



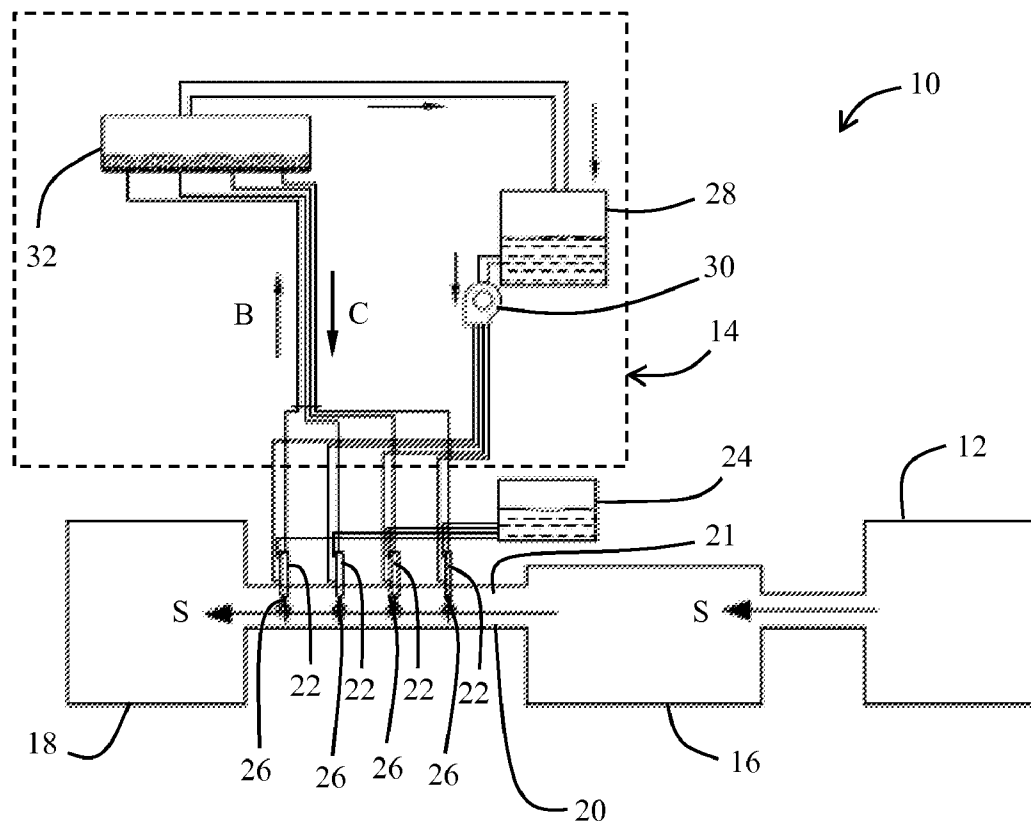
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(19) **United States**(12) **Patent Application Publication**
Gharpure(10) **Pub. No.: US 2015/0192046 A1**(43) **Pub. Date: Jul. 9, 2015**(54) **INJECTOR UNIT FOR AFTER-TREATMENT
SYSTEM**(52) **U.S. Cl.**CPC **F01N 3/04** (2013.01)(71) Applicant: **Perkins Engines Company,**
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Peterborough (GB)(21) Appl. No.: **14/660,993**(22) Filed: **Mar. 18, 2015****Publication Classification**(51) **Int. Cl.**
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(57) **ABSTRACT**

An after-treatment system for an engine is disclosed herein. The engine has a horizontal axis and a vertical axis. The after-treatment system includes a housing assembly, a coolant circuit with a coolant tank, and at least one injector unit. The injector unit includes a first port and a second port. The second port is in fluid communication with the first port. The first port is fluidly connected to the coolant tank. Further, the injector unit is mounted on the housing assembly, such that the first port is positioned substantially vertically above the second port, along the vertical axis. In addition, the injector unit includes a datum line that passes through the first port and the second port. An included angle defined by the datum line relative to the horizontal axis is generally about 60 degrees, when a width of the housing assembly is parallel to the horizontal axis.



