ABSTRACT

CYLINDER HEAD ASSEMBLY FOR INTERNAL COMBUSTION ENGINE

The present subject matter discloses an internal combustion engine (100). The internal combustion engine (100) disclosed herein includes a cylinder block (108) mounted over a crankcase (110). A cylinder head assembly (102) having a cylinder head (104) and a cylinder head cover (112) is provided. The cylinder head assembly (102) is mounted on the cylinder block (108) defining a space therebetween. An intake port (124) is formed in a first side (123) of the space defined between the cylinder head (104) and the cylinder block (108), while an exhaust port (126) is formed in a second side (125). The cylinder head (104) includes an integrated chamber (114) for accommodating a reactor (106). The integrated chamber (114) is disposed adjoining the exhaust port (126) with a longitudinal axis of the integrated chamber (114) not in line with a longitudinal axis of the exhaust port (126).

<To be published with Fig. 1(a)>

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I/ we claim:

1. An internal combustion engine (100) comprising:

a cylinder block (108) mounted over a crankcase (110);

a cylinder head assembly (102) having a cylinder head (104) and a cylinder head cover (112), the cylinder head assembly (102) is mounted on the cylinder block (108) defining a space therebetween;

an intake port (124) formed in a first side (123) of the space defined between the cylinder head (104) and the cylinder block (108); and

an exhaust port (126) formed in a second side (125) of the space defined between the cylinder head (104) and the cylinder block (108);

characterized in that, the cylinder head (104) comprises an integrated chamber (114) for accommodating a reactor (106), the integrated chamber (114) is disposed adjoining the exhaust port (126) with a longitudinal axis of the integrated chamber (114) not in line with a longitudinal axis of the exhaust port (126).

2. The internal combustion engine (100) as claimed in claim 1, wherein the integrated chamber (114) is disposed substantially above a plane intersecting the cylinder head (104) and the cylinder block (108).

3. The internal combustion engine (100) as claimed in claim 1, wherein the reactor (106) is mounted on plurality of slots (146) circumferentially disposed on the integrated chamber (114).

4. The internal combustion engine (100) as claimed in claim 1, wherein the reactor (106) is disposed inside a cavity (144) formed in the integrated chamber (114) such that the longitudinal axis of the integrated chamber (114) is substantially co-axial with a longitudinal axis (154) of the reactor (106).

5. The internal combustion engine (100) as claimed in claim 1, wherein the reactor (106) has a cylindrical cross-section, the reactor (106) comprises an outer wall (132), an inner core (152), a sleeve (118) having a plurality of grooves co-

axial with the plurality of mounting slots (146) disposed on the integrated chamber (114), a fluid inlet (120), and a fluid outlet (122).

6. The internal combustion engine (100) as claimed in claim 5, wherein the fluid inlet (120) and the fluid outlet (122) are disposed on the sleeve (118) projecting outwardly from the inner core (152), the reactor (106) is disposed on the integrated chamber (114) such that the fluid inlet (120) is substantially proximal to the exhaust port (126) and the fluid outlet (122) is substantially distal to the exhaust port (126).

7. The internal combustion engine (100) as claimed in claim 1, wherein the reactor (106) is made of a material that is inert with hydrogen and supercritical liquids, and wherein the reactor (106) is coated with a noble metal.

8. The internal combustion engine (100) as claimed in claim 1, wherein the reactor (106) disposed in the cavity (144) formed in the integrated chamber (114) defines an annular portion (130) between an inner wall (134) of the integrated chamber (114) and an outer wall (132) of the reactor (106) providing a passage for flow (138) of exhaust gases (128) expelled from the exhaust port (126).

9. The internal combustion engine (100) as claimed in claim 8, wherein the annular portion (130) is substantially 2.5 times larger in area than annular area (136) of the exhaust port (126).

10. The internal combustion engine (100) as claimed in claim 1, wherein the reactor (106) comprises a capacity of at least 45 CC for generating 1 standard litre per minute of hydrogen.

11. The internal combustion engine (100) as claimed in claim 1, wherein the reactor (106) is optionally provided with a heating element disposed internal to the sleeve (118).

12. The internal combustion engine (100) as claimed in claim 1, wherein the reactor (106) is mounted on the plurality of slots (146) provided on the integrated chamber (114) by means of one or more metal gaskets.

13. A cylinder head (104) for an internal combustion engine (100), the cylinder head (104) comprising:

a bottom surface (148) for mounting on a cylinder block (108) of the internal combustion engine (100);

a plurality of walls (150-1, 150-2, 150-3, 150-4) with each wall of the plurality of walls (150-1, 150-2, 150-3, 150-4) disposed substantially perpendicular to each edge of the bottom surface (148); and

an integrated chamber (114) adjoining an edge formed by at least two walls (150-1, 150-2) of the plurality of walls (150-1, 150-2, 150-3, 150-4).

14. The cylinder head (104) as claimed in claim 13, wherein the integrated chamber (114) is molded to the plurality of walls (150-1, 150-2, 150-3, 150-4) forming a connecting portion (142) between the at least two walls (150-1, 150-2) of the plurality of walls (150-1, 150-2, 150-3, 150-4).

15. The cylinder head (104) as claimed in claim 13, wherein the integrated chamber (114) has a cylindrical cross-section.

16. The cylinder head (104) as claimed in claim 13, wherein the integrated chamber (114) includes a flange (116) for mounting a muffler, wherein longitudinal axis of the flange (116) is substantially perpendicular to the longitudinal axis of the integrated chamber (114).

17. A vehicle comprising an internal combustion engine (100) as claimed in claims 1-12, and a cylinder head (104) as claimed in claims 13-16.

