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(54) **FUEL RAIL ASSEMBLY FOR A FUEL INJECTION SYSTEM AND METHOD OF MANUFACTURING SUCH A FUEL RAIL ASSEMBLY**

(57) A fuel rail assembly for a fuel injection system for an internal combustion engine comprises a plurality of components. The plurality of components may include at least an elongate fuel rail (2) having a fuel inlet (4) and a plurality of fuel outlets spaced along the fuel rail, each outlet has a fuel adapter (12) bonded thereto to provide a mechanical and hydraulic communication with a fuel injector cup (14) adapted to receive a fuel injector. At least two of the components comprise differing steels.

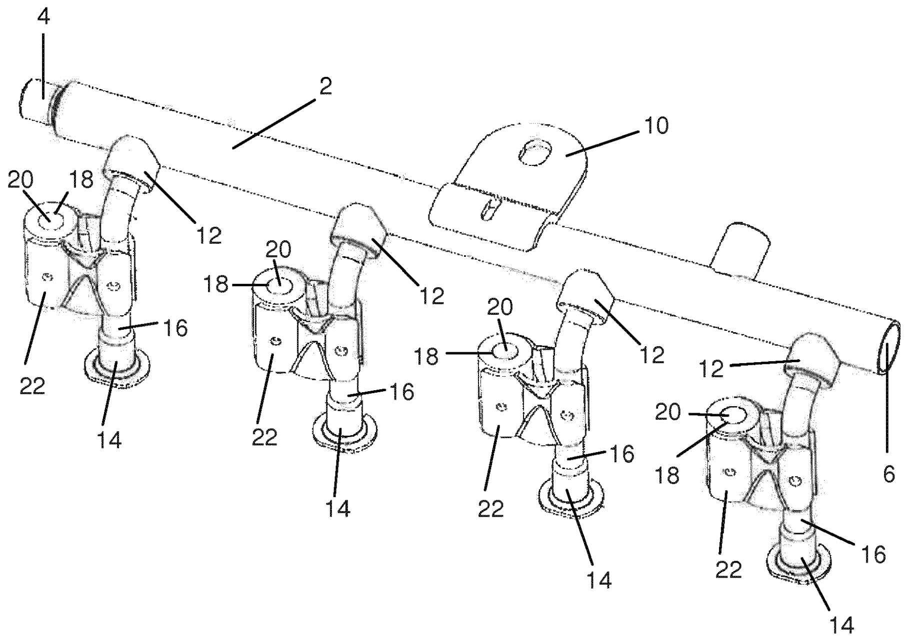

Fig.

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Description

[0001] The present disclosure relates to a fuel rail assembly for a fuel injection system for an internal combustion engine and to a method of manufacturing a fuel rail assembly.

[0002] A fuel rail assembly for a fuel injection system for an internal combustion engine comprises a fuel rail, also known as a common rail or a main gallery, which typically comprises an elongate tubular member forming a reservoir for fuel which is supplied to an inlet of the fuel rail under high pressure by a fuel pump. The fuel rail has a plurality of fuel outlets spaced along its length each of which is in hydraulic communication with a fuel injector by which fuel is injected into the engine. In one form referred to as direct injection each cylinder of a multicylinder internal combustion engine has a fuel injector which injects fuel directly into the combustion chamber.

[0003] When installed in a motor vehicle, such fuel rail assemblies are subjected to high stresses caused by the harsh environment of high temperatures, and vibration caused by the engine vibrating on its engine mounts in the vehicle and by the general vibration in the vehicle as it moves along. In addition, further vibration and stress is applied to the fuel rail assembly by virtue of the high pressure in the fuel rail and of pressure variations caused by the fuel injection process.

[0004] It is, therefore, desirable to provide a fuel rail assembly which has improved mechanical behaviour, for example during and after subjection to stress, higher temperatures and vibration, that is also compact.