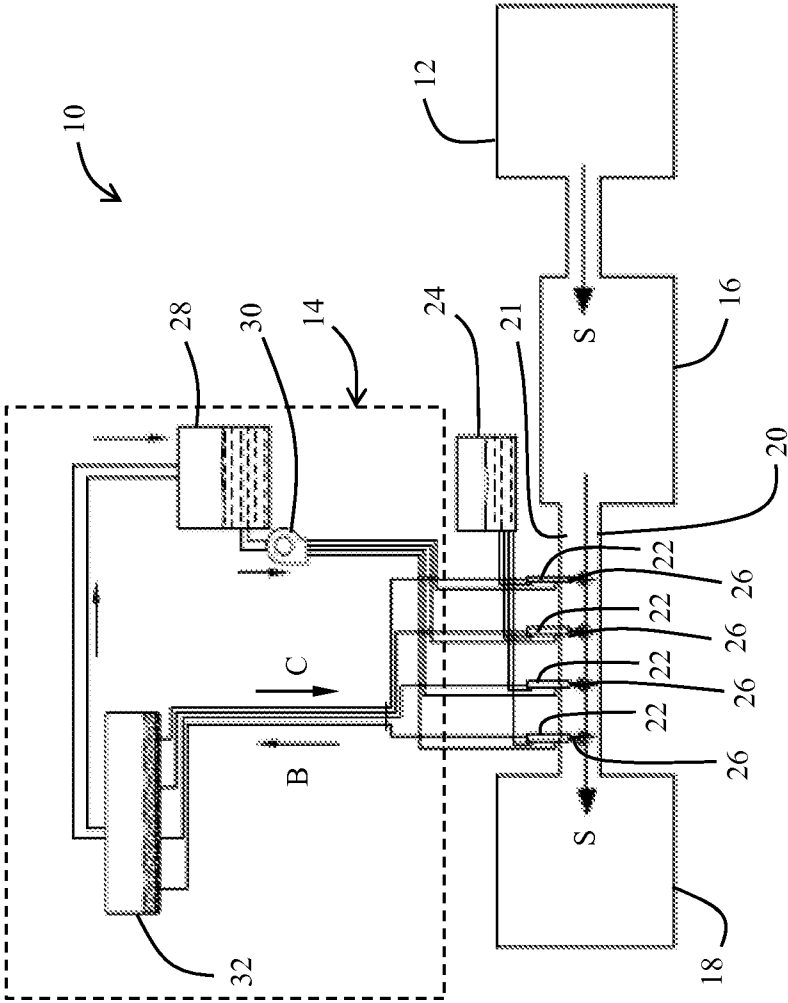


FIG. 1

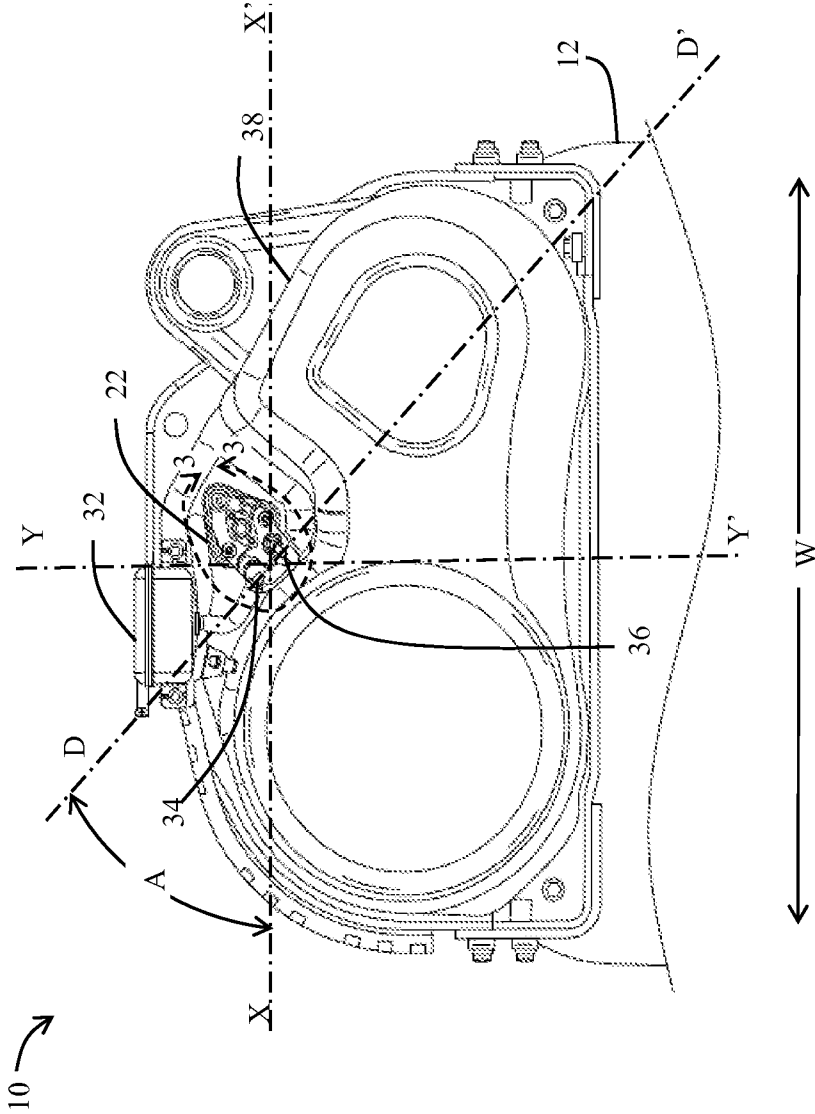