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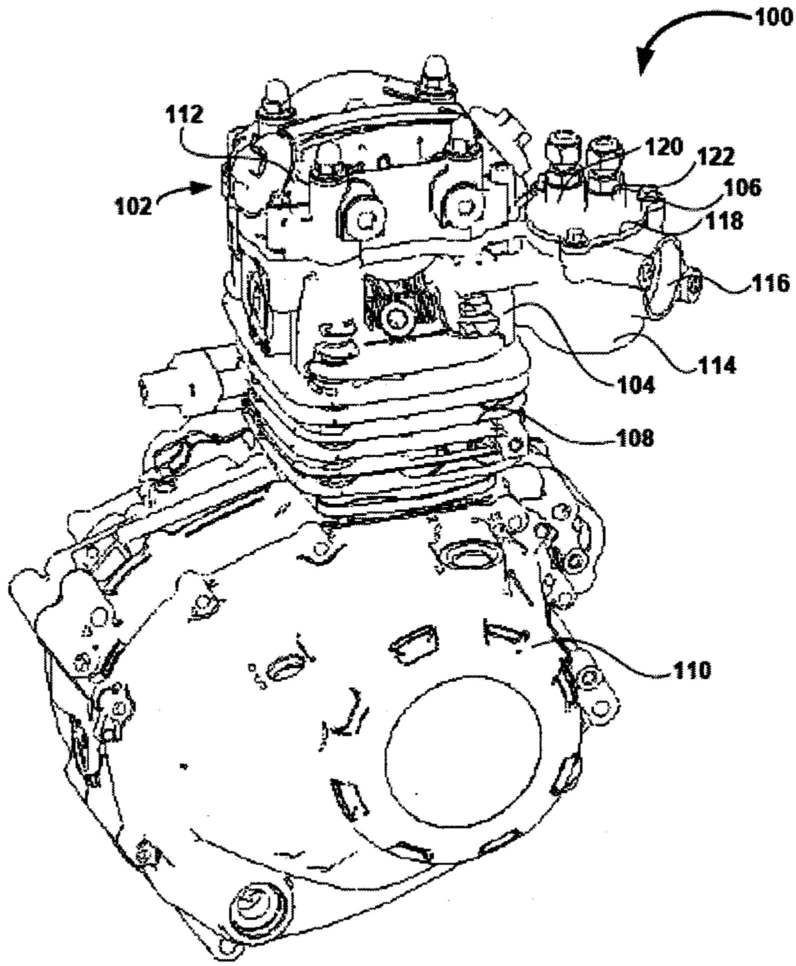

Fig. 1(a)

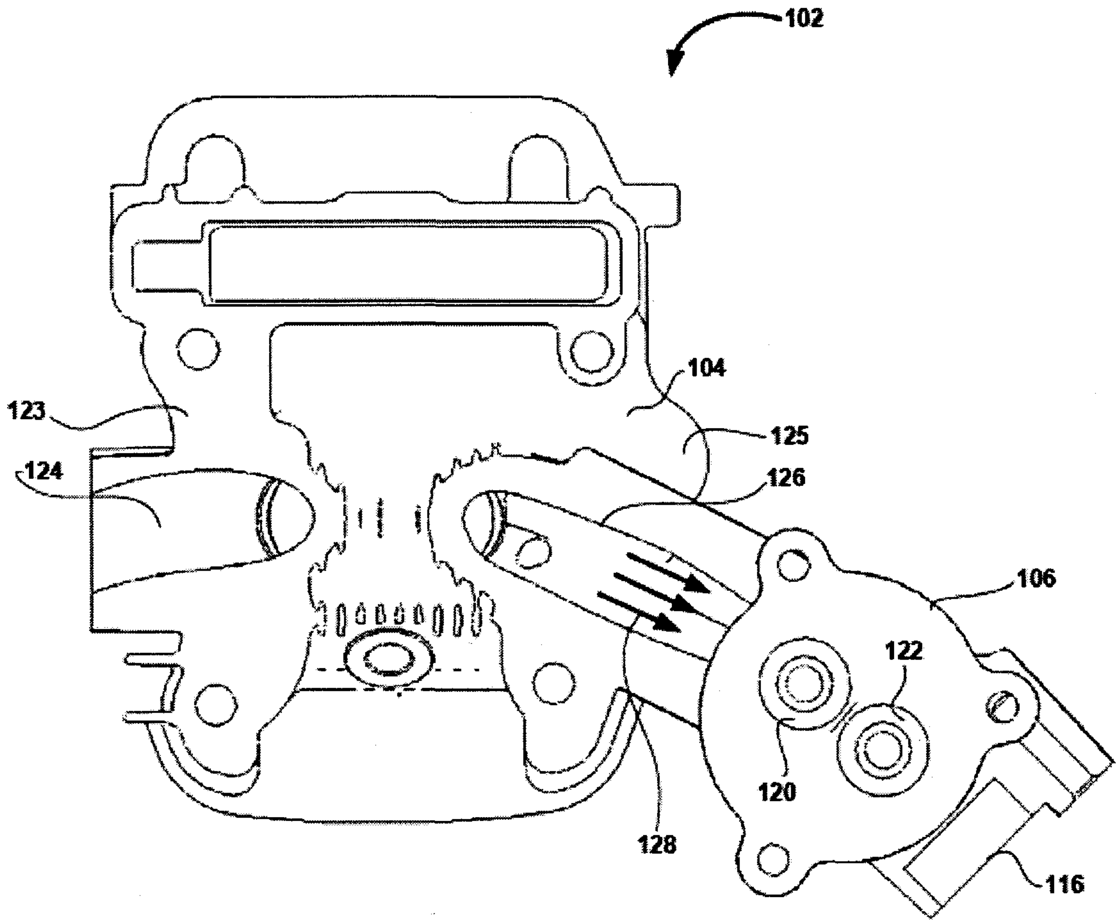

Fig. 1(b)

