



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
17.04.2019 Bulletin 2019/16

(51) Int Cl.:
F02M 55/02 (2006.01) **F02M 69/46** (2006.01)
B23K 33/00 (2006.01) **F02M 55/00** (2006.01)
F02M 61/16 (2006.01)

(21) Application number: **17196196.4**

(22) Date of filing: **12.10.2017**

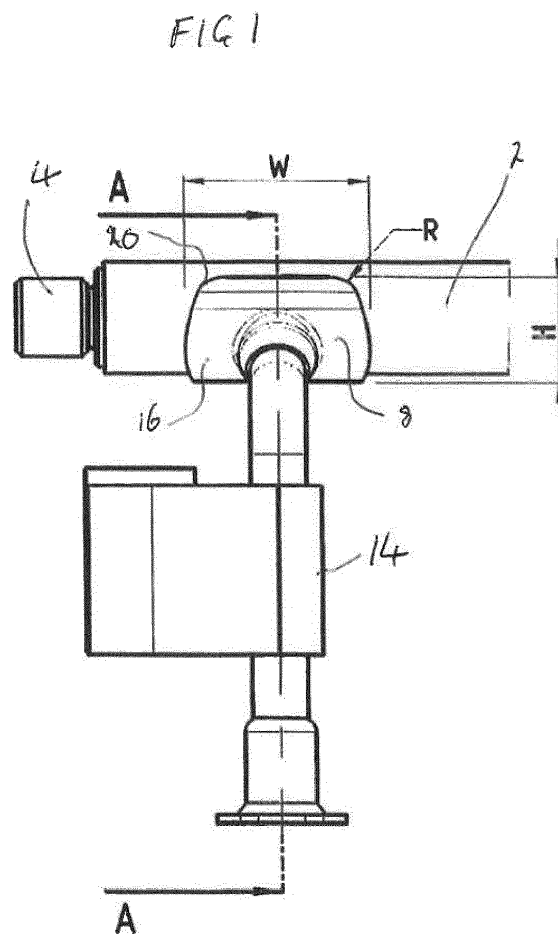
(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD

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(54) **A FUEL RAIL ASSEMBLY FOR A FUEL INJECTION SYSTEM FOR AN INTERNAL COMBUSTION ENGINE**

(57) A fuel rail assembly for a fuel injection system for an internal combustion engine comprises an elongate fuel rail having a fuel inlet and a plurality of fuel outlets spaced along the fuel rail. Each outlet has a fuel adapter bonded thereto to provide a hydraulic communication with a fuel injector cup adapted to receive a fuel injector for injecting fuel into the engine. The fuel adapter has a variable material thickness, the thickness being adapted to the characteristics of the fuel rail and the communication to the fuel injector cup in order, in use, to equalise substantially the stresses applied to these components, and the bond therebetween.



Description

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

[0002] Fuel rails, also referred to as common rails or main galleries, are widely used in fuel injection systems for internal combustion engines, and consist of a reservoir typically in the form of an elongate tube having a fuel inlet and a plurality of fuel outlets spaced along the rail. Fuel at high pressure is fed to the fuel inlet of the fuel rail from whence it is delivered through the fuel outlets to fuel injectors. The fuel injectors may inject fuel into a manifold of the internal combustion engine but, more usually, each cylinder of the engine has an associated fuel injector which injects fuel directly into the combustion chamber of the cylinder.

[0003] The fuel rail assembly has a fuel adapter that is bonded, usually by brazing, to each of the fuel outlets of the fuel rail. The fuel adapter has an outlet providing a hydraulic connection between the fuel rail, the fuel adapter and the fuel injector, the hydraulic connection including a fuel injector cup into which the fuel injector is inserted. In one form, the fuel injector cup is formed as an integral part of the fuel adapter and in another form, a pipe leads from the fuel adapter to a fuel injector cup.

[0004] Such systems operate in a harsh environment when placed in a vehicle which involves high temperatures and high pressure which is variable throughout each induction phase of the engine. The systems are also subject to vibration from the vehicle and its movement and also to separate vibration of the engine on its engine mounts. The components subject to the fuel pressure, in particular, are additionally subjected to substantial stresses caused by the variation in the fuel pressure. As a result of this harsh environment, components and the brazed joints between them are subject to stresses which can lead to premature failure and insufficient durability.

