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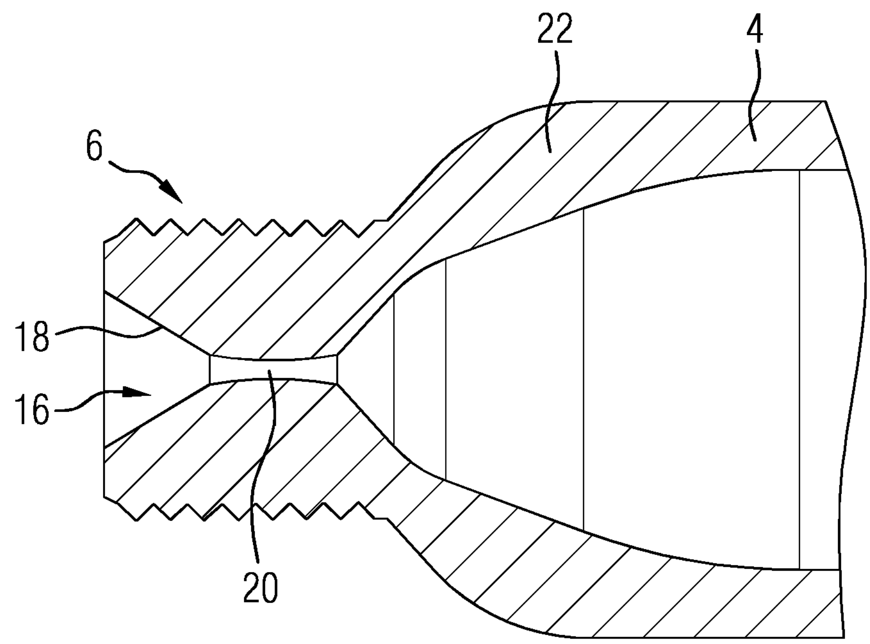
(54) FUEL RAIL FOR A FUEL INJECTION SYSTEM FOR AN INTERNAL COMBUSTION ENGINE AND METHOD FOR MANUFACTURING A FUEL RAIL

(57) In an embodiment, a fuel rail (2) for a fuel injection system for an internal combustion engine is provided. The fuel rail (2) comprises an elongate generally tubular body (4) forming a fuel reservoir and having one or more of a fuel inlet (6), one or more fuel outlets (9) and one or more mounting brackets (12) formed integrally therewith.

FIG 2



EP 3 636 912 A1

Description

[0001] The present disclosure relates to a fuel rail for a fuel injection system for an internal combustion engine and particularly but not exclusively to a fuel rail for incorporation in a fuel injection system for a multicylinder direct injection internal combustion engine.

[0002] A fuel rail commonly comprises an elongate reservoir for fuel in which the fuel is supplied to a fuel inlet by a high-pressure fuel pump. The fuel rail has spaced along its length fuel outlets for supplying fuel to a fuel injector for injecting fuel directly into each cylinder of the engine. The volume of fuel in the fuel rail is intended to damp out fluctuations in the pressure of the fuel supplied by the pump so that the pressure at each outlet is equal and substantially constant. Further components, such as the fuel outlet ports and mounting brackets are secured to the generally tubular element by brazing.

[0003] The fuel rail is typically a substantial generally tubular element which has to be strong enough to cope with the stresses of the load applied to the fuel rail by the high pressure of fuel in the reservoir and also to cope with the additional operating stresses caused by the harsh environment in a vehicle caused by vibration of the engine and the high temperatures to which the fuel rail is subjected. As a result, the fuel rail tends to be heavy and costly to construct because of the amount of material used in its construction. These inherent problems are accentuated by the stress concentrations which inevitably arise in the region of the openings in the fuel rail providing the fuel inlet and outlets.

[0004] The present disclosure seeks to provide a fuel rail which overcomes or mitigates the disadvantages of the known fuel rails.

[0005] According to the present disclosure there is provided a fuel rail for a fuel injection system for an internal combustion engine, the fuel rail comprising an elongate generally tubular body forming a fuel reservoir and having formed integrally therewith one or more of a fuel inlet and one or more fuel outlets and one or more mounting brackets.