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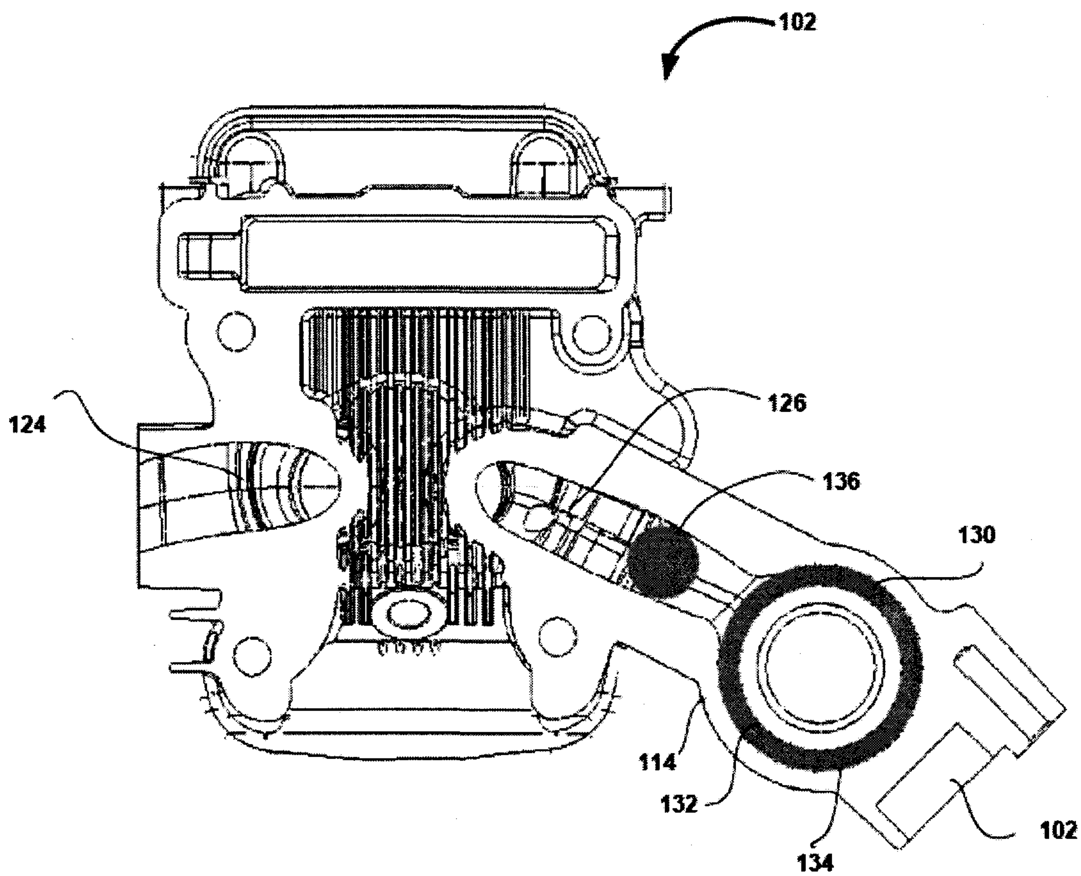

Fig. 1(c)

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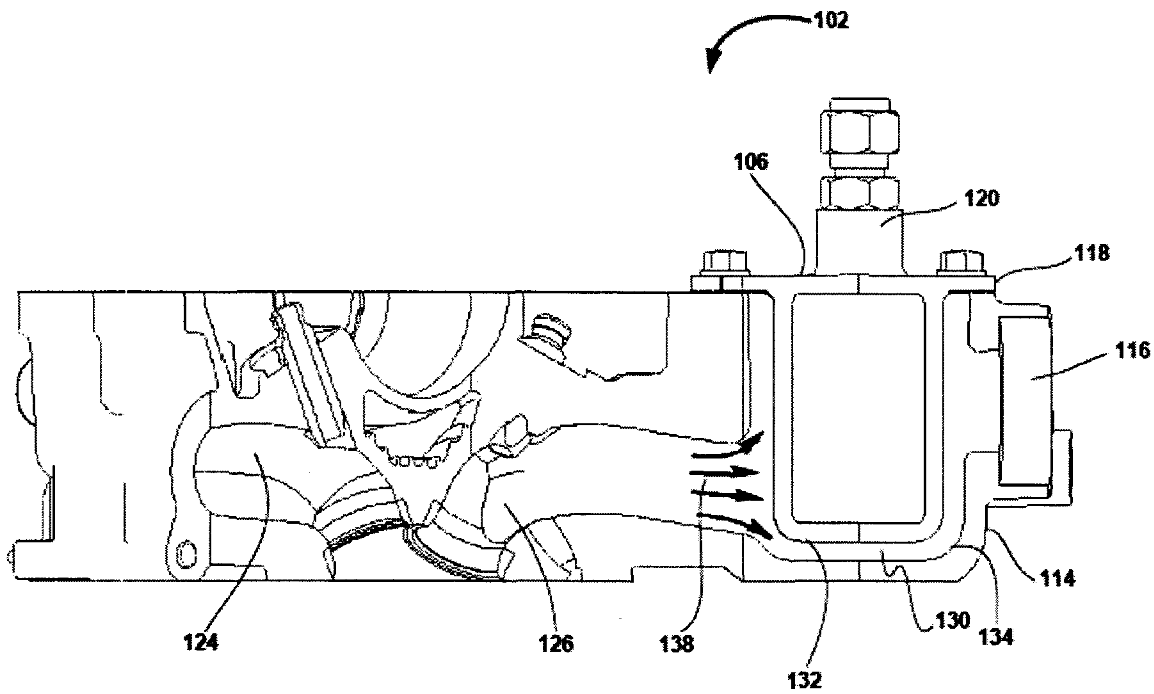

Fig. 1(d)

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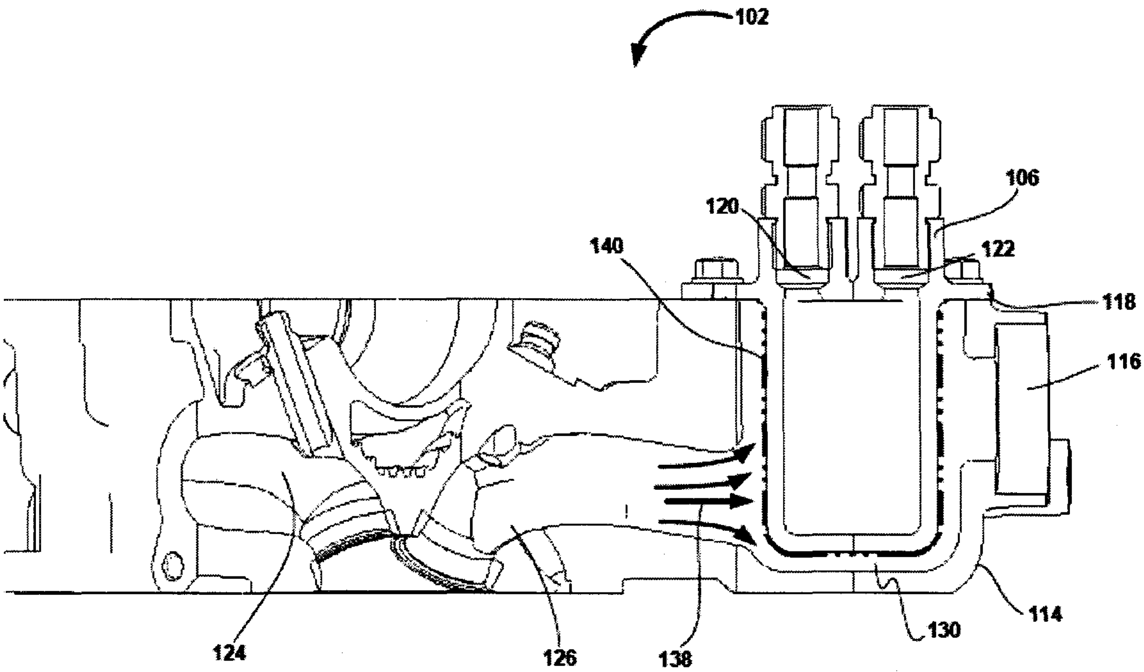

