The invention relates to a metering device for dosing pressurized fluids, comprising a housing (12) having an end part provided with an outlet passage (20) terminating with a metering opening (22), an axially moveable valve needle passing through the outlet passage (20) and controlling opening and closing of the metering opening (22), a piezoelectric actuator assembly (30) in axial alignment with the valve needle and cooperating with the valve needle to control its axial movement, means for transmitting an axial extension of the piezoelectric actuator assembly (30) to the valve needle to displace the needle from the closing position when activated, and spring means for urging the valve needle in the closing position. An adjustment element (40) is arranged at the end part of the housing (12) opposite to the end part provided with the outlet passage (20), applying an adjustable pressure force on the piezoelectric actuator assembly (30), the valve needle and the spring means, thereby setting a flow rate for the metering device.
Description

[0001] The present invention relates to a metering device for dosing pressurized fluids, particularly an injection valve for a fuel injection system in an internal combustion engine. The metering device is of the type which comprises a housing having an end part provided with an outlet passage terminating with a metering opening, an axially moveable valve needle passing through the outlet passage, a piezoelectric actuator assembly in axial alignment with the valve needle and cooperating with the valve needle to control its axial movement, means for transmitting an axial extension of the piezoelectric actuator assembly to the valve needle to displace the needle from the closing position when activated, and spring means for urging the valve needle in the closing position. The invention further relates to a method for setting a flow rate of such a metering device.

[0002] An injection valve of this type is disclosed, for example, in the European Patent application EP 1 046 809 A2. It is essential that the flow rate delivered by the injector can be set to a defined value at the end of the assembly process in the factory. Presently, the calibration of such an injector is carried out with the injector assembled but not finally welded. In this state, the injector to be calibrated is introduced in an appropriate blocking tool. The regulation of the flow rate through the injector is carried out by inserting special washer rings with several heights between the spring means and the valve body to modify the spring stiffness and the needle stretch until a desired flow rate is reached. After the calibration process is completed, the injector proceeds to the final welding of the inlet fitting on the housing. Such an iterative operational sequence is time consuming and expensive and may not be adapted to the mass production in a factory. Further, as the washer rings have to be changed repeatedly, it is not possible to calibrate the injector during a flow phase of the fluid.

[0003] In view of the foregoing, it is an object of the present invention to improve the calibration process for a metering device of the above mentioned type.

[0004] This object is achieved by a metering device with the features of appended claim 1, and by the method of independent claim 6. Advantageous embodiments of the invention are disclosed in the dependent claims.

[0005] According to the invention, in a metering device of the type mentioned above, an adjustment element is arranged at the end part of the housing opposite to the end part provided with the outlet passage, the adjustment element applying an adjustable pressure force on the piezoelectric actuator assembly, the valve needle and the spring means, thereby setting a flow rate for the metering device.

[0006] The invention is thus based on the idea to set the flow rate by applying an adjustable pressure on the series of elements formed by the piezoelectric actuator assembly and the valve needle with its associated spring means. This allows the flow rate to be calibrated after the completed assembly of the injector in a simple and straightforward manner.

[0007] In a preferred embodiment of the invention, the adjustment element is formed by a threaded element and the pressure force exerted on the piezoelectric actuator assembly, the valve needle and the spring means is increased by tightening the threaded element in its seat and is decreased by slackening the threaded element in its seat. The flow rate may thus be set by simply turning an axial force transmitting screw, thereby increasing or decreasing the pressure on the above mentioned group of components.

[0008] Advantageously, a thermal compensator unit is arranged between the adjustment element and the piezoelectric actuator assembly in axial direction such that the adjustment element applies the adjustable pressure force on the chain formed by the thermal compensator unit, the piezoelectric actuator assembly and the valve needle with its associated spring means. This allows to incorporate the thermal compensator unit while maintaining the advantages of the invention mentioned above.

[0009] According to the invention it is preferred that the adjustment element is provided in axial alignment with the valve needle and the piezoelectric actuator assembly. Such an arrangement facilitates the transmission of the axial force.

[0010] In a further preferred embodiment of the invention, a fluid inlet for supplying the fluid under pressure is arranged off-centered at the end part of the housing provided with the adjustment element.

[0011] According to the invention, in a method for setting a flow rate of any of the metering devices described above, the flow rate through the metering device is repeatedly measured and the pressure force applied by the adjustment element is increased or decreased by tightening or slackening the adjustment element in its seat until a predetermined flow rate through the metering device is achieved.

[0012] The advantages gained by the technical features of the invention include

- an easy method for setting the desired flow rate;
- no necessity to take apart the assembled parts for the calibration process;
- the possibility to calibrate the flow rate after the completed assembly of the injector; and
- the possibility to adapt the method in a mass production process for metering devices.

[0013] The invention, both its construction as its method of operation together with additional objects and advantages thereof, will best be understood from the following description of specific embodiments when read in connection with the accompanying drawings, wherein
Figure 1 is a schematic axial cross section of the top part of an injector valve according to an embodiment of the invention; and

Figure 2 is a schematic axial cross section of the injector valve of Fig. 1 in its fully assembled state.