[0005] In order to provide the necessary durability and mechanical behaviour of the fuel rail, it is currently the practice to use the same material or similar material for the components of the fuel rail assembly and to provide the necessary strength by increasing the amount of material used in the various components.

[0006] It is an object of the present disclosure to provide an improved fuel rail assembly.

[0007] This object is achieved by a fuel rail assembly and a method for manufacturing the same according to the independent claims. Advantageous embodiments and developments of the assembly and the method are disclosed in the dependent claims, the following description and the drawings.

[0008] The present disclosure makes use of the idea to manufacture the individual components of the fuel rail assembly by different materials having different characteristics selected from a group of materials, in particular steels.

[0009] Accordingly, the present disclosure provides a fuel rail assembly for a fuel injection system for an internal combustion engine. The fuel rail assembly comprises a plurality of components. The plurality of components of the fuel rail assembly includes at least an elongate fuel rail having a fuel inlet and a plurality of fuel outlets spaced along the fuel rail, each outlet having a fuel adapter bonded thereto to provide a mechanical and hydraulic communication with a fuel injector cup adapted to receive a fuel injector. Two or more of the components comprise differing materials, in particular differing steels, preferably differing stainless steels.

[0010] The material from which the two or more of the components is manufactured may be selected from a group of materials in dependence upon one or more characteristics or properties required for the component.

[0011] The group of materials may be the group of steels and in some embodiments the group of stainless steels. In these embodiments, the fuel rail assembly may be thought of as a multi-steel fuel rail assembly.

[0012] The group of steels may comprise duplex stainless steel, austenitic stainless steel, ferritic stainless steel, martensitic stainless steel and carbon steel. The differing steels may be differing steels of a class of steels, for example, differing types of austenitic steel, or may belong to different classes of steels, for example a duplex steel and a ferritic steel.

[0013] The characteristic of the material and of the component may be corrosion resistance against fuel. In some embodiments, the components of the fuel rail assembly which in use come into contact with fuel may comprise a steel, in particular, a stainless steel which has better corrosion resistance against fuel. The components of the fuel rail assembly which in use do not come into contact with fuel may comprise a steel, including a stainless steel, which has a worse corrosion resistance against fuel than the steel used for the components or some of the components that come into contact with fuel.

[0014] For example, the component parts which, in use, are in contact with the fuel, may include the fuel rail, a blanking plate, the fuel inlet, a sensor adapter port, the fuel outlet adapters, the fuel cup and a fuel pipe. The component parts which, in use, are in contact with the fuel may be formed of one or more stainless steels with a better corrosion resistance against fuel, for example a duplex stainless steel or an austenitic stainless steel. One or more or all of the components of this group may be formed of the same stainless steel or all of the components may be formed from different stainless steels.

[0015] The components which are not in contact with the fuel, for example the mount bracket, straps and the fuel rail mounting bracket, may be formed from a steel that is less corrosion resistant to fuel, for example carbon steel, austenitic stainless steel, or ferritic stainless steel. These materials may be cheaper and/or easier to manufacture. One or more or all of the components of this group may be formed of the same steel or all of the components may be formed from different steels.

[0016] In a preferred embodiment, the fuel rail is formed of duplex stainless steel. Duplex stainless steels have a two-phase microstructure consisting of grains of ferritic and austenitic stainless steel. The austenitic phase may be present as "islands" surrounded by the ferritic phase. A duplex stainless steel may include approximately 50% austenite phases and 50% ferrite phases.

[0017] This duplex structure gives duplex stainless steels a combination of attractive properties:

Strength: Duplex stainless steels are about twice as strong as regular austenitic or ferritic stainless steels;
Toughness and ductility: Duplex stainless steels have better toughness and ductility than ferritic grades but do not reach the values of austenitic grades;
Corrosion resistance: Duplex stainless steel grades have a range of corrosion resistance, similar to the range for austenitic stainless steels, i.e. from (SAE-) Type 304 or 316 to 6% molybdenum stainless steels;
Stress corrosion cracking resistance: Duplex stainless steels show very good stress corrosion cracking (SCC) resistance;
Cost: Duplex stainless steels have lower nickel and molybdenum contents than their austenitic counterparts of similar corrosion resistance and, due to the lower alloying content, duplex stainless steels can be lower in cost.