FIG. 2

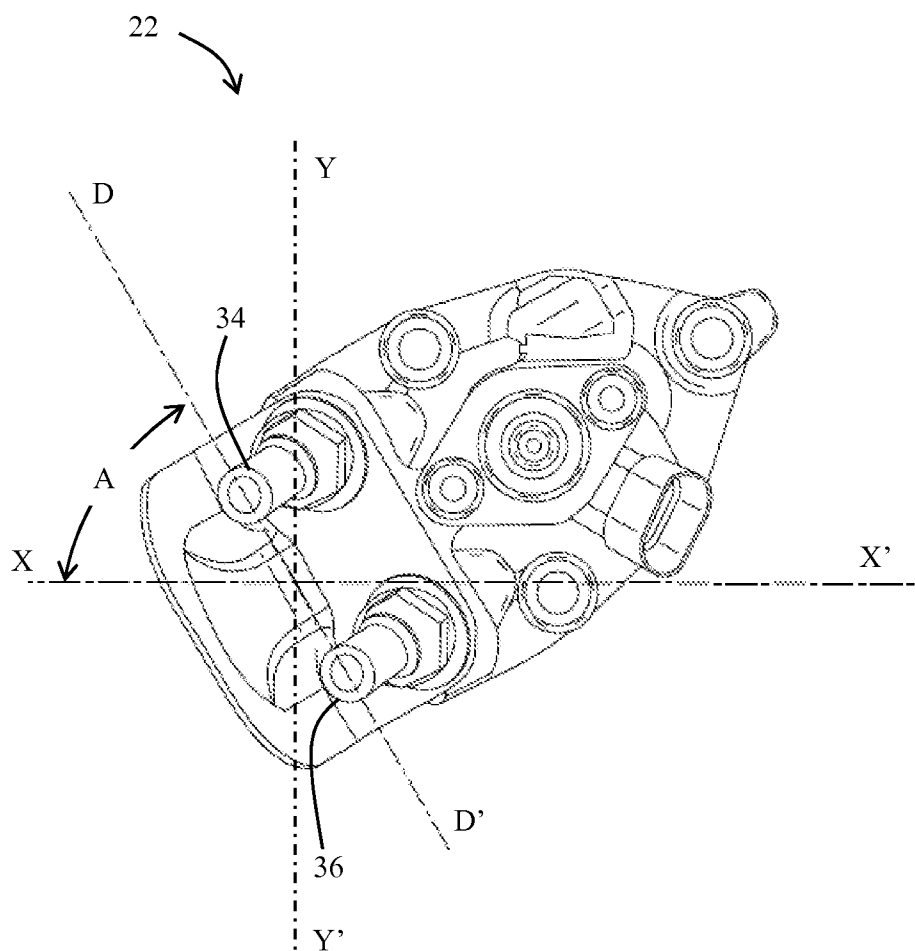


FIG. 3

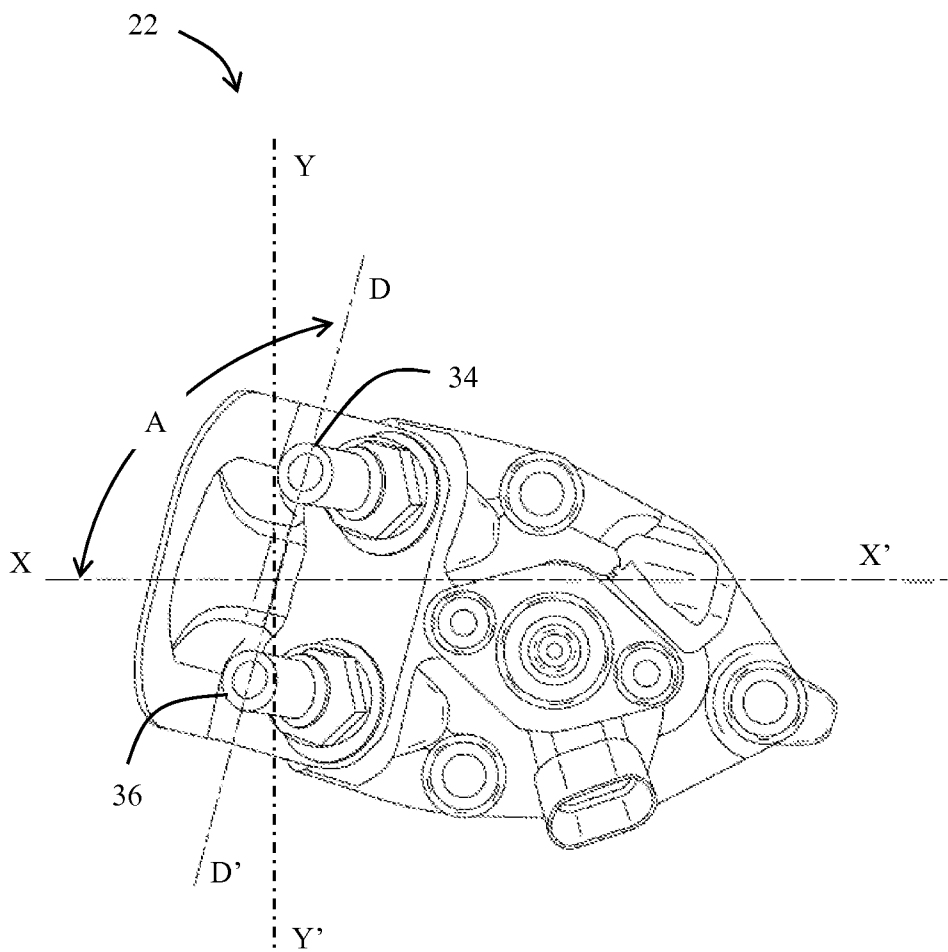