Fig. 1(e)

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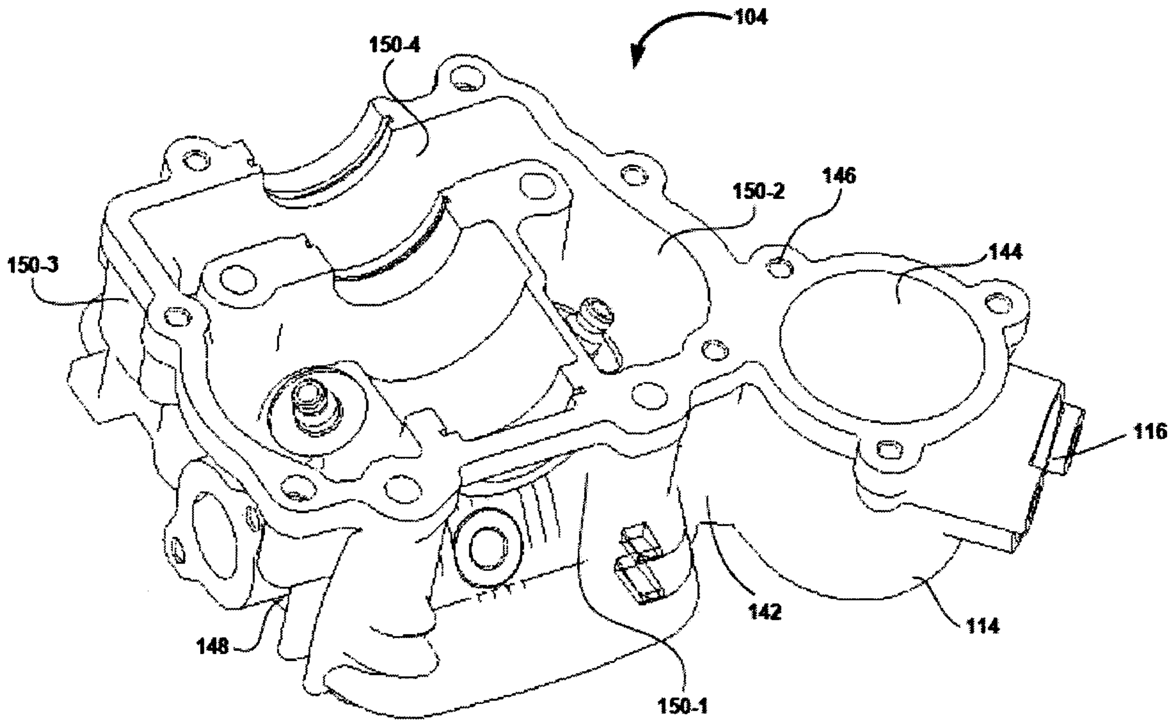

Fig. 1(f)

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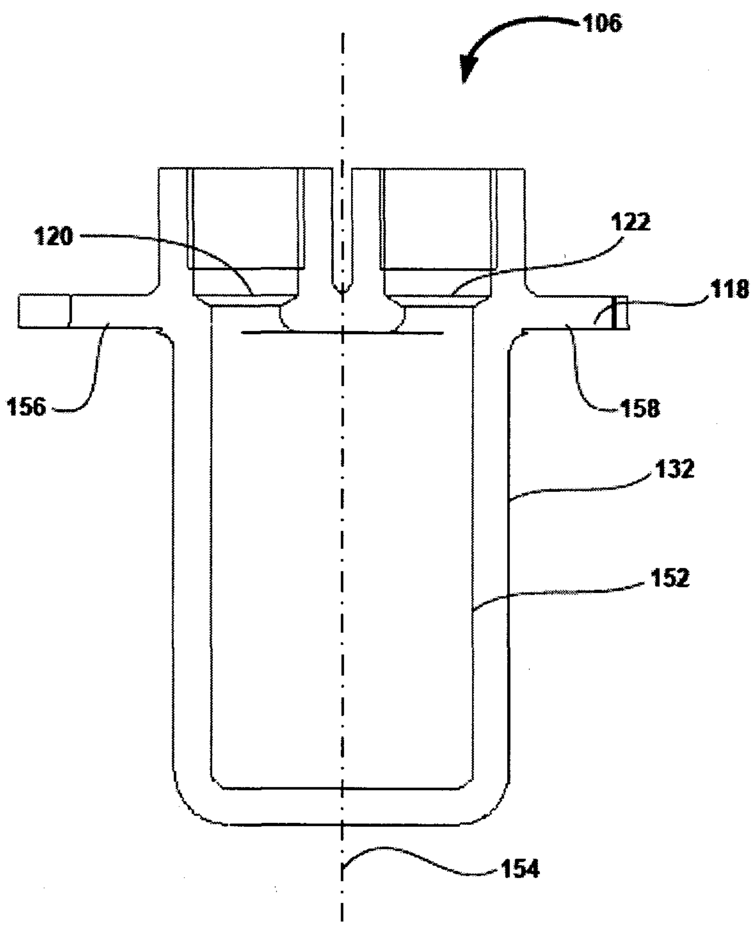

Fig. 1(g)

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TECHNICAL FIELD

[0001] The present subject matter relates generally to internal combustion engines and more particularly, but not exclusively, to a cylinder head assembly for internal combustion engine.

BACKGROUND

[0002] Generally, internal combustion engines utilize non-renewable source of energy in the form of gasoline and diesel as fuel to provide power for achieving the desired motion. Other known sources, especially some of the renewable source of energy for providing power to the internal combustion engines include bio-fuel, electricity, solar energy, and so on. Recently, there has been a huge global demand for fuel obtained from the non-renewable sources that has substantially raised the cost of crude oil. There are also other notable concerns towards meeting the stringent emission norms for internal combustion engines operated on such fuels. This has lead to the utilization of alternative fuel sources for powering internal combustion engines.