[0005] European Patent No. EP 246 6111 discloses an arrangement in which a separate mounting structure is provided which is adapted to disperse the stress caused by an impact applied to an injector cup due to a repulsive force when the fuel is injected. The structure has a mount unit which is connected to the fuel rail by brazing and is also connected to a fuel adapter which incorporates an injector cup. Thus, the injector cup is bonded to the fuel pipe and to the mount via a bridge. The mount unit is secured to the fuel rail adjacent the fuel adapter but in one form is spaced from the fuel adapter further along the fuel rail in order to spread the stresses. This arrangement is expensive to manufacture, takes up extra space in the engine bay and also limits the manner in which the fuel rail can be installed in the engine as it must be very close to the engine cylinder head.

[0006] These shortcomings are acknowledged in US 2014/032 6217 in which the disadvantages of such de-

signs are acknowledged and a simpler solution is suggested by providing a securing strap which is attached to the outer curvature of the fuel adapter and also to an adjacent mount.

[0007] However, further improvements to fuel rail assemblies which are simple to manufacture and install and which are reliable in operation are desirable.

[0008] According to the present disclosure there is provided a fuel rail assembly for a fuel injection system for an internal combustion engine, comprising an elongate fuel rail having a fuel inlet and a plurality of fuel outlets spaced along the fuel rail, each outlet has a fuel adapter bonded thereto to provide a hydraulic communication with a fuel injector cup. The fuel injector cup is in particular adapted - i.e. in particular shaped and arranged - to receive a fuel injector. The fuel adapter has a variable material thickness. With advantage, the thickness may be adapted to the characteristics of the fuel rail and the fuel adapter in order, in use, to equalise substantially the stresses applied to these components and the bond therebetween.

[0009] The present disclosure describes an advantageous approach in which the fuel adapter and its bonding area, where it is bonded to the fuel rail, are designed to dissipate the stresses in a particularly uniform manner throughout the components and the brazed joint.

[0010] Stresses may be exacerbated by variations in the thickness of the components, such as the fuel rail and the fuel adapter which can cause stress concentration which leads to premature failure. The use of larger and heavier components and the use of additional components in an attempt to spread the stresses are avoided herein by the use of a material thickness of wall thickness that is varied in order to reduce stress concentrations and to substantially equalise the stresses. This solution also addresses the space requirements and provides a flexibility in the design whilst not requiring an extra component with the inevitable complexity and cost penalties.

[0011] In a preferred embodiment, the fuel adapter is brazed to the fuel rail over a bonding area, the size of the bonding area and its shape being determined to provide a uniform stress in the brazed joint. The shape of the fuel adapter may also be formed to provide a uniform stress, in particular a uniform stress in and around the brazed joint, for example by avoiding edges and points and/or by providing a smoothly varying shape. The cross-sectional area of the fuel adapter may be varied along its length by varying its lateral extent as well as, or alternatively by varying its thickness.

[0012] The fuel adapter may be brazed to the fuel rail over a bonding area defined by a fuel adapter base, the bonding area and its shape being determined to provide, in use, a substantially uniform stress across the brazed joint. In some embodiments, the inner face of the fuel adapter base is shaped to mate with the periphery of the fuel rail. For example, if the fuel rail has an arcuate surface, for example a convex surface as it has the form of a cylindrical tube, the inner face of the base of the fuel

adapter has an arcuate surface, for example a concave surface, so that it can mate with the periphery of the fuel rail.

[0013] Preferably, the periphery of the bonding area has no sharp changes in direction which would result in stress concentration in the joint.

[0014] The thickness of the material of the fuel adapter is reduced towards the periphery of the bonding area so that the uniformity of the stress is increased and the stress distribution is more uniform in order that little or no stress concentration arises as a result of the change in material thickness between the fuel adapter and the fuel rail at the junction at the periphery of the bonding area, for example at the periphery of the base of the fuel adapter.

[0015] In a further embodiment, the hydraulic connection between the fuel adapter and the fuel injector cup includes a delivery pipe which is brazed to the fuel adapter. Preferably, the delivery pipe is located in a bore in a spigot of the fuel adapter and the thickness of the material of the fuel adapter is reduced towards the outer end of the bore or spigot. In this way, little or no stress concentration may arise as an advantageous result of the change in material thickness at the junction between the fuel adapter and the pipe. The spigot may be positioned at the opposing end of the fuel adapter to the fuel adapter base.