[0018] Due to the increased yield strength of duplex stainless steels compared to austenitic stainless steel, it may be possible to reduce the section thickness of a component fabricated from a duplex stainless steel. This can lead to significant cost and weight savings compared to a solution in austenitic stainless steels.

[0019] In another embodiment, the mechanical and hydraulic communication between the fuel adapter the mechanical and hydraulic communication between the fuel adapter and the fuel injector cup includes a fuel pipe. The fuel pipe may be formed of duplex stainless steel.

[0020] In particular examples, the fuel rail may be formed of duplex stainless steel, for example 1.4162. The blanking plate, fuel inlet, sensor adapter port, fuel outlet adapters, and injector cups may be formed of austenitic stainless steel, for example 1.4305. The fuel pipe may be formed of austenitic stainless steel, for example 1.4301, and the mount bracket may be formed of carbon steel, for example 1.0214. Straps and the fuel rail mounting bracket may be formed of ferritic stainless steel, for example 1.4509. The numbers 1.4162, 1.4305, 1.4301, 1.0214 and 1.4509 in this paragraph and elsewhere in this disclosure denote the respective steel grades according to the Euronorm (EN).

[0021] In one particular example, the combination of a fuel rail formed of duplex stainless steel 1.4162, a blanking plate, fuel inlet, sensor adapter port, a fuel outlet adapter and an injector cup formed of austenitic stainless steel 1.4305, a fuel pipe formed in austenitic stainless steel 1.4301, a mount bracket formed of carbon steel 1.0214, and straps and a fuel rail mounting bracket formed of ferritic stainless steel 1.4509 may be used.

[0022] The present disclosure also provides a method of manufacturing a fuel rail assembly for a fuel injection system for an internal combustion engine. The fuel rail assembly comprises a plurality of components. The plurality of components may include at lest an elongate fuel rail having a fuel inlet and a plurality of fuel outlets spaced along the fuel rail each outlet having a fuel adapter bonded thereto to provide a mechanical and hydraulic communication with a fuel injector cup adapted to receive a fuel injector. The method comprises selecting the material from which two or more of the components is manufactured from a group of materials in dependence upon at least one characteristic required for the component, such that at least two of the components comprise differing steels. The group of materials may consist of a group of steels or a group of stainless steels and may comprise duplex stainless steel, austenitic stainless steel, ferritic stainless steel, martensitic stainless steel and carbon steel

[0023] In some embodiment, the at least one characteristic comprises corrosion resistance to fuel. Alternatively, or in addition, one or more of characteristics including mechanical strength, formability, for example ductility, machinability, suitability for welding or brazing, for example, may be taken into consideration for selecting the material for a particular part.

[0024] In some embodiments, the components that come into contact with fuel such as the fuel rail, a blanking plate, the fuel inlet, a sensor adapter port, the fuel outlet adapters, the fuel cup and a fuel pipe are formed of an austenitic steel or a duplex steel.

[0025] The components which in use do not come into contact with the fuel, for example the mount bracket, straps and the fuel rail mounting bracket, may be formed from a steel that is less corrosion resistant to fuel, for example carbon steel, austenitic stainless steel, or ferritic stainless steel.

[0026] In some embodiments, the fuel rail assembly further comprises at least one mounting bracket adapted to enable the fuel rail assembly to be fastened to the engine. The method further comprises forming the mounting bracket from ferritic stainless steel.

[0027] In some embodiments, the materials of the components have different coefficients of thermal expansion. If two components which are to be brazed together having different coefficients of thermal expansion, the method may further comprise manufacturing the components with dimensions such that when the components are heated to a predetermined brazing temperature in a furnace the gap between the surfaces to be brazed together is at a predetermined spacing. This enables a reliable brazed joint to be formed despite the change in relative dimensions between the parts to be joined at the brazing temperature compared to room temperature.