FIG. 4

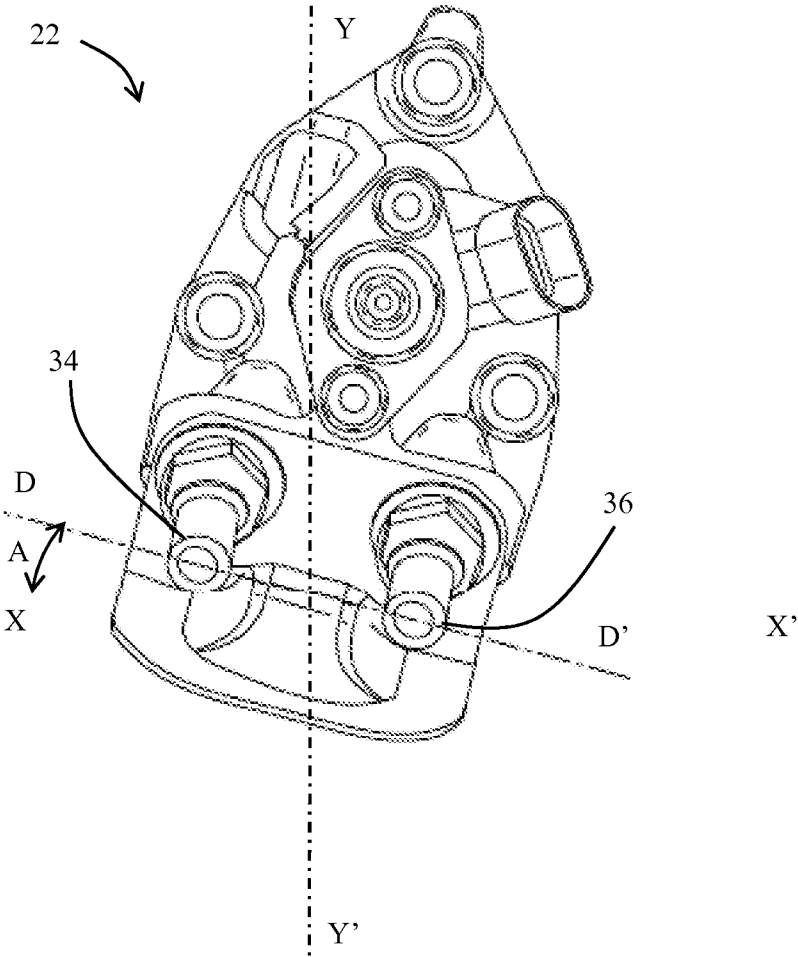


FIG. 5