[0006] The fuel inlet and/or one or more fuel outlets and/or one or more mounting brackets are integrally formed with the elongate body forming the fuel reservoir of the fuel rail and form a single component. This structure avoids joints, such as brazed joints, between the elongate body and additional elements of the fuel rail such as the fuel inlet, the fuel outlets and the mounting brackets and complexities associated with manufacturing the fuel rail form several parts. For example if forging technologies are used, at least two components are required since a shaft is used during the forging process to create the internal volume of the fuel rail. The hole for the shaft insertion then has to be closed or plugged with an additional element.

[0007] The fuel rail including the additional integrally formed functional components can be fabricated using additive manufacturing techniques.

[0008] The fuel inlet and the fuel outlets may each have the form of a port comprising a passageway. In some embodiments, the integrally formed inlet may be provided in the form of an inlet fitting or inlet port including an interface part, for example a outer screw thread, which is adapted to be connected to the high-pressure pipe through which the fuel is introduced into the fuel rail, a part with a small diameter hole or orifice, which may have a diameter and/or length selected to reduce pressure oscillation in the fuel and a structural part which has a mechanical robustness function. The structural part can be formed by the transition to the elongate tube of the fuel rail and may have a variable thickness which is dimensioned to minimise the stress distribution with the use of the minimum amount of material. For example, the transitional region downstream of the orifice may have an increased wall thickness to provide additional mechanical robustness.

[0009] A fuel rail is, therefore, provided as a single component which includes two or more, or all of the functional parts integrated into the single component. This fuel rail may be fabricated using additive manufacturing, for example. The design and position of the functional parts as well as the number of occurrences in the design, for example, the number of outlets and mounting brackets, can also be different depending on the application. The use of additive manufacturing allows shapes to be produced which are difficult or expensive to produce with traditional technologies.

[0010] Due to the greater freedom in material distribution, better stress distribution is enabled or a fuel rail with the same maximum stress with less material usage can be provided. The parameters which can be optimised include the internal shape and internal volume, the external shape and interfaces for connections, such as the position and shape of the mounting brackets, outlets and inlet. These parameters can also be different depending on the engine environment and the application. The thickness, in particular the wall thickness of the single component, is variable and may be varied by varying the internal and/or external profile. The variation in the thickness as well as the absolute thickness can also be optimized depending on the application by increasing the thickness at regions where the stress on the fuel rail is higher and by decreasing the wall thickness at regions of the fuel rail which are subjected to less stress.

[0011] In an embodiment, the fuel inlet has formed integrally therewith a screw thread adapted to receive a high-pressure fuel supply connection. In some embodiments, the inlet port comprises an orifice through which fuel is supplied to the fuel reservoir in the tubular body. In a further embodiment, the orifice may be an elongate passage and may have a non-uniform cross-section along its length. The dimension of the orifice may be selected to dampen pressure fluctuations in the fuel passing through the orifice.

[0012] In an embodiment, a plurality of fuel outlets is spaced along the fuel rail, in particular, spaced along the tubular body, and integrally formed in the fuel rail. The outlets may each have the form of an outlet port having a passageway. The outlets may each incorporate a fuel injector cup adapted to receive a fuel injector.

[0013] In a further embodiment, a plurality of said mounting brackets are spaced along the tubular body and being formed integrally with the tubular body.

[0014] In another embodiment, the tubular body has a non-uniform wall thickness, the wall thickness being increased at high stress points such as near the inlet and in the region of the outlets and the mounting brackets. In some embodiments, the wall thickness is increased in a region downstream of the fuel inlet, for example in the transition between the fuel inlet port and the tubular body and/or in a transition region between the outlet and the tubular body and/or in a transition region between the mounting bracket and the tubular body.

[0015] In further embodiments, the fuel rail may have formed integrally therewith a further outlet for a sensor and/or an end closure at the end of the tubular body opposite the fuel inlet. The further outlet for the sensor may have the form of a sensor port.