[0028] In preferred embodiments, at least two of the components are welded together. Alternatively and/or additionally, at least two of the components are brazed together.

[0029] A preferred embodiment of the present disclosure will now be described by way of example with reference to the accompanying drawing.

Figure 1 illustrates a fuel rail assembly for a four-cylinder multi-cylinder internal combustion engine.

[0030] The fuel rail assembly comprises a fuel rail 2 which comprises an elongate tubular member forming a reservoir for fuel. The fuel rail 2 is formed of duplex stainless steel. At one end the tube is supplied with a fuel inlet 4 connected to a high-pressure fuel pump by which fuel is supplied to the fuel rail. The other end of the fuel rail 2 is closed by a blanking plate 6. Intermediate its length, the fuel rail has a sensor adapter port 8 for a sensor (not shown) monitoring the fuel pressure in the fuel rail 2. A fuel rail mounting bracket 10 by which the fuel rail 2 is secured to the engine is provided intermediate the length of the fuel rail 2 at a position determined by the installation conditions of the engine.

[0031] Spaced along its length the fuel rail 2 has four fuel adapters 12, or fuel outlet adapters, which provide a mechanical and hydraulic connection to a fuel cup 14 which is adapted to receive an inlet port of a fuel injector (not shown). The fuel outlet adapter 12 is connected mechanically and hydraulically to the fuel cup 14 by means of a fuel pipe 16. It will be understood that the present disclosure may be adapted for use for engines having one or more cylinders, particularly for example, in designs in which the fuel is injected into the engine intake manifold.

[0032] The fuel rail assembly is connected to the engine by mount brackets 18 which have a through bore 20 through which a bolt (not shown) passes to secure the mount brackets 18 to the engine. The mount brackets 18 are secured to the respective fuel pipes 16 by straps 22.

[0033] The component parts which, in use, are in contact with the fuel, for example the fuel rail 2, the blanking plate 6, fuel inlet 4, sensor adapter port 8, the fuel outlet adapters 12, fuel cup 14 and the fuel pipe 16 may all be formed of a stainless steel selected from the group consisting of duplex stainless steel, and austenitic stainless steel. The components which are not in contact with the fuel, for example the mount bracket 18, straps 22 and the fuel rail mounting bracket 10, may be formed from a carbon steel, austenitic stainless steel, ferritic stainless steel or in principle any other steel material more suited to manufacture by techniques such as cold-forming or stamping.

[0034] In one particular example, the fuel rail 2 is formed of duplex stainless steel, for example, 1.4162, which, because of its strength, enables the fuel rail to be formed of a thinner, and hence lighter, material than previous fuel rails, which reduces considerably the stresses applied to the fuel rail and its related components caused by vibration. The blanking plate 6, fuel inlet 4, sensor adapter port 8, fuel outlet adapter 12, and injector cup 14 are formed in austenitic stainless steel, for example, 1.4305. The fuel pipe 16 is formed in austenitic stainless steel, for example 1.4301, and the mount bracket 18 is formed in carbon steel, for example 1.0214. The straps 22 and the fuel rail mounting bracket are formed of ferritic stainless steel, for example 1.4509.

[0035] It is thus possible in some installations to eliminate the necessity of providing the fuel rail mounting bracket 10. The reduction in stress caused by the lower weight of the fuel rail 2 enables the mass of material used in the fuel pipe 16 and the fuel cup 14, together with the mount brackets 18 and the straps 22 also to be reduced with a consequent saving in weight and cost. The components may be welded together but in order to ensure reliable corrosion resistance between the components particularly those contacted by the fuel, it may be preferable that they are brazed together.

[0036] It is possible in certain installations for the fuel outlet adapters 12 to be formed of a lower cost stainless steel such as ferritic stainless steel because of its easier machinability, which, apart from its lower cost, facilitates the production of the item at a lower cost.