[0003] Recently, hydrogen is being widely used as an alternative fuel for powering internal combustion engines. Several research initiatives have been undertaken for effectively utilizing hydrogen as an alternative fuel both as an auxiliary fuel to engines powered by gasoline and diesel, and as an independent fuel powering internal combustion engines run only on hydrogen. Hydrogen as an alternative fuel could prove to act as an effective addendum to currently used non-renewable sources due to its high combustion efficiency at the same time could act as an environment friendly fuel on account of its low emission capability.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] The detailed description is described with reference to the accompanying figures. In the figures, the left-most digit(s) of a reference number identifies the figure in which the reference number first appears. The same numbers are used throughout the drawings to reference like features and components.

[0005] FIG. 1(a) illustrates an internal combustion (IC) engine, in accordance with an embodiment of the present subject matter.

[0006] FIG. 1(b) illustrates a top view of a cylinder head assembly of the IC engine, in accordance with an embodiment of the present subject matter.

[0007] FIG. 1 (c) illustrates a sectional top view of the cylinder head assembly of the IC engine, in accordance with an embodiment of the present subject matter.

[0008] FIG. 1 (d) illustrates a cut-sectional view of the cylinder head assembly of the IC engine, in accordance with an embodiment of the present subject matter.

[0009] FIG. 1 (e) illustrates a cut-sectional view of the cylinder head assembly of the IC engine, in accordance with another embodiment of the present subject matter.

[00010] FIG. 1 (f) illustrates a cylinder head, in accordance with an embodiment of the present subject matter.

[00011] FIG. 1 (g) illustrates a cross-sectional view of a reactor, in accordance with an embodiment of the present subject matter.

DETAILED DESCRIPTION

[00012] Conventionally, systems utilizing hydrogen as an alternative fuel involve two modes, a first mode in which hydrogen is directly used as a fuel for the IC engine, and a second mode in which hydrogen is used as a fuel in fuel cells for later utilization as a power source for vehicles capable of being propelled by fuel cells. Hydrogen generally exists abundantly in nature in the form of hydrocarbons and water. To produce hydrogen on a commercial scale, various methods are employed. Generally, hydrogen is produced by reforming hydrocarbons or their derivatives, such as Methyl alcohol, in the presence of steam at high pressure and temperature, for example, at about the supercritical point of hydrocarbon and water mixture. Further, conventional systems for producing hydrogen require bulky reactors for carrying out the reformation reaction. These reactors use electric heating coils to attain high temperature and require a high capacity power source for operation.

[00013] Typically, on-board generation of hydrogen acted as an important factor contributing towards overcoming the limitations associated with bulky hydrogen reactors. This type of hydrogen production also helps in lowering of emissions. Further, on-board generation of hydrogen also enable enhancing combustion. Conventional systems of on-board hydrogen production involve hydrogen gas production from water by electrolysis, in which oxygen and water are supplied in appropriate proportions for production of hydrogen.

[00014] Generally, the electrolysis method of producing on-board hydrogen involves electrolyzing water source stored in the vehicle based on several factors, for example, engine load requirement. The electrolysis of the water source results in separation of oxygen gas and hydrogen gas, which in turn is supplied to the IC engine as an alternative fuel. However, the process of on-board generation of hydrogen using electrolysis is a tedious process and involves several electric circuitry, which poses a serious threat for vehicle operation and also acts as a barrier for accommodation of required electric circuitry in the available space in the vehicle.

[00015] Further, the conventional techniques of using hydrogen as alternative fuel involve generating hydrogen elsewhere and storing in the form of fuel cells for later utilization as a fuel in only those vehicles that are capable of being run on fuel cells. In such techniques, the challenge is often associated with powering the IC engines that are not adapted to be run on fuel cells. Further, prior storing of hydrogen and later utilization in the form of fuel cells also involve losses due to external generation of hydrogen.

[00016] In an embodiment, the present subject matter provides a modified cylinder head that enable on-board production of hydrogen. The modified cylinder head assembly ensures that the IC engine optimally utilizes the exhaust gases for production of hydrogen. The modified cylinder head assembly helps in accommodate reactor for hydrogen production at an optimal location such that the required hydrogen is produced without heat losses. The integration of an additional chamber also called as a reaction chamber with the cylinder head enables optimal utilization of space in the IC engine. The integrated chamber accommodates the reactor for hydrogen production without interfering with other components of the IC engine. Further, the integrated chamber of the cylinder head assembly is so disposed that it does not act as an obstruction for the rider. The integrated chamber of the cylinder head assembly secures the reactor for hydrogen production thereby preventing any leakage of hydrogen.

[00017] In an embodiment, the modified cylinder head that includes the integrated chamber enable hydrogen production under supercritical conditions without using a catalyst. In an embodiment, the present subject matter describes on-board production of hydrogen using methanol. The use of methanol as an on-board hydrogen source is attractive for IC engines in transportation applications because of its safe handling, low cost and ease of synthesis from a variety of naturally available sources such as coal, natural gas, and biomass. Further, methanol as a source of hydrogen provides high H/C ratio with low soot formation as compared to other hydrocarbons. Furthermore, methanol as a source of hydrogen is effective due to its low boiling point and ease of storage. Using methanol under sustained pressure and temperature helps in achieving hydrogen yields of approximately 70% to 75%.

[00018] Methanol reacts with water generally according to the following equation:

$$CH_3OH + H_2O \rightarrow 3H_2 + CO_2$$

[00019] In an embodiment, the present subject matter relates to producing hydrogen by a process comprising the step of reacting methanol with water, at a pressure of at least about 200 bar and at a temperature of approximately 600°C.

[00020] In another embodiment, the present subject matter relates to producing on-board hydrogen in an internal combustion engine provided with a separate methanol source, and a water source. Further, the exhaust gases from the internal combustion engine acts as a heat source. In one embodiment, the internal combustion engine is further provided with a pressure pump helps in providing the methanol and the water in desired pressure to a reactor that produces on-board hydrogen, which when heated by the exhaust gases expelled by the internal combustion engine generates hydrogen.

[00021] In an embodiment, the integrated chamber of the present subject for accommodating the reactor is integrated with the cylinder head of the IC engine.

In one embodiment, the integrated chamber is integrated in such a manner that the entire chamber is mounted above the top portion of the cylinder block to enhance ease of manufacturing. Further, in one embodiment, the integrated chamber is integrated closer to the exhaust port to prevent heat losses.

