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(54) Fuel injector with a damping element and method for manufacturing a fuel injector

(57) The proposed fuel injector comprises a fuel passage way in which a harmonic damper 25 is arranged. The harmonic damper dampens the noise and vibration of the fuel injector. The harmonic damper is fixed to the inlet tube of the fuel injector. The harmonic damper has a cylindrical shape with a central bore. An outer face of the harmonic damper is adjacent to an inner face of the inlet tube. The harmonic damper may be made of plastics or metal.

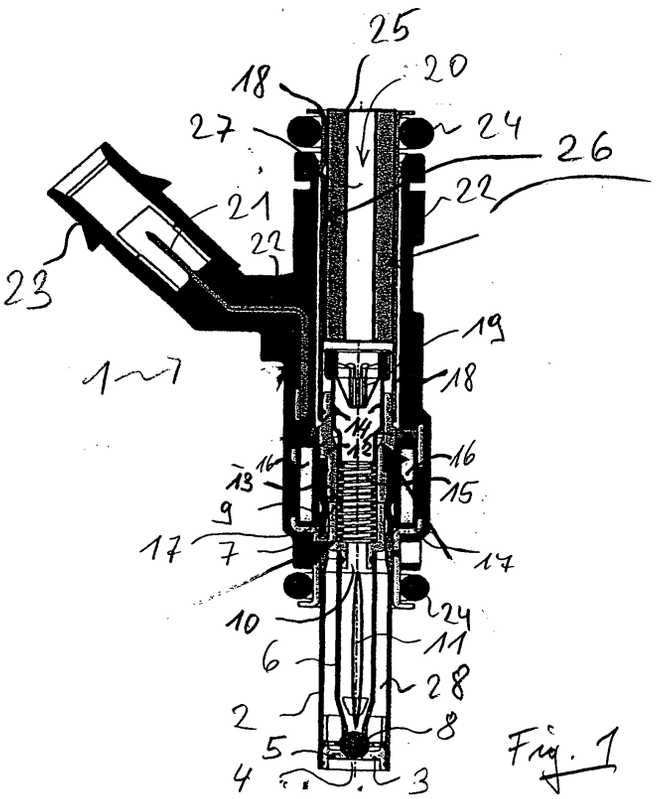

Fig. 1

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Description

Field of the invention

[0001] The invention relates to fuel injectors and more particularly to methods for dampening noise and vibration created by fuel injectors.

Background of the invention

[0002] Electromagnetic fuel injectors are common in modern internal combustion engines. The fuel injectors deliver fuel to the engine in metered pulses which are appropriately timed to the engine operation. To produce the metered pulses of fuel, electromagnetic fuel injectors typically include a metallic valve member that is actuated by an electromagnetic coil to open and close the fuel valve. When the valve member is actuated to open the fuel valve, the top portion of the valve member, or armature, reaches its upper limit of travel and strikes a metallic support tube. The metal-to-metal contact sends an impulse through the injector that is radiated from the exterior surface of the injector as noise and vibration. Furthermore the vibration of the injector gives also pulses to the fuel that are passed through the fuel injector. This causes pressure waves in the fuel that have an influence on the opening function of the valve and on the mass of fuel that is injected by the fuel injector.

[0003] When the valve member closes the fuel valve, the bottom portion, or valve ball, reaches its lower limit of travel and strikes a metallic valve seat. Again the metal-to-metal contact sends an impulse through the injector that is radiated from the exterior surface of the injector as noise and vibration. Also this metal-to-metal contact generates pressure waves in the fuel within the fuel injector. The pressure waves are guided by fuel lines to other fuel injectors or to a common rail generating pressure waves within the common rail. Also these pressure waves are disadvantageous for a precise injection.

[0004] US Patent No. 5,967,419 describes an injector with improved noise reduction. A valve sound emitted from an operated injector is suppressed to be transmitted through a fuel passage in a core to a delivery pipe, thus reducing operating noise. A sound insulating member is fixed within the fuel passage in the core of the fuel injector. It has been recognized that transmission of sound is effectively suppressed even with a sound insulating member of such a size that does not prohibit fuel flow. Preferably, the sound insulating member is integrally assembled to a strainer. A cylindrical strainer is provided with a bottom including a synthetic resin cover with an opening groove on its cylindrical portion and a net member and a stopper each being insert molded into a cover. The strainer is fixed into a core of the injector by press fitting the stopper into the core. The fuel flows from the inside of the strainer through the net member and the opening groove of the cover and into a fuel passage of the core. The bottom surface of the cover is formed into a sound insulator. The sound insulator has a cylindrical shape and extends coaxially with the core. The sound insulator is positioned at the axial center of the fuel passage. Therefore, an actual flow path corresponds to an annular hollow space formed between the sound insulator and the core. The sound insulator is tapered so as to gradually reduce the diameter toward the front end thereof.