[0037] The components which are not subjected to the corrosive effects of the fuel such as the mount brackets 18 and the straps 22 are formed of a lower grade stainless steel, and as well as other components not in contact with the fuel, may alternatively be formed of carbon steel with its easier workability and low cost compared with stainless steel.

[0038] When different materials are used for the different components, it is possible that the components have different coefficients of thermal expansion. At higher temperatures, for example at the higher temperatures used for brazing components together, which may be in the range of 1000°C to 1150°C for example, this difference in thermal expansion coefficients can produce practical changes in the dimensions of the components. The difference in thermal expansion coefficient, particularly for adjoining components that are brazed together, may be taken into account when selecting and determining the dimensions of the components. It is therefore desirable for the dimensions of the components as manufactured to take the difference in thermal expansion into account such that when heated to the brazing temperature in a furnace, the gap between the surfaces to be brazed is at the correct spacing for the brazing to be successfully carried out.

Claims

1. A fuel rail assembly for a fuel injection system for an internal combustion engine, the fuel rails assembly comprising a plurality of components, the plurality of components comprising at least an elongate fuel rail (2) having a fuel inlet (4) and a plurality of fuel outlets spaced along the fuel rail (2), each outlet having a fuel adapter (12) bonded thereto to provide a mechanical and hydraulic communication with a fuel injector cup (14) adapted to receive a fuel injector, wherein two or more of the components comprise

differing steels.

2. A fuel rail assembly according to claim 1, wherein the two or more components comprise differing steels from the group of steels comprising duplex stainless steel, austenitic stainless steel, ferritic stainless steel, martensitic stainless steel and carbon steel.

3. A fuel rail assembly according to claim 1 or claim 2, wherein the fuel rail (2) is formed of a duplex stainless steel.

4. A fuel rail assembly according to claim 3, wherein the duplex stainless steel is EN 1.4162 grade steel.

5. A fuel rail assembly according to any one of claims 1 to 4, wherein the fuel injector cup (14) and the fuel adapter (12) are formed of an austenitic steel.

6. A fuel rail assembly according to claim 5, wherein the austenitic steel is EN 1.4305 grade steel.

7. A fuel rail assembly according to any one of claims 1 to 6, wherein the mechanical and hydraulic communication between the fuel adapter (12) and the fuel injector cup (14) includes a fuel pipe (16) formed of an austenitic stainless steel.

8. A fuel rail assembly according to claim 7, wherein the fuel pipe (16) is formed of austenitic stainless steel of steel grade EN 1.4301.

9. A fuel rail assembly according to any one of the preceding claims, further comprising at least one mounting bracket (10) adapted to enable the fuel rail assembly to be fastened to the engine.

10. A fuel rail assembly according to claim 9, wherein the mounting bracket (10) is formed of ferritic stainless steel.

11. A method of manufacturing a fuel rail assembly for a fuel injection system for an internal combustion engine, the fuel rail assembly comprising a plurality of components, wherein the plurality of components comprises at least an elongate fuel rail (2) having a fuel inlet and a plurality of fuel outlets spaced along the fuel rail each outlet having a fuel adapter (12) bonded thereto to provide a mechanical and hydraulic communication with a fuel injector cup (14) adapted to receive a fuel injector, the method comprising:

selecting the material from which two or more of the components is manufactured from a group of materials in dependence upon at least one characteristic required for the component, the group of materials comprising duplex stainless steel, austenitic stainless steel, ferritic stainless steel, martensitic stainless steel and carbon steel, such that at least two of the components comprise differing steels.

12. The method according to claim 11, wherein the at least one characteristic comprises corrosion resistance to fuel.

13. The method according to claim 11 or claim 12, wherein components that come into contact with fuel are formed of an austenitic steel or duplex steel.