[00022] In one embodiment, the integrated chamber is mounted in such a manner that the longitudinal axis of the integrated chamber is not in line to the longitudinal axis of the exhaust port. Further, the integrated chamber is provided with a flange for mounting of muffler. For example, in an embodiment, the integration of the integrated chamber with the cylinder head is applicable for different types of engines including single cylinder engine, multi cylinder engine, air-cooled engine, water-cooled engine, oil-cooled engine, and forced air-cooled engine.

[00023] In an embodiment, the reactor is mounted inside the integrated chamber of the cylinder head. The reactor is made of a material, for example, inconel 625 that is inert with hydrogen and other supercritical liquids. In another embodiment, the reactor is capable of being made with any other known material that exhibits similar properties as that of inconel 625, that is to say, being inert with hydrogen and other supercritical fluids. In one embodiment, the reactor is mounted in such a manner that a fluid inlet, for example, for fluid such as methanol-water mixture is disposed proximal to the exhaust port of the IC engine so that the heat from the exhaust gases is readily available for effective heating of the reactor. Similarly, a fluid outlet of the reactor is situated distally or away from the exhaust port.

[00024] In one embodiment, the reactor is coated with a noble metal, for example, platinum to enable quick heating of the methanol-water mixture. In another embodiment, the reactor is capable of being coated with any other noble metal that exhibits similar properties as that of platinum. Further, in one embodiment, the reactor is mounted in such a manner that there exists a substantial space between the outer surface of the reactor and the inner surface of the integrated chamber. The space provides effective passage for the exhaust gases to circulate around the reactor and allows the exhaust gases to impinge on the reactor wall. In one embodiment, the reactor is optionally provided with a heating element that enables quick heating of the methanol-water mixture to the required temperature within the shortest possible time.

[00025] Further, in an embodiment, the reactor is provided with a capacity of at least 45 cc for generating 1 standard litre per minute (SLPM) of Hydrogen. In one embodiment, the annular area of the space between the additional chamber and the reactor is approximately 2.5 times that of the exhaust port to prevent creation of back-pressure and engine performance variations. Further, in an embodiment, the reactor is mounted on the additional chamber of the cylinder head with the help of metal gasket joint arrangement for improved sealing and preventing leakage of hot gases. In another embodiment, other known sealing means that exhibits similar properties as that of the metal gasket joint arrangement is advantageously used.

[00026] These and other advantages of the present subject matter would be described in greater detail in conjunction with the figures in the following description.

[00027] FIG. 1(a) illustrates an internal combustion (IC) engine, in accordance with an embodiment of the present subject matter. In an embodiment, the present subject matter describes an internal combustion (IC) engine 100. In one example, the IC engine 100 is a two-stroke internal combustion engine. In another example, the IC engine 100 can be a four-stroke internal combustion engine. In one embodiment, the IC engine 100 includes a crankcase 110 connected to a charging device (not shown). The crankcase 110 houses a crankshaft (not shown). Further, a cylinder block 108 having a cylinder bore (not shown) is mounted on the crankcase 110. In one embodiment, the cylinder block 108 is provided with an induction valve (not shown) for enabling a unidirectional induction of a scavenging fluid, such as fresh air or a lean composition of charge formed by mixture of air and fuel, into the crankcase 102.

[00028] During operation of the IC engine 100, a piston (not shown) disposed within the cylinder bore engages in reciprocating movement for effecting combustion of the air-fuel mixture that is drawn inside. In one example, the IC engine 100 is provided with more than one cylinder bore. Further, the piston is connected to the crankshaft (not shown) through a connecting rod (not shown) to drive the crankshaft. Inside the cylinder bore, the piston has two extreme positions - a top dead centre (TDC) position when the IC engine 100 has completed a compression stroke and a bottom dead centre (BDC) position from where the piston commences actuation at the beginning of the compression stroke.

[00029] Further, in an embodiment, the IC engine 100 of the present subject matter includes a cylinder head assembly 102. In one embodiment, the cylinder head assembly 102 includes a cylinder head 104, a cylinder head cover 112, and a reactor 106 disposed within an additional chamber, hereinafter referred to as an integrated chamber 114.

[00030] In one embodiment, the cylinder head 104 of the present subject matter includes one or more ports, for example, an intake port 124 and an exhaust port 126. In one embodiment, the intake port 124 is disposed on a first side 123 (shown in Fig. 1 (b)) of the cylinder head 104 while the exhaust port 126 is disposed on a second side 125 (shown in Fig. 1 (b)) of the cylinder head 104. In one embodiment, the cylinder head 104 includes at least one inlet port 124 for intake of charge into the cylinder block 108, and at least one exhaust port 126 for discharge of combustion products from the cylinder bore of the cylinder block 108. In one embodiment, the intake port 124 is connected to a combustion chamber (not shown) of the IC engine 100 for induction of charge into the combustion chamber. Each of the ports 124, 126 is provided with a valve to control the opening and closing of the ports 124, 126. Further, the ports 124, 126 are provided with a valve seat, corresponding to each valve. The valve lifts and rests at the valve seat during the opening an closing of the ports 124, 126.

[00031] In one embodiment, the cylinder head 104 is integrated with an integrated chamber 114. For example, in one embodiment, the integrated chamber 114 is moulded with the cylinder head 104 to form a continuous space. In one embodiment, the integrated chamber 114 has a cylindrical cross-section, while the cylinder head 104 has a different cross-section, for example, a rectangular cross-section. In one embodiment, the integrated chamber 114 is capable of receiving a reactor 106 inside a cavity 144 (shown in Fig. 1(f)).

[00032] In one embodiment, the integrated chamber 114 is disposed in such a manner that it adjoins the exhaust port 126. In one embodiment, the integrated chamber 114 is disposed with its longitudinal axis not in line with the longitudinal axis of the exhaust port 126. For example, the integrated chamber 114 can be inclined at any angle ranging from 1° to 179° and preferably in a range of 75° to 105° with respect to the longitudinal axis of the exhaust port 126.

[00033] In one embodiment, the integrated chamber 114 of the cylinder head 104 is disposed substantially above a plane intersecting the cylinder head 104 and the cylinder block 108. For example, moulding the integrated chamber 114 above an imaginary line passing in the intersection of the cylinder head 104 and the cylinder block 108 enhances the ease of manufacturing of the IC engine 100.