[0016] There is also disclosed a method of joining at least one component of a fuel rail assembly to a fuel rail including the step of varying the material thickness of the component over at least part of the component and reducing the thickness of the material towards the periphery of its contact area with the fuel rail so that the change in thickness of the material at the junction between the component and the fuel rail is minimal to reduce stress concentration at the junction.

[0017] The method may further comprise bonding the component to the fuel rail by brazing the contact area to the fuel rail. In some embodiments, the component is a fuel adapter and the contact area is provided by an inner face of a base of the fuel adapter, the inner face being shaped to mate with the periphery of the fuel rail. The thickness of the material of the base of the fuel adapter may be increasingly reduced towards the periphery. Additionally, the form of the base and periphery may be without corners and edges to provide a smooth surface which avoids possible positions of stress concentration.

[0018] The fuel adapter may comprise a spigot defining a bore for a delivery pipe. The spigot may be positioned at the opposing end of the adapter from the base. A delivery pipe is located in the bore and bonded to the spigot. The method may further comprise reducing the thickness of the material of the fuel adapter towards the outer end of the spigot of the fuel adapter to avoid a stress concentration arising as a result of a change in material thickness between the fuel adapter and the pipe.

[0019] The method may further comprise inserting the delivery pipe into the bore of the spigot and brazing the

delivery pipe to the spigot to bond the delivery pipe to the fuel adapter.

[0020] The fuel rail assembly of the present disclosure has a structure of the components, in particular structure of the components at the joints between components which is shaped to avoid spatially localised areas of increased stress in order to improve the reliability and durability of the assembly. The fuel rail assembly of the present disclosure also provides a very cost effective solution to improving the durability of the assembly since it does without the necessity of having an extra stress-relieving component thus also providing a more compact design. It also enables flexibility in the location of the fuel rail relative to the engine.

[0021] Embodiments of the disclosure will now be described by way of example with reference to the accompanying informal drawing in which:-

Figure 1 illustrates a side view of a fuel rail with a fuel connection to a fuel injector, and

Figure 2 shows a cross-section of Figure 1 along the line A-A.

[0022] Referring now to Figure 1 there is shown a fuel rail 2 of a fuel injection system for an internal combustion engine. The fuel rail 2 comprises an elongated tube forming a reservoir for fuel which is supplied to an inlet 4. The fuel rail 2 has a plurality of fuel outlets 6 (shown in Figure 2) spaced along the length of the fuel rail 2 but only one is shown for the purposes of illustration.

[0023] A fuel adapter 8 is brazed to the fuel rail 2 and provides a connection to a fuel pipe 10 which provides a fluid connection between the fuel rail to and a fuel injector cup 12 which is adapted to receive a fuel inlet port of a fuel injector (not shown) to provide a fuel passage from the fuel rail into the injector for injection into the engine. The fuel adapter 8 has a fuel adapter base 16 which provides a bonding area by which the fuel adapter 8 is brazed to the fuel rail 2. As can be seen more clearly in Figure 2, an interior surface of the adapter base 16 provides a bonding area shaped to provide a mating surface adapted to the exterior surface of the fuel rail 2 to enable the two components to be brazed together. The size and shape of the bonding area may be determined by the loads to which the brazed joint is subject in operation.

[0024] The periphery of the fuel adapter base 16 is shaped so as not to have any sudden changes in direction which would lead to a stress concentration point, thus, it can be seen that changes in direction of the periphery have a radius 20.

[0025] As can be seen from figure 2 in particular the thickness of the base 16 is at a minimum at the periphery 18 so that the change in material thickness at the junction between the fuel adapter base 16 and the fuel rail 2 is at a minimum to minimise stress concentrations at this point. The material thickness of the base 16 increases to merge with a spigot 22 into which the fuel pipe 10 is

inserted stop the fuel pipe 10 is brazed to the spigot 22 at the outer end 24 of the spigot 22. The thickness of the outer end of the spigot is gradually reduced so that it is at a minimum at the junction between the outer ends 24 of the spigot and the fuel pipe 10 to thereby minimise stress concentrations at this point.

[0026] The thickness of the spigot wall and the spacing between the inlet end of the pipe 10 and the fuel rail 2 is determined by the stress levels encountered in practice, for example in a particular internal combustion engine. In this way the stresses applied to the components, the fuel rail 2, the fuel adapter 8 and the fuel pipe 10 and the brazed junctions between them are kept as low as possible by appropriate dimensions of the components. In this way, the cross-sectional area of the fuel adaptor 8 may be varied along its length by varying its lateral extent as well as, or alternatively and/or in addition to, varying its thickness. Thus, the stress level throughout the adapter and in the transition between adjacent components is achieved by gradual changes in material thickness and dimensions where appropriate to avoid stress concentrations.