[0016] The fuel rail according to any of the embodiments described herein may be formed by an additive manufacturing technology. Additive manufacturing techniques may be used to build up the fuel rail layer by layer. For example, the elongate body and additional functional elements, such as the fuel inlet, fuel outlet(s) and mounting bracket(s) may be built up layer by layer using 3D (Three-dimensional) printing or Powder Bed Fusion or Directed Energy Deposition. The fuel rail may be built up layer by layer by movement of the metal jet print head, laser or electron beam controlled according to a three dimensional model of the fuel rail.

[0017] The fuel rail may be formed of a synthetic plastics material or a metal such as stainless steel or other alloy.

[0018] A preferred embodiment of the present disclosure will now be described with reference to the accompanying drawings.

Figure 1 shows a schematic view of a fuel rail formed by means of additive manufacturing technology, and

Figure 2 shows a cross-sectional view of the inlet port region of the fuel rail of figure 1.

[0019] Referring now to Figure 1 there is shown a fuel rail 2 which consists of an elongated generally tubular body 4 which has a fuel inlet 6 at one end. The fuel inlet 6 may have the form of a port or fitting. At the other end the tubular body 4 is closed by an end closure in the form of a blanking plug 8. Spaced along the tubular body 4 are a plurality of outlets 9 in the form of injector cups 10 each adapted to receive a fuel injector (not shown).

[0020] In the embodiment shown, four injector cups 10 are shown, each being adapted to receive a fuel injector for direct fuel injection into the combustion chamber of a multicylinder internal combustion engine. However, the fuel rail 2 is not limited to included four outlets 9 and injector cups 10, but may have fewer or more than four outlets 9 and injector cups 10. The tubular body 4 also includes four mounting brackets 12 by which the fuel rail can be secured to the engine. Tubular body 4 also incorporates a sensor port 14 for receiving a sensor (not shown) through which the fuel in the tubular body is monitored.

[0021] In the illustrated embodiment, the tubular body 4, the fuel inlet 6, blanking plug 8, the injector cups 10, mounting brackets 12 and the sensor port 14 are all formed integrally as a single component by means of an additive manufacturing technology. However, in other non-illustrated embodiments, fewer component may be integrated into a single component, for example the fuel inlet and the tubular body may be integrated and provided as a single component.

[0022] In this embodiment, the elements of the single component are formed of the same material, which may be a metal such as stainless steel. However, alternative material for certain parts of the fuel rail may also be used in the additive manufacturing process.

[0023] In an alternative embodiment, the single component may be moulded from a synthetic plastics material.

[0024] Referring now to Figure 2 in particular, there is shown a cross-section of the fuel inlet end of the tubular body 4. The fuel inlet 6 has the form of an inlet fitting or port that includes an external screw thread by which a high-pressure pipe or connector can connect the fuel rail 2 to a high-pressure fuel pump (not shown) by which fuel is supplied to the fuel rail, and hence to the injector cups 10. The fuel inlet 6 has a fuel inlet orifice 16 having a generally frusto-conical inlet 18 through which fuel enters into a narrow passage 20 which has dimensions adapted to damp down oscillations in the fuel pressure. The oscillations in the fuel pressure may be caused by the characteristics of the high pressure fuel pump and/or parameters such as the volume of the high pressure tube, the volume of the fuel rail, the distribution of the volumes, etc.

[0025] The wall thickness of the tubular body 4 is varied along its length in dependence upon the stress levels at particular parts such as the inlet smoothing passage 20, the outlet ports 9 in the region of the injector cups 10 and the mounting brackets 12. For example, the wall thickness may be increased at a transition between two parts having different outer dimensions to provide additional strengthening to mitigate any additional stress to which the fuel rail 2 is subjected at this transitional region. In this way, the material used in the formation of the body is minimised since the wall thickness in the low stress areas can be kept relatively thin, the wall thickness only being increased in higher stress regions with the result that the overall stress levels throughout the fuel rail 2 can be kept relatively constant. This has the advantage that the fuel rail can be manufactured with less material and hence lower weight and cost.