[00034] FIG. 1(b) illustrates a top view of the cylinder head assembly 102 of the IC engine, in accordance with an embodiment of the present subject matter. In an embodiment, the cylinder head assembly 102 includes the cylinder head 104 and the reactor 106. The cylinder head 104 is provided with the intake port 124 on the first side 123 and the exhaust port 126 on the second side 125 of the cylinder head 104. In one embodiment, the air-fuel mixture is introduced into the combustion chamber through the intake port 124. In an embodiment, a carburettor (not shown) can be used to supply fuel to the combustion chamber. In another embodiment, a fuel injection device that communicates with the intake port 124 providing the necessary air-fuel mixture for combustion can replace the carburettor. The intake port 124 is capable of being opened and closed by means of an intake valve arrangement, which can be disposed within an intake valve seat provided on the intake port 124.

[00035] In one embodiment, the cylinder head 104 is provided with the exhaust port 126 that acts as a channel for expelling the waste gases that are produced as a result of combustion in the combustion chamber. For example, the waste gases are referred to as exhaust gases 128 hereinafter. Similar to the arrangement with respect of the intake port 124, the exhaust port 126 is also opened and closed in a known manner by means of an exhaust valve arrangement, which is conveniently disposed within an exhaust valve seat provided on the exhaust port 126.

[00036] In one embodiment, the cylinder head 104 is further provided with the integrated chamber 114. For example, the integrated chamber 114 is moulded to the cylinder head 104 in the vicinity of the second side 125 of the cylinder head 104 such that the integrated chamber 114 is proximal to the exhaust port 126 as compared to the intake port 124. The proximity of the integrated chamber 114 and the exhaust port 126 ensures that the exhaust gases 128 that are expelled out of the exhaust port 126 do not go unutilized. For example, the heat available in the exhaust gases 128 is utilized as a heat source for the synthesis of hydrogen within the integrated chamber 114 of the cylinder head 104. The modified construction of the IC engine 100 where the cylinder head 104 is integrated with the integrated chamber 114 that acts as a housing for the reactor 106 ensures that the heat otherwise lost in the form of exhaust gases 128 are available for the synthesis of hydrogen.

[00037] In one embodiment, the reactor 106 of the cylinder head assembly 102 is disposed within the cavity 144 (shown in Fig. 1(f)) of the integrated chamber 114 in such a manner that the longitudinal axis of the integrated chamber 114 is substantially co-axial with a longitudinal axis 154 (shown in Fig. 1 (g)) of the reactor 106. Further, in one embodiment, the reactor 106 is provided with a fluid inlet 120 and a fluid outlet 122. For example, a central axis of the fluid inlet 120 and a central axis of the fluid outlet 122 are provided substantially parallel to the longitudinal axis 154 of the reactor and on either side to an imaginary central line passing along the longitudinal axis 154 of the rector 106.

[00038] In one embodiment, the fluid inlet 120 of the reactor 106 is disposed substantially proximal to the exhaust port 126 and the fluid outlet 122 of the reactor 106 is disposed substantially distal to the exhaust port 126. The substantially proximal location of the fluid inlet 120 ensures that the heat from the exhaust gases 128 are available immediately to the fluid, for example, mixture of methanol and water, that is entering the fluid inlet 120. Further, the substantial proximal location of the fluid inlet 120 also helps in achieving an optimal reaction between methanol and water mixture and helps in increasing the percentage of hydrogen generated as a result of the reaction in addition to quickening the reaction time. In one embodiment, the exhaust gases 128 are expelled out of the exhaust port 126 in a direction that is substantially perpendicular to the longitudinal axis 154 of the reactor 106.

[00039] In one embodiment, the integrated chamber 114 of the present subject matter is provided with a flange 116 for mounting a muffler device (not shown) that expels out the exhaust gases 128 after utilization for on-board hydrogen production.

[00040] FIG. 1 (c) illustrates a sectional top view of the cylinder head assembly 102 of the IC engine 100, in accordance with an embodiment of the present subject matter. In one embodiment, the reactor 106 is disposed within the cavity 144 (shown in Fig. 1 (f)) of the integrated chamber 114 in such a manner that an annular portion 130 is formed between an inner wall 134 of the integrated chamber 114 and the outer wall 132 of the reactor 106. In one embodiment, the annular portion 130 provides a passage for flow 138 (shown in Fig. 1 (d)) of the exhaust gases 128 that are expelled out of the exhaust port 126.

[00041] In one embodiment, the annular portion 130 possess an annular area of approximately 2 to 3.5 times more than an annular area of the exhaust port 126. In a preferred embodiment, the annular portion 130 is approximately 2.5 times more than an annualr area of the exhaust port 126 thereby preventing creation of back-pressure while the exhaust gases 128 flow from the exhaust port 126 into the annular portion 130 of the integrated chamber 114. The prevention of back-pressure is directly related to engine performance variations as a raise in the back-pressure potentially increases the variations in the engine output causing the engine performance to deteriorate.

[00042] FIG. 1 (d) illustrates a cut-sectional view of the cylinder head assembly 102 of the IC engine 100, in accordance with an embodiment of the present subject matter. In one embodiment, the exhaust gases 128 that are expelled out of the exhaust port 126 flows 138 in a direction that is substantially perpendicular to the reactor 106. In an embodiment, the exhaust gas flow 138 is directed to impinge on the outer wall 132 of the reactor 106. After impinging on the outer wall 132 of the reactor 106, the exhaust gas flow 138 immediately occupies the space available in the annular region 130 that is created between the outer wall 132 of the reactor 106 and the inner wall 134 of the integrated chamber 114. The enclosure formed by the exhaust gases 128 in the annular region 130 around the reactor 106 ensures that the heat from the exhaust gases 128 is completely utilized for heating the fluid entering the reactor 106 through the fluid inlet 120. In one embodiment, the fluid inlet 120 of the reactor 106 is disposed proximal to the exhaust port 106 such that any form of heat losses occuring due to the distance between the exhaust port 106 and the fluid entering the fluid inlet 120 of the reactor 106 is substantially eliminated. Further, in one embodiment, the exhaust gases 128 that enter the annular region 130 is routed out through the flange 116 for mounting muffler after transferring the maximum available heat to the reactor 106 for heating the reaction fluid used for on-board hydrogen production.