[0005] The US Patent No. 6,382,532 describes an overmold constrained layer damper for a fuel injector. The fuel injector assembly includes a body portion, a valve seat fixed relative to the body portion, a valve member movable relative to the valve seat, an outer layer substantially surrounding the body portion, and a damping material between the body portion and the outer layer, the damping material cooperating with the outer layer to dampen noise and vibration produced during operation of the fuel injector. Preferably, the fuel injector also includes an electrical connector mounted on the body portion, and the damping material is adjacent to the electrical connector. In the preferred embodiment, the damping material is made of viscoelastic material.

Summary of the invention

[0006] Accordingly, an object of the present invention is to provide an injector in which operating noise is reduced. Another object of the invention is to suppress the sound of colliding metal of a valve being transmitted through a fuel passage to a delivery pipe.

[0007] In the present invention, in order to attain the objects, a damping element is provided in the fuel passage between the valve and an inlet of the fuel passage. The damping element is provided as a separate element that is fixed with a tube that is part of the fuel passage of the injector. The damping element has the shape of a hollow cylinder with a central bore. The outer face of the cylinder is adjacent to an inner surface of the fuel tube and the central bore of the cylinder is part of the fuel passage. This arrangement shows the advantage that the operating noise of the injector is reduced and also pressure waves are reduced. The provided solution has the advantage that it is cheap to produce and easily mounted.

[0008] Further advantageous embodiments of the invention are disclosed in the dependent claims and in the drawings.

[0009] In a preferred embodiment of the invention the damping element is arranged at the inlet of the fuel injector. In this embodiment, a filter element is provided between the damping element and the valve of the injector. This embodiment has the advantage that the flow of the fuel between the filter and the valve is not influenced by the damping element.

[0010] In a further preferred embodiment of the invention, the fuel injector comprises an armature, a coil assembly and an abutment against which the armature stops when the coil is energized. The abutment is real-

ized in the shape of a sleeve that is fixed to a housing of the injector. Within the sleeve abutment, a filter sleeve is arranged. Between the filter sleeve and the armature there a spring is provided that stresses the armature with a needle assembly against the valve seat. Using a filter sleeve that is arranged within an abutment sleeve provides a short fuel injector. Therefore a damping element can be provided as a relatively long part.

[0011] In a preferred embodiment of the invention the cylinder of the damping element has a flat inwardly protruding end.

[0012] In another preferred embodiment of the invention the cylinder of the damping element has a conical inwardly protruding end.

[0013] In a further preferred embodiment of the invention the damping element is made of an elastic material.

[0014] In a further preferred embodiment of the invention the damping element is made of a metallic material. Using metal as a material for the damping element has the advantage that the damping element has a relatively great mass that generates a great damping effect.

[0015] A cheap embodiment of the invention is realized with a damping element made of plastics. Using plastic has the advantage that it is very cheap to produce and could also be used for a damping function especially for damping pressure waves within the fuel passage.

[0016] In a preferred manufacturing method, the damping element is pressed in a fuel tube adjacent to an inner face of the fuel tube. This method has the advantage that it is not necessary to design the shape of a fuel passage of the fuel injector for a given damping element but the damping element is designed for introducing and fixing within the fuel passage of the injector. A press fit connection between the damping element and the fuel tube provides a secure connection.

Brief description of the drawings

[0017]

Fig. 1 is a longitudinal sectional view of an injector according to an embodiment of the present invention.

Fig. 2 is a perspective view of the damping element.

Fig. 3 is a longitudinal sectional view of the damping element.

Fig. 4 is a further embodiment of the injector.

Detailed description of the preferred embodiment

[0018] A preferred embodiment of a fuel injector according to the present invention will now be described with reference to the drawings. Fig. 1 is a longitudinal view of an fuel injector 1 used in a vehicle engine. The fuel injector is basicly symmetrical to a central axis of symmetry.

[0019] Before one embodiment of the inventions is explained in detail, it is to be understood that the invention is not limited in this application to the details of construction and the arrangements of the components set forth in the following description or illustrated in the drawings. The invention is capable of other embodiments and of being practiced or being carried out in various ways.