[0026] As can be seen in Figure 2, the thickness of the wall 22 of the tubular body 4 is increased in the region of the inlet 6 to accommodate stresses caused by the change in diameter between the inlet 6 and the tubular body 4 and/or turbulence of the fuel adjacent the inlet as the fuel expands from the smoothing passage 20 into the volume of the tubular body 4.

Claims

1. A fuel rail (2) for a fuel injection system for an internal combustion engine, the fuel rail (2) comprising an elongate generally tubular body (4) forming a fuel reservoir and having formed integrally therewith one or more of a fuel inlet (6), at least one or more fuel outlets (9) and one or more mounting brackets (12).

2. A fuel rail (2) for a fuel injection system for an internal combustion engine according claim 1, wherein the fuel inlet (6) has formed integrally therewith a screw thread adapted to receive a high-pressure fuel supply connection, the fuel inlet (6) having an orifice (16) through which fuel is supplied to the fuel reservoir in the tubular body (4).

3. A fuel rail (2) for a fuel injection system for an internal combustion engine according to claim 2, wherein the orifice has an elongate passage (20).

4. A fuel rail (2) for a fuel injection system for an internal combustion engine according to claim 3, wherein the elongate passage (20) has a non-uniform cross-section along its length.

5. A fuel rail (2) for a fuel injection system for an internal combustion engine according to one of claims 1 to 4, wherein a plurality of fuel outlets (9) are spaced along the fuel rail (2).

6. A fuel rail (2) for a fuel injection system for an internal combustion engine according to one of claims 1 to 5, wherein the or each outlet (9) incorporates integrally therewith a fuel injector cup (10) adapted to receive a fuel injector.

7. A fuel rail (2) for a fuel injection system for an internal combustion engine according to any one of claims 1 to 6, wherein a plurality of said mounting brackets (12) are spaced along the tubular body (4) and are formed integrally with the tubular body (4).

8. A fuel rail (2) for a fuel injection system for an internal combustion engine according to any one of the preceding claims, wherein the tubular body (4) has a non-uniform wall thickness, the wall thickness being increased in high stress regions.

9. A fuel rail (2) for a fuel injection system for an internal combustion engine according to claim 8, wherein the wall thickness is increased in a region downstream of the fuel inlet (6) and/or in a transition region between the outlet (9) and the tubular body (4) and/or in a transition region between the mounting bracket (12) and the tubular body (4) .

10. A fuel rail (2) for a fuel injection system for an internal combustion engine according to any one of the preceding claims, wherein the fuel rail (2) has formed integrally therewith an outlet port (14) for a sensor and an end closure at the end of the tubular body (4) opposite the fuel inlet (6) .

11. A fuel rail (2) for a fuel injection system for an internal combustion engine according to any one of the preceding claims, wherein the fuel rail (2) is formed of a metal.

12. A fuel rail (2) for a fuel injection system for an internal combustion engine according to any one of the preceding claims, wherein the fuel rail (2) is formed of stainless steel.

13. A method of forming a fuel rail (2) according to any one of the preceding claims by the use of an additive manufacturing technology.

14. A method of forming a fuel rail (2) according to claim 13, wherein the additive manufacturing technology comprises Three-dimensional printing or Powder Bed Fusion or Directed Energy Deposition.

15. A method of forming a fuel rail (2) according to claim 13 or claim 14, wherein alternative materials for different parts of the fuel rail (2).

