGABE 98/99, STUTTGART : ROBERT BOSCH GMBH, DE pages FP - 50, XP002209528**

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Description

TECHNICAL FIELD

[0001] The present invention relates to a new, improved system of the Common Rail (CR) type, with particular reference to a pump of a CR type system.

BACKGROUND ART

[0002] A CR system comprises a high pressure pump, which aspirates diesel fuel from a tank by means of a low pressure pump (LP), a plurality of injectors, which inject the fuel received from the pump into respective combustion chambers, a rail mounted to the motor between the pump and the injectors, a pressure sensor for measuring the pressure in the rail and a valve for adjusting the pressure in the rail by means of the action of a control unit and of the pressure sensor.

[0003] In the past, the study for improving the performance of a CR system initially concentrated on how to make injectors. In particular, on how to make micrometric apertures and the respective electromagnetically actuated actuators.

[0004] Subsequently, studies aimed at analyzing the problems related to the propagation of undesired pressure waves along the feeding ducts between the rail and the injectors were conducted. The pressure waves are caused by the opening and closing cycles of the injectors and propagate in each feeding duct toward the rail. Perfecting studies were thus conducted to optimize the geometry of the feeding ducts to either avoid or reduce resonance phenomena caused by pressure valve interference.

[0005] The role of the rail was only recently investigated, for example in SAE paper n. 2007-01-1258, 'Common Rail without accumulator: development, theoretical-experimental analysis and performance enhancement at DI-HCCI level of a new generation FIS' by Catania, Ferrari, Mittica and Spessa. Such a preliminary study ascertained that the rail volume can be reduced to the value of 2.5 cm^3. Such a value is much lower than the normally used value of 20-40 cm^3. Such a small volume value of the rail could negatively affect the damping capacity of the rail, and it is therefore advisable to contemplate a duct geometry such as to compensate for such a shortcoming. In particular, the ducts may be made equal in pairs so that two subsequent injectors in firing order (with firing order 1, 3, 4, 2) are connected to respective pipes having a different geometry. In this manner, an at least partially destructive interference can be obtained between the pressure waves triggered by two consequently actuated injectors, so as to avoid excessive perturbations in the storage volume.

[0006] Experimental measurements have proved that a CR system with a smaller volume than the volumes normally used has operating features similar to those of a system made and operating on currently marketed vehicles.

[0007] In the publication mentioned above, it was indicated for the first time that the performance of the pressure control system in the rail is linked to the synergy between the actions of the pressure adjusting valve and of the storage volume rather than only the action of the latter. In particular, the working cycle of the adjusting valve can be modified by varying the volume of the rail while the required pressure level can still be satisfactorily controlled.

[0008] From this it was possible to take into consideration the possibility of considerably decreasing the volume of the rail without negatively affecting, rather even improving, the dynamic features of the system.

[0009] Furthermore, a system is described in the aforesaid article in which the pressure inside the storage volume is controlled by a throttling valve on the pump delivery. However, such a method has a relatively low energy efficiency.

[0010] It is worth noting that the system used to obtain the results shown in SAE paper n. 2007-01-1258 is a phototype and can be further optimised in view of standard production.

[0011] WO-A-02/084105 discloses a pump unit according to the preamble of claim 1.

DISCLOSURE OF INVENTION

[0012] It is the object of the present invention to make an injection apparatus of the CR type with high dynamic performance, low costs and which is easy to install on the engine.

[0013] Such an object is reached by a CR type system with a high pressure pump unit according to claim 1.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] The invention will now be described with reference to the accompanying drawings which illustrate non-limitative embodiments thereof, in which:

- figure 1 is a diagrammatic view of a CR system according to the present invention;
- figure 2 is a diagrammatic view of an alternative embodiment of the present invention.

BEST MODE FOR CARRYING OUT THE INVENTION

[0015] Figure 1 shows a CR system comprising a preferably electrically actuated LP pump 2 for aspirating diesel fuel from a tank 3, a constant displacement high pressure pump 4 connected to the delivery of the LP pump 2, a storage volume 5 connected to the delivery of the pump 4 and a plurality of injectors 6 connected to the storage volume 5 and controlled by a control unit, not shown in the figure.