[0020] The fuel injector 1 includes a valve body 2. Inside the jacket 2 is an orifice plate 3 adjacent to a lower end of the jacket 2. The orifice plate 3 includes an orifice that is coaxial with an orifice in the lower end of the jacket 2. The orifice in the orifice plate 3 and the orifice in the lower end of the jacket 2 provide fluid communication between the fuel injector 1 and a combustion chamber of a motor engine. Adjacent to the orifice plate 3 a metallic valve seat 5 is provided, the purpose of which will be described below.

[0021] The metal jacket 2 also houses a needle assembly. The needle assembly comprises an armature 7 that is connected by a valve member 6 with a ball member 8. The ball member 8 is a closing member that is dedicated to the valve seat 5. The armature 7 is movably guided in the valve body 2 in a longitudinal axis of the fuel injector 1. Depending on the position of the armature 7, the ball member 8 is pressed against the valve seat 5 closing the orifice 4 preventing a fuel injection.

[0022] The armature 7 is shaped as a sleeve with an upper end ring face 9 and a central bore 10. Holes 11 are arranged on the face of the hollow cylindrical valve member 6. Therefore a fluid communication between the bore 10 of the armature 7 and the interior space of the jacket 2 is possible. The ball member 8 is mounted on the lower end of the armature 7 in any suitable manner to form a valve member that is movable relative to the jacket 2. Typically, the armature 7 and the ball member 8 are both metallic and the ball member 8 is welded on the armature 7. The ball member 8 is appropriately sized to be received in the valve seat 5. Together, the valve member 6 and the valve seat 5 operate as a fuel valve that selectively opens and closes the injector 1.

[0023] The jacket 2 houses a support tube 12. The support tube 12 is typically made from metal and includes a lower end ring face 13. The end ring face 13 is adjacent to the upper end ring face 9 of the armature 7. The support tube 12 also includes a bore that houses at least a portion of an adjustment sleeve 14 and at least a portion of a spring 15. The spring 15 is constrained between the lower end of the adjustment sleeve 14 and a seat inside the armature bore 10. The adjustment sleeve 14 is adjustably fixed relative to the jacket 2 and biases the spring 15 against the seat in the armature bore 10, thereby biasing the valve member 6 into a first position, wherein the ball member 8 rests in the metal valve seat 5 and blocks fluid communication between the fuel injector 1 and the combustion chamber. While in the first position, the upper end ring face.9 of the armature 7 is spaced from the lower end ring face 13 of the support tube 12 creating a gap of approximately 17 microns between the armature 7 and the support tube 12.

[0024] The injector 1 further includes an electromagnetic coil assembly 16 that encircles a portion of the jacket 2 and is housed inside a metallic housing 17. The electromagnetic coil assembly 16 can be selectively charged to create a magnetic field that attracts the valve member 6 towards the lower end ring face 13 of the support tube 12 into a second position. The biasing force of the spring 15 is overcome such that the ball member 8 is raised from the valve seat 5, allowing fuel to flow through the orifice of the orifice plate 3 into the combustion chamber. While in the second position, the upper end ring face 9 of the armature 7 contacts the lower end ring face 13 of the support tube 12. The valve member 6 remains in the second position until the charge is removed from the electromagnetic coil assembly 16 at which point the spring 15 biases the valve member 6 back into the first position.

[0025] The injector 1 further includes an inlet tube 18 that is press fit and welded into the upper end of the support tube 12. The inlet tube 18 is preferably metallic and has an outer surface. The inlet tube 18 has an inner surface 26, at which a harmonic damper 25 is adjacent. The harmonic damper 25 functions as a harmonic damper. The harmonic damper 25 has a cylindrical shape with a central bore and the outer surface of the harmonic damper 25 is arranged at the inner surface 26 of the inlet tube 18. The central bore 27 of the damping element is a part of the fuel passage over which the fuel is delivered from a fuel tank to the valve of the fuel injector 1. The harmonic damper 25 is fixed to the inlet tube 18. An easy fixing is attained by a press fit connection between the harmonic damper 25, and the inlet tube 18. Depending on the material of the harmonic damper 25 also other means for fixing the harmonic damper 25 to the inlet tube 18 could be used. If the harmonic damper 25 is made of plastics, the harmonic damper 25 could also be glued to the inlet tube 18.