14. A method according to any one of claims 11 to 13 wherein the fuel rail assembly further comprises at least one mounting bracket (10) adapted to enable the fuel rail assembly to be fastened to the engine, the method further comprising forming the mounting bracket (10) from ferritic stainless steel

15. A method according to any one of claims 11 to 14, wherein two of the components comprise steels having different coefficients of thermal expansion, and the dimensions of the two components as manufactured are such that when heated to a predetermined brazing temperature the gap between surfaces of the two component which are to be brazed together is at a predetermined spacing.

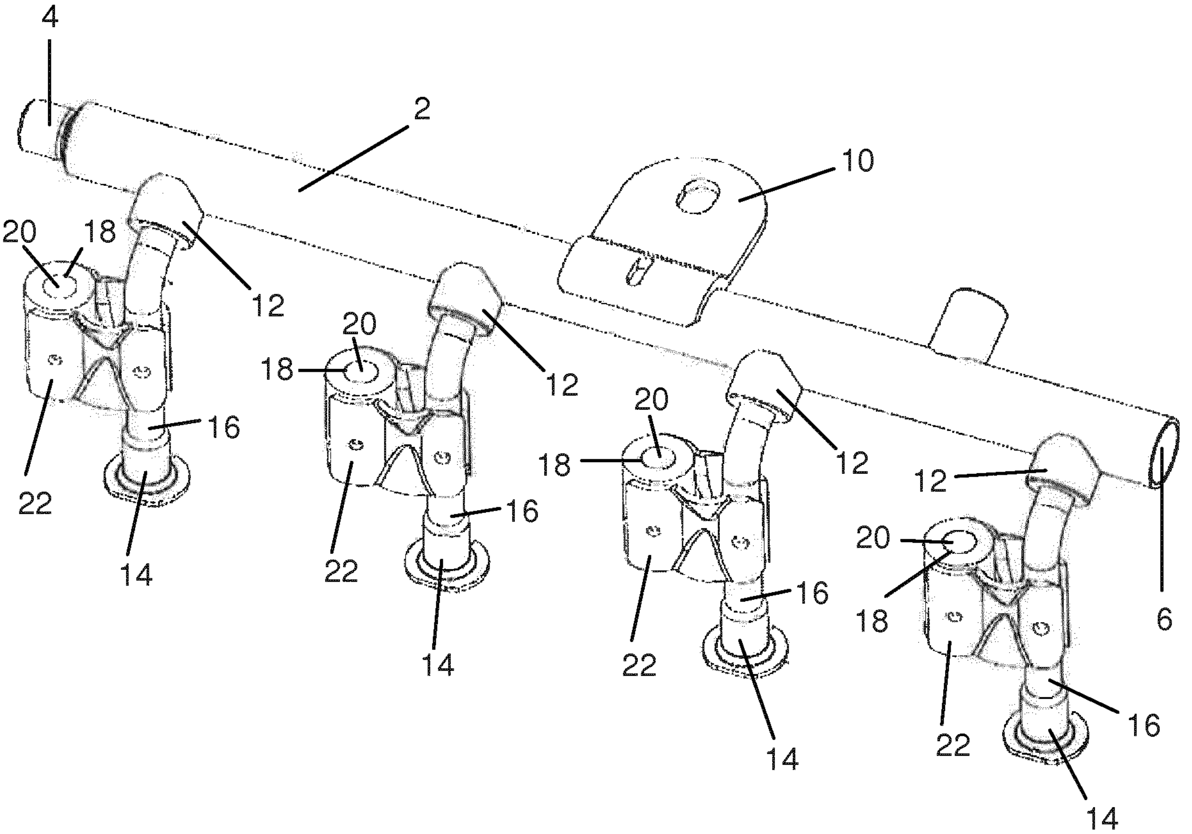
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Fig.

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EUROPEAN SEARCH REPORT

Application Number
EP 17 19 6394

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The present search report has been drawn up for all claims

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Place of search	Date of completion of the search	Examiner
The Hague	13 March 2018	Tortosa Masiá, A

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EUROPEAN SEARCH REPORT

Application Number
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