[0016] According to the invention, the storage volume 5 is obtained in an innovative pump body 9 diagrammat-

ically shown by the rectangular box in figures 1 and 2.

[0017] The volume is smaller than 5 cm^3, and preferably is approximately 2.5 cm^3, and this allows to easily modify the previously designed and existing pump body 4.

[0018] Furthermore, the innovative pump body 9 is made so as to define four outlet ports 12 connected to the storage volume 5 in parallel to one another. In this manner, the ducts which connect the pump to the injectors are mounted directly onto the pump body 9.

[0019] In order to allow to control pressure, the system in figures 1 and 2 comprise a control device connected to the electric control unit.

[0020] According to the embodiment shown in figure 1, the control device comprises a pressure sensor 7 and a throttling valve 8, in form of a solenoid valve. The pressure sensor 7 and the throttling valve 8 are installed on the pump body 9 and are fluid-dynamically connected to the storage volume 5.

[0021] The pressure sensor 7 and the throttling valve 8 are connected to the control unit. In particular, the control unit controls the throttling valve 8 so that the latter conveys to the tank 3 all the delivery flow in excess from the pump 4 on the basis of the pressure value measured by the pressure sensor 7. Such an embodiment has considerable advantages with regards to reducing the reaction time of the engine to acceleration/deceleration controls.

[0022] On the basis of the above, the advantages that the CR system described and illustrated in figure 1 allow to obtain are apparent.

[0023] A traditional pump body may be easily modified to define both the storage volume 5 and the connections, e.g. threaded, for the pressure sensor 7 and the throttling valve 8, as well as the feeding ducts connected to the injectors.

[0024] In this manner, the system in figure 1 is more compact than a traditional system, which comprises a dedicated element, i.e. the rail, to define the storage volume 5 external to the pump and mounted on the engine. Furthermore, the implementation costs may be lower because the system has a fewer number of components. In particular, the storage volume external to the pump (rail) can be avoided, as well as the duct connecting the rail to the high pressure pump. Weights are reduced as a consequence.

[0025] The saving of weight and volume are complemented by improved dynamic operating stability. All these aspects have a substantial, positive impact in the engine sector.

[0026] It is finally apparent that changes and variations can be made to the system described and illustrated in figure 1 without departing from the scope of protection defined by the appended claims.

[0027] For example, the principle of a volume storage smaller than 5 cm^3, can be applied to a system having a pressure control device other than that described above. The system in figure 2, unlike the system in figure 1, has a flow-control valve 11, in form of a solenoid valve, arranged upstream of the intake of pump 4. The flow-control valve 11 is connected to the control unit and adjusts according to the pressure valve measured by the pressure sensor 7. In this manner, the flow diverted towards the tank 3 has a relatively low pressure and energy is saved.

[0028] It is observed that traditional CR systems equipped with flow-control valve of the type 11 in figure 2 have a higher dynamic response with higher characteristic times than those of the system with throttling valve on rail. However, the use of a storage volume with dimensions smaller than 5 cm^3, allows to considerably reduce the hydraulic inertia, and therefore it is particular indicated for improving the performance of the CR system with control valve of the flow at inlet of the pump 4, in particular for reducing the dynamic response time of the system itself.

[0029] According to a further aspect of the present invention, it has been experimentally verified that the storage volume may also be smaller than, or equal to 2 cm^3.

[0030] Furthermore, according to a preferred embodiment, the pump 4 comprises a single stage which comprises in turn a pumping element, e.g. a cam, for moving a radial piston.