[0026] The lower end of the harmonic damper 25 is arranged at a given distance from an upper end of the support tube 12. The inlet tube 18 encircles an upper part of the support tube 12 and is fixed with the support tube 12. The adjustment sleeve 14 is screwed into the support tube 12. Depending on the position of the adjustment sleeve 14 the spring 15 is more or less biased against the armature 7. At an upper;end of the adjustment sleeve 14 a fuel filter 19 is arranged. The upper end of the adjustment sleeve 14 is arranged between the support tube 12 and the harmonic damper 25. A fuel passage way 20 leads through the central bore 27, the fuel filter 19, the bore of the adjustment sleeve 14, the bore of the support tube 12, the bore of the armature 7, the bore of the valve member 6 and the holes 11 of the valve member 6 to an injection chamber 28 that is arranged between the metal jacket 2 and the valve member 6.

[0027] The electromagnetic coil assembly 16 is selectively charged via an external power lead that applies electricity to the electromagnetic coil assembly 16. The power lead is connected to the coil assembly 16 via an connector terminal 21 that is mounted on an outer surface of the inlet tube 18 via a clip portion. The connector terminal 21 is electrically connected, via soldering or any other suitable method, to terminals of the coil assembly 16.

[0028] The fuel injector 1 also includes a second housing 22 that surrounds portions with the inlet tube 18, clip connector 21, metallic housing 17 and jacket 2. The second housing 22 is preferably plastic and is preferably molded over the injector 1.

[0029] The repeated movement of the valve member 6 between the first and the second positions create significant vibrations or impulses in the fuel that are emitted from the fuel injector 1 as audible noise. Every time the valve member 6 moves from the first position to the second position, the upper end ring face 9 of the armature 7 contacts the lower end ring face 13 of the support tube 12. This metal-to-metal contact creates noise and vibration impulses that travel through the valve body 2, metallic housing 17 and the inlet tube 18. Additionally, when the valve member 6 moves from the second position to the first position, the ball member 8 contacts the metal valve seat 5. This metal-to-metal contact also creates noise and vibration impulses that travel through the jacket, the first housing 17 and the inlet tube 18.

[0030] To elevate the noise and vibration emitted from the fuel injector 1 during operation, the harmonic damper 25 is used'. In a first embodiment of the harmonic damper 25, the harmonic damper 25 is made of metal. This has the advantage that the harmonic damper 25 has a great mass that prevents the inlet tube 18 from vibrating. The resonance frequency of the metallic harmonic damper 25 is different from the resonance frequency of the inlet tube 18, that causes a damping of the vibrations of the inlet tube 18.

[0031] In a further preferred embodiment of the invention, the harmonic damper 25 is made of plastics. The embodiment of the harmonic damper 25 in plastics has the advantage that the harmonic damper 25 is cheap and can easily be produced. Furthermore the resonance frequency of a plastic harmonic damper 25 is also different from the resonance frequency of the inlet tube 18.

[0032] Furthermore pressure waves in the fuel are transmitted to the harmonic damper 25 and guided within the plastic material. The plastic harmonic damper 25 is caused to vibrate and sends out pressure waves itself that dampen the pressure waves in the fuel that are caused by the metal-to-metal contact of the valve of the fuel injector. Depending on the elasticity of the plastic material different dampening behaviors are achieved. Therefore it might be of advantage to use a plastic material to produce the harmonic damper 25.

[0033] For attaining the dampening effect it is not necessary that the harmonic damper 25 is fixed on the entire outer face with the inner face 26 of the inlet tube 18. Depending on the shape of the fuel injector 1 it might be of advantage that the dampening tube 25 is fixed with a

ring face at the upper end of the inlet tube 18. But also in this embodiment there should only be a small distance between the outer face of the harmonic damper 25 and the inner face of the inlet tube 18. Also in this embodiment, the fuel flows only through the central bore 27 of the harmonic damper 25.

[0034] The embodiment of Fig. 1 has the advantage that the fuel filter 19 is not directly connected with the inlet tube 18, but connected to the support tube 12. Furthermore the filter 19 is arranged above the support tube 12 and retained within the adjustment sleeve 14. This construction also dampens the noise of the fuel injector. Furthermore the fuel filter 19 can easily be mounted in the fuel injector 1. Furthermore, it is possible in this construction to arrange the harmonic damper 25 at the inlet of the inlet tube 18. This shows a positive effect for the dampening function. Furthermore the harmonic damper 25 can easily be mounted in the inlet tube 18.

[0035] Fig. 2 shows a perspective view of the harmonic damper 25. In this view the cylindrical shape of the harmonic damper 25 with the central bore 27 is explicitly shown. At the upper end of the harmonic damper 25 a ring face 29 is depicted with which the harmonic damper 25 is connected to the inlet tube 18 in a preferred embodiment.