[00043] In one embodiment, the reactor 106 has a reactor sleeve 118 that has a cylindrical cross-section. The reactor sleeve 118 is formed on a top portion of the reactor 106 and acts as a cover for the reactor 106. In one embodiment, the reactor sleeve 118 has two extending arms 156, 158 (shown in Fig. 1 (g)) that is extended along the top surface of the integrated chamber 114. In one embodiment, the extending arms 156, 158 are coupled to the plurality of slots 146 for mounting the reactor 106 on the integrated chamber 114. In one embodimemt, any known fasteners in the art including nuts, bolts, and rivets can be used for mounting the extending arms 156, 158 of the reactor 106 to the integrated chamber 114. In one embodiment, the externding arms 156, 158 of the reactor 106 are mounted on the plurality of slots 146 of the integrated chamber 114 by means of one or more metal gaskets. In an embodiment, the one or more metal gaskets provides metal gasket joint arrangement, which substantially improves the sealing achieved between the reactor 106 and the integrated chamber 114 and thereby preventing any form of leakage of hot gases from the integrated chamber 114 of the cylinder head 104.

[00044] FIG. 1 (e) illustrates a cut-sectional view of the cylinder head assembly 102 of the IC engine 100, in accordance with another embodiment of the present subject matter. In an embodiment, the exhaust gas flow 138 through the annular region 130 of the integrated chamber 114 impinges on a reactor wall coating 140 provided on the outer wall 132 of the reactor 106. In an embodiment, the reactor wall coating 140 is formed by means of a noble metal known in the art.

In an embodiment, the reactor wall coating 140 is preferably formed by means of platinum, which is a noble metal. In an embodiment, coating the outer wall 132 of the reactor 106 with platinum substantially enhances the rate at which the fluid entering the reactor 106 is heated. For example, the fluid entering the reactor 106 at a predetermined pressure and temperature, when it is not coated with the noble metal is heated in n seconds. While, the fluid entering the reactor 106, when coated with the noble metal is heated in n-1 seconds thereby enhancing the rate of reaction for on-board hydrogen production. In one embodiment, the reactor 106 is provided with an additional heating element (not shown) internal to the reactor sleeve 118 for further heating of the reaction fluid in addition to the improved heating provided as a result of the reactor wall coating 140 with the noble metal.

[00045] FIG. 1 (f) illustrates a cylinder head 104, in accordance with an embodiment of the present subject matter. In one embodiment, the cylinder head 104 of the present subject matter has a hemispherical bottom surface 148 capable of being mounted on top of the cylinder block 108 of the IC engine 100. In an embodiment, the bottom surface 148 of the cylinder head 104 and the cylinder block 108 defines a combustion chamber (not shown) of the IC engine 100. In an embodiment, the bottom surface 148 has four edges overlapping a top surface of the cylinder block 108 of the IC engine 100. In an embodiment, the cylinder head 104 includes a plurality of walls 150-1, 150-2, 150-3, 150-4 that are disposed along the edges of the bottom surface 148 and substantially perpendicular to each edge of the bottom surface 148. In one embodiment, the bottom surface 148 along with the four walls 150-1, 150-2, 150-3, 150-4 and the cylinder head cover 112 (not shown) of the cylinder head assembly 102 forms a box-type structure that is capable of accommodating one or more devices that assists in fuel injection and combustion.

[00046] In an embodiment, the cylinder head 104 includes the integrated chamber 114 adjoining an edge formed by at least two walls 150-1, 150-2 of the plurality of walls 150-1, 150-2, 150-3, 150-4 of the cylinder head 104. In one embodiment, the integrated chamber 114 has a cylindrical cross-section and is molded along the edge formed between the adjoining walls 150-1, 150-2 of the cylinder head 104. The molding of the integrated chamber 114 adjoining the walls

150-1, 150-2 forms a connecting portion 142. In an embodiment, the integrated chamber 114 is provided with an externally projecting flange 116 for mounting the muffler. For example, the flange 116 is disposed in such a manner that a longitudinal axis of the flange 116 is substantially perpendicular to the longitudinal axis of the integrated chamber 114. In one embodiment, the integrated chamber 114 is provided with the plurality of slots 146 that are circumferentially disposed on top of the cylindrical integrated chamber 114 for enabling mounting of the reactor 106 within the cavity 144 of the integrated chamber 114.

[00047] FIG. 1 (g) illustrates a cross-sectional view of the reactor 106, in accordance with an embodiment of the present subject matter. In an embodiment, the reactor 106 has a cylindrical cross-section so as to enable mounting of the reactor 106 within the cavity 144 (shown in Fig. 1(f)) of the integrated chamber 114 of the cylinder head 104 (shown in Fig. 1 (f)). In one embodiment, the cylindrical reactor 106 is provided with the outer wall 132 and an inner core 152. In an embodiment, the reaction fluid that enters the reactor 106 through the fluid inlet 120 substantially fills the inner core 152 of the reactor 106. In an embodiment, for example, the reaction fluid is a mixture of methanol and water that is filled in the reactor core 152. When heated by the exhaust gases 128 that envelopes the outer wall 132 of the reactor 106, reaction occurs between the reaction fluid of methanol and water resulting in the generation of hydrogen along with a residue of carbon-di-oxide. The resultant hydrogen and carbon-di-oxide gases are routed out of the reactor 106 through the fluid outlet 122. In one embodiment, the resultant hydrogen and carbon-di-oxide is routed to the intake port 124 acting as an alternative fuel. In one embodiment, the resultant fluid passing out of the fluid outlet 122 contains a substantial amount of unreacted fluid in addition to the hydrogen-carbon-di-oxide gaseous mixture. In order to separate the unreacted fluid from the hydrogen, the resultant fluid is routed to a separator (not shown) that separates the unreacted fluid from hydrogen and routes back to the fluid inlet 120 of the reactor 106.

[00048] In one embodiment, the reactor 106 is provided with the reactor sleeve 118 that has a plurality of extending arms 156, 158 extending outwardly from the longitudinal axis 154 of the reactor 106. The extending arms 156, 158 is provided with a plurality of grooves that are co-axial with the plurality of mounting slots 146 disposed on the integrated chamber 114. In one embodiment, the fluid inlet 120 and the fluid outlet 122 are disposed on the reactor sleeve 118 projecting outwardly from the inner core 152. Further, in an embodiment, the reactor 106 is made of a material that is inert with hydrogen and other supercritical liquids that reaches a predetermined pressure and temperature. For example, the reactor 106 is made of the alloy inconel 625 that possess the required characteristics. Furthermore, in one embodiment, the reactor 106 is provided with a capacity of approximately at least 45 CC for generating 1 standard litre per minute (SLPM) of hydrogen.

[00049] Although the subject matter has been described in considerable detail with reference to certain embodiments thereof, other embodiments are possible. It is to be understood that the appended claims are not necessarily limited to the features described herein. Rather, the features are disclosed as embodiments of the IC engine 100 and the cylinder head 104.