Claims

1. A high pressure pump unit for an injection apparatus of the CR type of an internal combustion engine, comprising at least one pump body (9) housing at least one pumping element adapted to be rotatably fed to send pressurized fuel to a delivery port, said pump body (9) defining a storage volume (5) connected in a fixed, undetachable manner to said delivery port, the pump unit comprising a pressure sensor (7) and a solenoid valve (8, 11) fluid-dynamically connected to said storage volume (5) for adjusting the delivery pressure by means of said pressure sensor (7) in that a control unit of said pump is connected to said solenoid valve (8, 11) and pressure sensor (7) to control said solenoid valve (8, 11) so as to react to acceleration/deceleration controls to said engine, the pump unit **characterized in that** the storage volume (5) is smaller than 5 cm^3.

2. A pump unit according to claim 1, **characterized in that** the solenoid valve (8, 11) is connected to discharge into a fuel tank (3).

3. A pump unit according to any one of the preceding claims, **characterized in that** it comprises a single compression stage comprising the pumping element.

4. A pump unit according to any one of the preceding claims, **characterized in that** said storage volume

is equal or smaller than 2 cm^3.

5. A pump unit according to any one of the preceding claims, **characterized in that** the solenoid valve (8) is a throttling valve for controlling pressure.

6. A pump unit according to any one of the claims from 1 to 4, **characterized in that** the solenoid valve (11) is a flow-control valve.

7. A pump unit according to claim 6, **characterized in that** the solenoid valve (11) is arranged upstream of said pumping element.

8. A pump unit according to any one of the preceding claims, **characterized in that** said pumping unit (9) defines a plurality of outlet ports (12) connected to said storage volume (5) and adapted to be fluid-dynamically connected to a plurality of injectors of said injection apparatus.

9. An injection apparatus for a diesel engine comprising a LP pump, a high pressure pump unit according to any one of the preceding claims connected to the delivery of said low pressure pump, a plurality of ducts connected to the delivery of said high pressure pump unit and to a plurality of injectors, said injection system being **characterized in that** it does not comprise a dedicated component or rail to be mounted to the engine for defining a storage volume.

Patentansprüche

1. Eine Hochdruckpumpeneinheit für eine Einspritzvorrichtung des CR(Common Rail)-Typs eines Verbrennungsmotors aufweisend wenigstens einen Pumpenkörper (9), der wenigstens ein Pumpenelement (9) aufnimmt, das angepasst ist, sich zu drehen, um unter Druck stehenden Brennstoff zu einem Auslassanschluss zu senden, wobei der Pumpenkörper (9) ein Speichervolumen (5) definiert, das in einer festen, nicht abnehmbaren Weise mit dem Auslassanschluss verbunden ist, aufweisend einen Drucksensor (7) und ein Magnetventil (8, 11), das fluid-dynamisch mit dem Speichervolumen (5) zum Einstellen des Förderdrucks mittels des Drucksensors (7) verbunden ist, indem eine Steuereinheit der Pumpe mit dem Magnetventil (8, 11) und dem Drucksensor (7) verbunden ist, um das Magnetventil (8, 11) zu steuern, um auf die Beschleunigungs/Verzögerungs-Steuerungen des Motors zu reagieren, **dadurch gekennzeichnet, dass** das Speichervolumen (5) kleiner als 5 cm^3 ist.

2. Eine Pumpeneinheit nach Anspruch 1, **dadurch gekennzeichnet, dass** das Magnetventil (8, 11) mit dem Auslass in den Kraftstofftank (3) verbunden ist.

3. Eine Pumpeneinheit nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** diese eine einzige Kompressionsstufe mit einem Pumpenelement aufweist.

4. Eine Pumpeneinheit nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** das Speichervolumen gleich oder kleiner als 2 cm^2 ist.

5. Eine Pumpeneinheit nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** das Magnetventil (8) ein Drosselventil zur Steuerung des Drucks ist.

6. Eine Pumpeneinheit nach einem der Ansprüche 1 bis 4, **dadurch gekennzeichnet, dass** das Magnetventil (11) ein Stromregelventil ist.

7. Eine Pumpeneinheit nach Anspruch 6, **dadurch gekennzeichnet, dass** das Magnetventil (11) stromauf des Pumpenelements angeordnet ist.