[0036] Fig. 3 shows a sectional view of the harmonic damper 25 of Fig. 2. In this picture a conical inlet face 30 at the upper end of the harmonic damper 25 is shown. The conical inlet face 30 is shaped in such a way that pressure waves that are generated by the fuel injector 1 are dampened at the harmonic damper 25. A simple shape of the harmonic damper 25 is shown in Fig. 1 with a plane end face at the inlet of the cylindrical central bore 27.

[0037] Fig. 4 shows a part of a fuel injector 1 with an inlet tube 18 that is fixed by the ring face 29 at the inlet with the harmonic damper 25. As it is shown in Fig. 4, there is only a little distance between the harmonic damper 25 and the inlet tube 18. This distance creates a ring chamber 31 between the inlet tube 18 and the harmonic damper 25.The ring chamber 31 shows an advantageous effect for dampening the noise that is generated by the fuel injector 1.

[0038] The invention was explained by an example using a fuel injector with an electromagnetic actuator. However, the invention can also be used for fuel injectors with a piezo-electric actuator.

Claims

1. Fuel injector (1) comprising:

a housing (14) with a valve seat (5);
a valve member (8) movable relative to the valve seat (5);
a fuel passageway (20) in the housing that delivers fuel from an inlet over the valve seat (5) to an outlet;
a damping element (25) that is arranged in the passageway (20) and fixed to the housing, the damping element (25) cooperating with the housing (18) to dampen noise and vibration produced during operation of the fuel injector,

wherein the damping element (25) is a separate element that is fixed to a fuel tube (18) that is part of the fuel passageway (20),
wherein the damping element (25) has the shape of a cylinder with a central bore (27),
wherein an outer face of the damping element (25) is adjacent to an inner surface of a fuel tube (18) and that the central bore (27) is a part of the fuel passageway (20).

2. Fuel injector according to claim 1, wherein the damping element has a flat inwardly protruding end.

3. Fuel injector according to any claim 1, wherein the damping element (20) has a conical inwardly protruding end.

4. Fuel injector according to any one of the claims 1 to 3, wherein the damping element (25) is made of an elastic material.

5. Fuel injector according to one of the claims 1 to 3, wherein the damping element (25) is made of a metallic material.

6. Fuel injector according to one of the claims 1 to 4, wherein the damping element (25) is made of plastics.

7. Fuel injector according to one of the preceding claims, wherein a fuel filter (19) is provided between the damping element (25) and the valve seat (5) and the damping element (25) is arranged at the inlet of the fuel tube (18).

8. Fuel injector according to any one of the preceding claims, wherein an armature (7), a coil assembly (16) and a sleeve abutment (12) are provided, whereby the armature (7) stops at the abutment (12) when the coil (16) is energized, whereby the armature (7) is connected with a valve member (8) that is lifted from a valve seat (5) opening a valve, whereby a filter sleeve (19) is arranged within a sleeve abutment (12), whereby the filter sleeve (19) stresses a spring (15) against the armature (7).

9. A method of manufacturing a fuel injector (1), the method comprising: providing a jacket (2); inserting a needle assembly (6, 7, 8) in the jacket (2); providing an actuator (7, 16) for moving the needle assembly (6, 7, 8); connecting a fuel tube (18) with the

jacket (2); inserting a damping element (25) with a shape of a hollow cylinder in the fuel tube (18), whereby an outer face of the cylinder is adjacent to an inner face of the fuel tube (18), and fixing the damping element with the fuel tube (18).

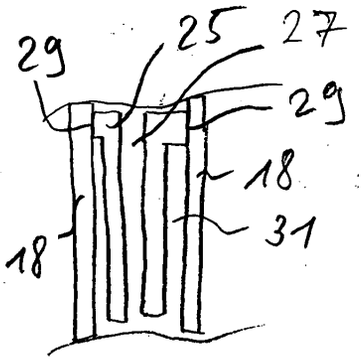

Fig. 4

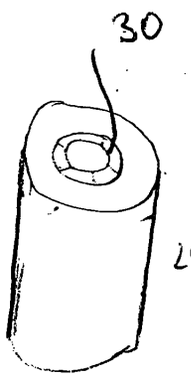

Fig. 2

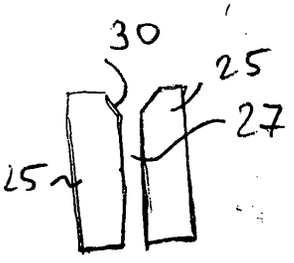

Fig. 3

Fig. 1

European Patent Office

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Application Number
EP 03 00 6018

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F02M

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	23 July 2003	Blanc, S

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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