[0027] Figures 1 and 2 also illustrate a schematic view of a mount 14 by which the fuel rail 2 is secured to the engine via the fuel pipe 10. The mount 14 by which the fuel rail 2 is secured to the engine is not tied to the fuel rail 2 so it can be located in a more convenient position, which facilitates the installation in the engine bay.

[0028] The provision of a specific shape for the bonding area between the fuel adapter and the fuel rail and the variable thickness of the fuel adapter, in particular the wall thickness of the material providing the fuel adapter, enables a neat solution to the problem of ensuring a uniform distribution of stress throughout the components and the bond, without the need of providing a further component to assist in distributing the stress. This leads to a smaller, neater solution which provides a much more compact design for packaging purposes. Varying the thickness of the fuel adapter and, particularly, its reduction in thickness at the junctions between the components leads to a very compact cost effective solution in a region which is otherwise prone to premature failure and metal fatigue. The fact that the size and shape of the bonding area between the fuel adapter and the fuel rail is readily adjustable to suit the circumstances of a particular installation is particularly cost effective. This is particularly useful where the materials of the two mating components that are brazed together are formed of different materials with different characteristics and different acceptable stress limits.

[0029] Although described with reference to providing the variable thickness of the fuel adapter 8 at the joints to both the fuel rail 2 and the fuel pipe 10 it will be appreciated that the technique could be adapted to only one of these positions.

[0030] Although described with reference to the variation in the thickness of the various parts of the fuel adapter 8 it will be understood that certain parts of the fuel rail

and the passage therethrough could be of constant thickness.

5 Claims

1. A fuel rail assembly for a fuel injection system for an internal combustion engine, comprising an elongate fuel rail (2) having a fuel inlet (4) and a plurality of fuel outlets (6) spaced along the fuel rail (2), each outlet (6) has a fuel adapter (8) bonded thereto to provide a hydraulic communication with a fuel injector cup (12) adapted to receive a fuel injector, wherein the fuel adapter (8) has a variable material thickness, the thickness being adapted to the characteristics of the fuel rail (2) and the fuel adapter (8) in order, in use, to equalise substantially the stresses applied to the fuel rail (2) and the fuel adapter (8) and the bond therebetween.
2. A fuel rail assembly according to claim 1, wherein fuel adapter (8) is brazed to the fuel rail (2) over a bonding area defined by a fuel adapter base (15), the bonding area and its shape being determined to provide, in use, a substantially uniform stress across the brazed joint.
3. A fuel rail assembly according to claim 2, wherein the periphery (18) of the bonding area has no sharp changes in direction which would result in stress concentration in the joint.
4. A fuel rail assembly according to claim 2 or 3, wherein the thickness of the material of the fuel adapter (8) is reduced towards the periphery (18) of the bonding area to minimise stress concentration arising as a result of the change in material thickness between the fuel adapter (8) and the fuel rail (2) at the junction at the periphery (18) of the bonding area.
5. A fuel rail assembly according to any one of the preceding claims, wherein the cross-sectional area of the fuel adaptor is varied along its length by varying its lateral extent as well as varying its thickness.
6. A fuel rail assembly according to any one of the preceding claims, wherein the hydraulic connection between the fuel adapter (8) and a fuel injector cup (12) includes a delivery pipe (10) which is brazed to the fuel adapter (8).
7. A fuel rail assembly according to claim 6, wherein the delivery pipe (10) is located in a bore in the fuel adapter (8) and the thickness of the material of the fuel adapter (8) is reduced towards the outer end of a spigot (22) of the fuel adapter (8) to avoid a stress concentration arising as a result of the change in

material thickness between the fuel adapter (8) and the pipe (10).