[0014] Figures 1 and 2 show an injection valve for direct-injection gasoline engines, generally designated by 10. The injection valve has a double tube design in which the housing 12 comprises an outer tubular member 121 and an inner tubular member 123, forming an annular fluid supply passage 14 between them. An inlet fitting 16 is provided off-centered on the support flange 44.

[0015] From the inlet fitting 16 and the annular fluid supply passage 14 the gasoline enters an axial outlet passage 20. The outlet passage 20 projects through the lower part of the housing 12 and terminates in a metering opening 22. The metering opening 22 is surrounded by a valve seat which is opened or closed by the axial movement of the valve needle passing through the outlet passage 20.

[0016] The closed state of the injection valve 10, where a mushroom-shaped plunger of the valve needle is pressed against the valve seat is provided by the biased pressure of a helical spring.

[0017] Gasoline is injected into the engine cylinder by activating a piezoelectric actuator assembly 36. Applying an excitation voltage to the piezoelectric actuator increases its length in axial direction by a predetermined amount, for example 20 µm. This extension in length is transmitted to the valve needle which depresses the biasing spring and lifts from the valve seat to begin the injection of pressurized gasoline into the cylinder. When the excitation voltage is switched off, the length of the piezoelectric actuator in axial direction decreases to its normal value and the biasing pressure of the helical spring forces the valve needle and the plunger back to its closing position on the valve seat.

[0018] A thermal compensator 38 is provided to fix the position of the piezoelectric actuator assembly 36 during fast changes of its length, but compensates for slow changes in the position of the piezoelectric actuator assembly 36 due to, for example, thermal changes.

[0019] The flow rate of the injector is set by adjusting the threaded element 40. The threaded element 40 is used to adjust the load applied to the following components in series: the thermal compensator 38, the piezoelectric actuator assembly 36, the needle of the injector and the spring.

[0020] Whereas the thermal compensator 38 and the piezoelectric actuator assembly 36 are free to move axially inside the housing 12, the valve needle is counter-balanced by the force of the spring. Upon progressive tightening of the threaded element 40 in its seat 42 the valve needle experiences a mechanical relaxation be-

cause of the increasing Hertzian load transmitted by the chain of components consisting of the threaded element 40, the thermal compensator 38, and the piezoelectric actuator assembly 36. The increasing load is counter-balanced by the helical spring.

[0021] On the other hand, upon progressive slackening of the threaded element 40 in its seat 42 the valve needle experiences a mechanical tensile stretching, because the force of the spring is decreasingly counter-balanced by the chain of Hertzian contacts between the threaded element 40, the thermal compensator 38, the piezoelectric actuator assembly 36, and the valve needle.

[0022] It will be appreciated that the closure force of the plunger of the valve needle against its sealing seat is a fundamental parameter in the adjustment process.

[0023] The features disclosed in the foregoing description, in the drawings, and in the claims may alone as well as in any possible combination be important for the realization of the invention.

Claims

1. A metering device for dosing pressurized fluids, particularly an injection valve for a fuel injection system in an internal combustion engine, comprising

   - a housing (12) having an end part provided with an outlet passage (20) terminating with a metering opening (22),

   - an axially moveable valve needle passing through the outlet passage (20), and controlling opening and closing of the metering opening (22),

   - a piezoelectric actuator assembly (36) in axial alignment with the valve needle and cooperating with the valve needle to control its axial movement,

   - means for transmitting an axial extension of the piezoelectric actuator assembly (36) to the valve needle to displace the needle from the closing position when activated, and

   - spring means for urging the valve needle in the closing position

characterized in that

an adjustment element (40) is arranged at the end part of the housing (12) opposite to the end part provided with the outlet passage (20), the adjustment element (40) applying an adjustable pressure force on the piezoelectric actuator assembly (36), the valve needle and the spring means, thereby setting a flow rate for the metering device.
2. The metering device according to claim 1, characterized in that
the adjustment element is formed by a threaded element (40), wherein the pressure force exerted on the piezoelectric actuator assembly (36), the valve needle and the spring means is increased by tightening the threaded element (40) in its seat (42) and is decreased by slackening the threaded element (40) in its seat (42).

3. The metering device according to claim 1 or 2, characterized in that
a thermal compensator unit (38) is arranged between the adjustment element (40) and the piezoelectric actuator assembly (36) in axial direction such that the adjustment element (40) applies the adjustable pressure force on the chain formed by the thermal compensator unit (38), the piezoelectric actuator assembly (36) and the valve needle with its associated spring means.

4. The metering device according to any of the preceding claims, characterized in that
the adjustment element (40) is provided in axial alignment with the valve needle and the piezoelectric actuator assembly (36).

5. The metering device according to any of the preceding claims, characterized in that
a fluid inlet (16) for supplying the fluid under pressure is arranged off-centered at the end part of the housing (12) provided with the adjustment element (40).

6. A method for setting a flow rate of a metering device according to any of claims 1 to 5, wherein the flow rate through the metering device is repeatedly measured and the pressure force applied by the adjustment element (40) is increased or decreased by tightening or slackening the adjustment element (40) in its seat (42) until a predetermined flow rate through the metering device is achieved.
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The present search report has been drawn up for all claims.

**Place of search** THE HAGUE

**Date of completion of the search** 13 January 2003

**Examiner** Sideris, M

**CATEGORY OF CITED DOCUMENTS**

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