8. Eine Pumpeneinheit nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die Pumpeneinheit (9) eine Mehrzahl von Auslassanschlüssen (12) definiert, die mit dem Speichervolumen (5) verbunden sind und angepasst sind, fluid-dynamisch mit einer Mehrzahl von Injektoren der Einspritzvorrichtung verbunden zu sein.

9. Eine Pumpeneinheit für einen Dieselmotor mit einer LP(Niedrig Druck)-Pumpe, einer Hochdruckpumpeneinheit nach einem der vorhergehenden Ansprüche, die mit dem Auslass der LP-Pumpe verbunden ist, einer Mehrzahl von Leitungen, die mit dem Auslass der Hochdruckpumpeneinheit und einer Mehrzahl von Injektoren verbunden sind, wobei das Einspritzsystem **dadurch gekennzeichnet ist, dass** dieses nicht eine bestimmte Komponente oder Rail aufweist, die zur Bildung eines Speichervolumens an dem Motor zu befestigen ist.

Revendications

1. Unité de pompe à haute pression pour un appareil d'injection du type à rampe commune d'un moteur à combustion interne, comprenant au moins un corps de pompe (9) accueillant au moins un élément de pompage adapté à être introduit de manière rotative pour envoyer un carburant sous pression vers un orifice de refoulement, ledit corps de pompe (9) définissant un volume de stockage (5) raccordé de manière fixe et non amovible audit orifice de refoulement, l'unité de pompe comprenant un capteur de pression (7) et une électrovanne (8, 11) en communication fluidique dynamique avec ledit volume de

stockage (5) pour régler la pression de refoulement au moyen dudit capteur de pression (7) en ce qu'une unité de commande de ladite pompe est raccordée à ladite électrovanne (8, 11) et audit capteur de pression (7) pour commander ladite électrovanne (8, 11) de manière à réagir à des commandes d'accélération/décélération envoyées audit moteur, l'unité de pompe **caractérisée en ce que** le volume de stockage (5) est inférieur à 5 cm^3.

2. Unité de pompe selon la revendication 1, **caractérisée en ce que** l'électrovanne (8, 11) est raccordée pour décharger dans un réservoir de carburant (3) .

3. Unité de pompe selon l'une quelconque des revendications précédentes, **caractérisée en ce qu'**elle comprend un étage de compression unique comprenant l'élément de pompage.

4. Unité de pompe selon l'une quelconque des revendications précédentes, **caractérisée en ce que** ledit volume de stockage est égal ou inférieur à 2 cm^3.

5. Unité de pompe selon l'une quelconque des revendications précédentes, **caractérisée en ce que** l'électrovanne (8) est une vanne d'étranglement pour réguler la pression.

6. Unité de pompe selon l'une quelconque des revendications 1 à 4, **caractérisée en ce que** l'électrovanne (11) est une vanne de régulation du débit.

7. Unité de pompe selon la revendication 6, **caractérisée en ce que** l'électrovanne (11) est agencée en amont dudit élément de pompage.

8. Unité de pompe selon l'une quelconque des revendications précédentes, **caractérisée en ce que** ladite unité de pompe (9) définit une pluralité d'orifices de sortie (12) raccordés audit volume de stockage (5) et adaptés à être en communication fluidique dynamique avec une pluralité d'injecteurs dudit appareil d'injection.

9. Appareil d'injection pour un moteur diesel comprenant une pompe à basse pression, une unité de pompe à haute pression selon l'une quelconque des revendications précédentes raccordée au refoulement de ladite pompe à basse pression, une pluralité de conduites raccordées au refoulement de ladite unité de pompe à haute pression et à une pluralité d'injecteurs, ledit système d'injection étant **caractérisé en ce qu'**il ne comprend pas d'élément ou de rampe dédié(e) devant être monté (e) sur le moteur pour définir un volume de stockage.