8. A fuel rail assembly according to any one of claims 2 to 7, wherein the inner face of the fuel adapter base (16) is shaped to mate with the periphery of the fuel rail (2). 5
9. A method of joining at least one component of a fuel rail assembly to a fuel rail, comprising varying the material thickness of the component over at least part of the component and reducing the thickness of the material towards the periphery of its contact area with the fuel rail so that the change in thickness of the material at the junction between the component and the fuel rail is minimal to reduce stress concentration at the junction. 10 15
10. A method according to claim 9, further comprising bonding the component to the fuel rail by brazing the contact area to the fuel rail. 20
11. A method according to claim 9 or claim 10, wherein the component is a fuel adapter and the contact area is provided by an inner face of a base (16) of the fuel adapter base (8), the inner face being shaped to mate with the periphery of the fuel rail (2). 25
12. A method according to any one of claims 9 to 11, wherein the fuel adapter (8) comprises a spigot (22) defining a bore, a delivery pipe (10) is located in the bore and brazed to the spigot (22), wherein the method further comprises reducing the thickness of the material of the fuel adapter (8) towards the outer end of the spigot (22) of the fuel adapter (8) to avoid a stress concentration arising as a result of a change in material thickness between the fuel adapter (8) and the pipe (10). 30 35
13. A method according to claim 12, further comprising inserting the delivery pipe (10) into the bore of the spigot (22) and brazing the delivery pipe (10) to the spigot (22) to bond the delivery pipe (10) to the fuel adapter (8). 40

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FIG 1

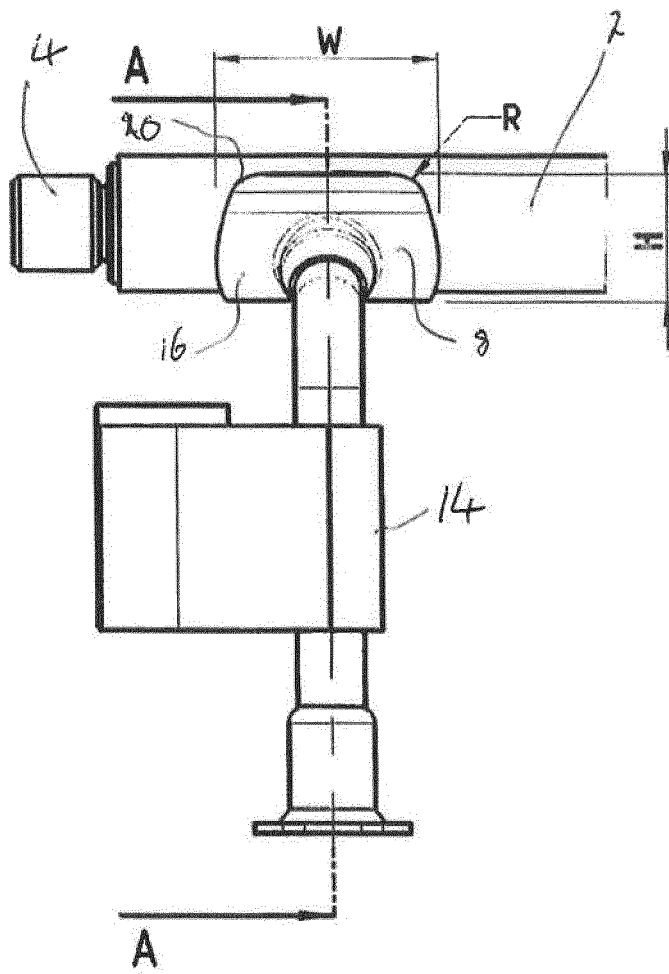
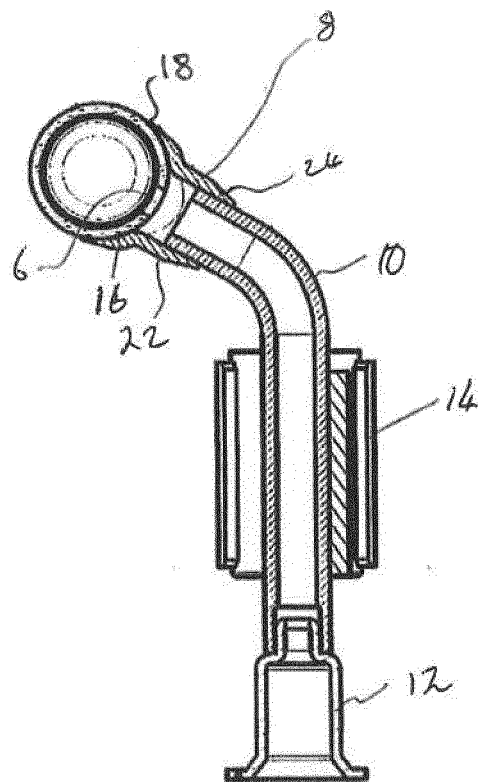


FIG 2



SECTION A-A



EUROPEAN SEARCH REPORT

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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