FIG 1

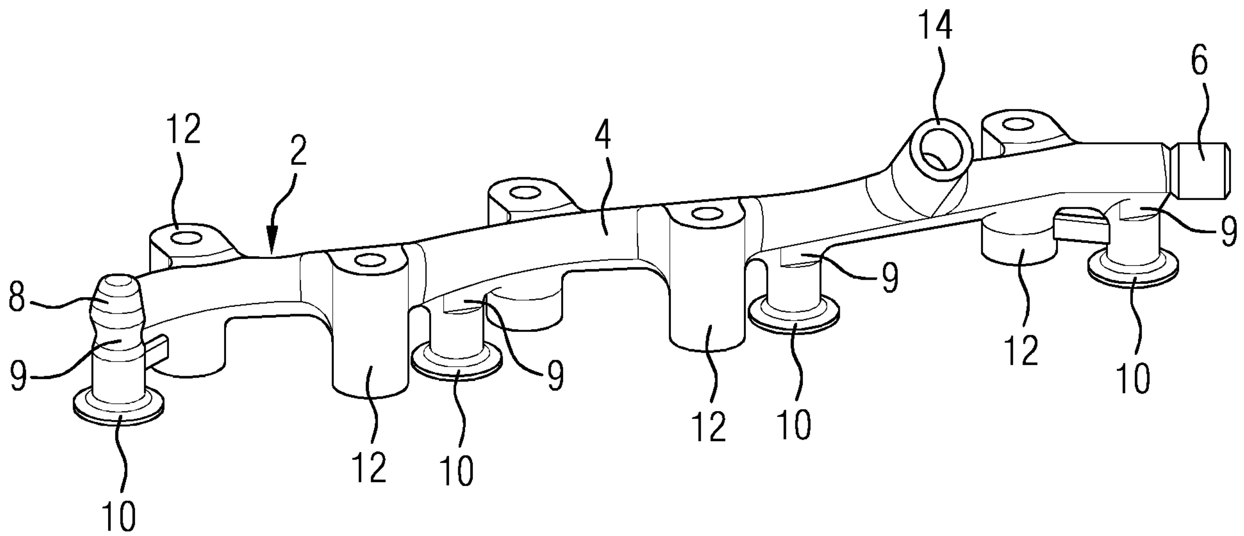
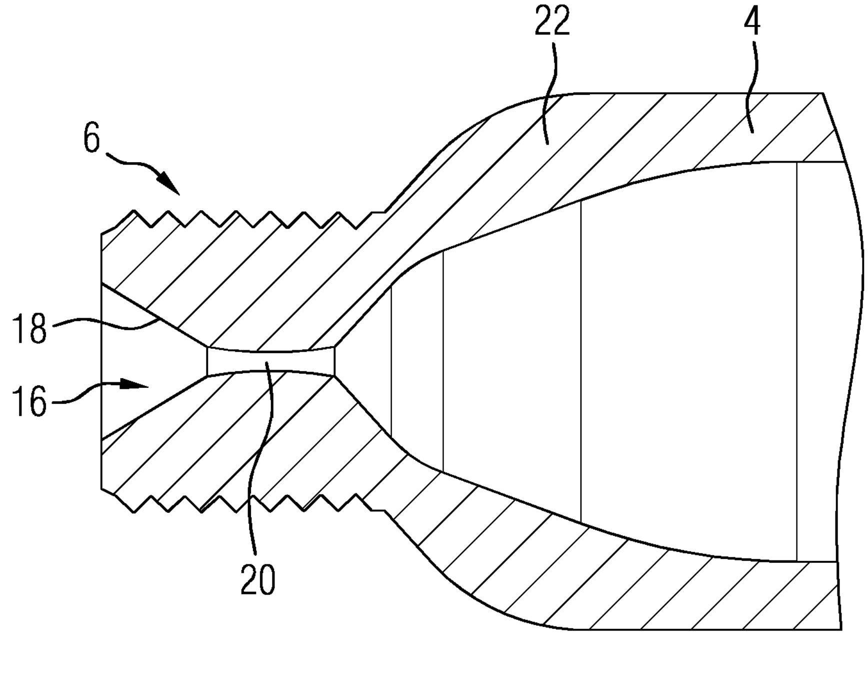


FIG 2



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EUROPEAN SEARCH REPORT

Application Number
EP 18 19 9032

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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	12 March 2019	Tortosa Masiá, A

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EUROPEAN SEARCH REPORT

Application Number
EP 18 19 9032

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The present search report has been drawn up for all claims

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page 2 of 2

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