FIG. 1

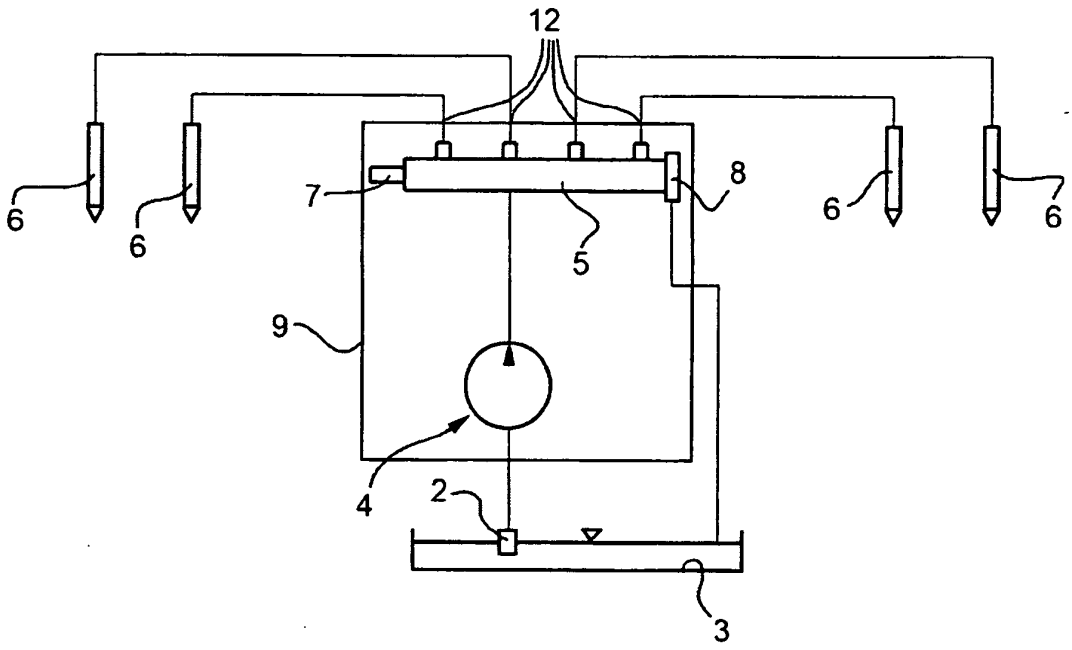
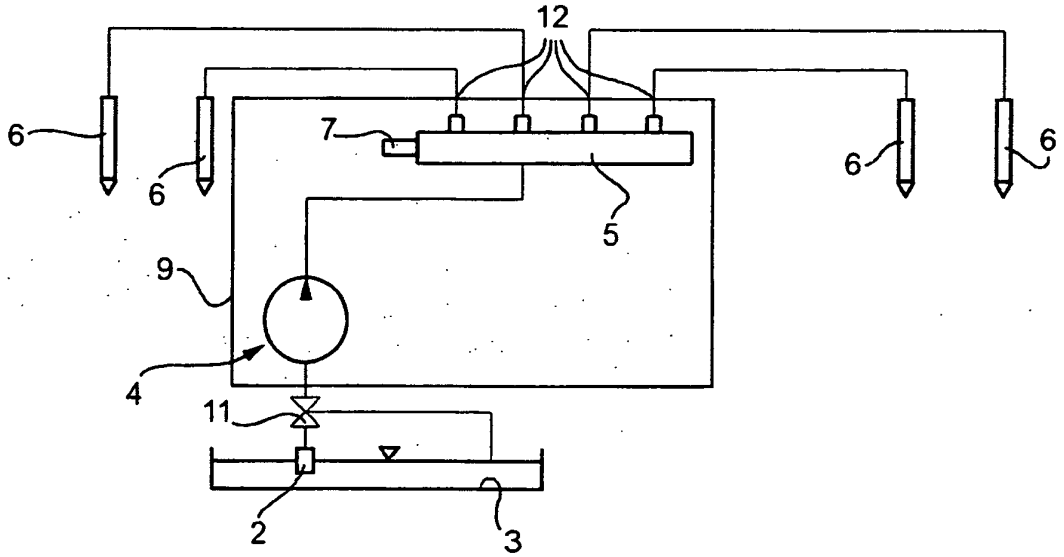


FIG. 2



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 02084105 A **[0011]**