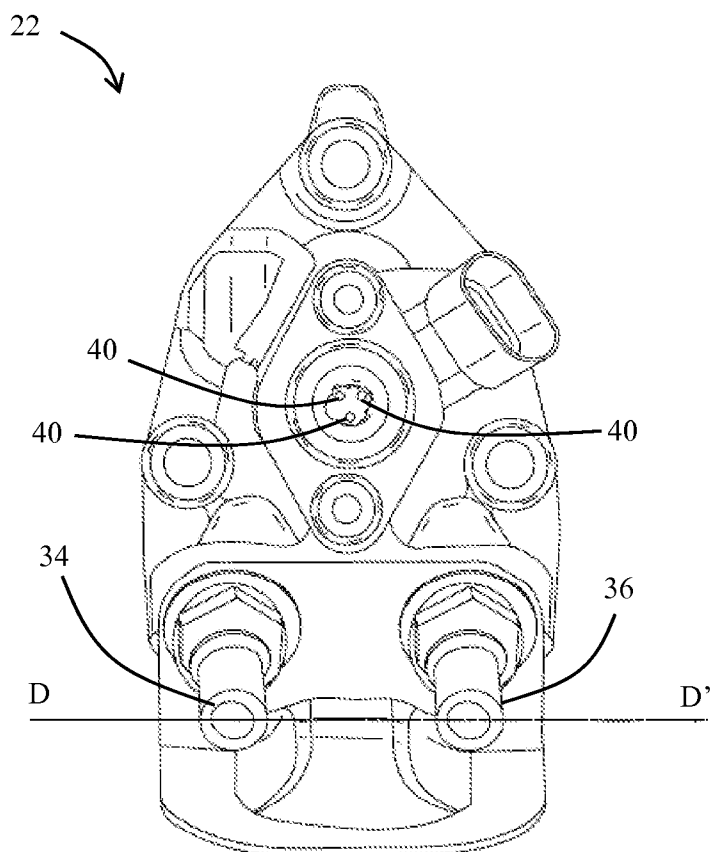


FIG. 6A

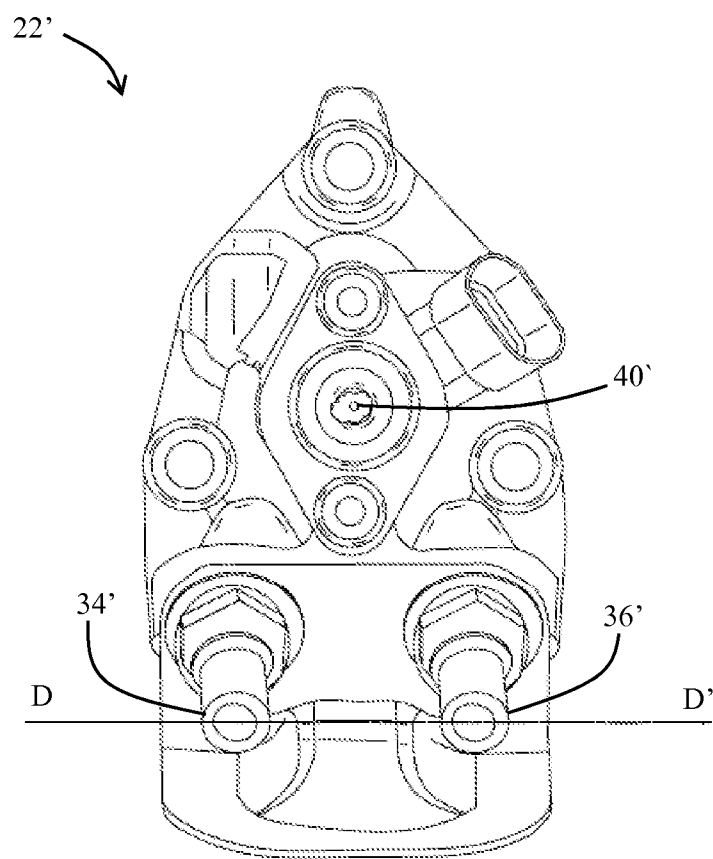


FIG. 6B

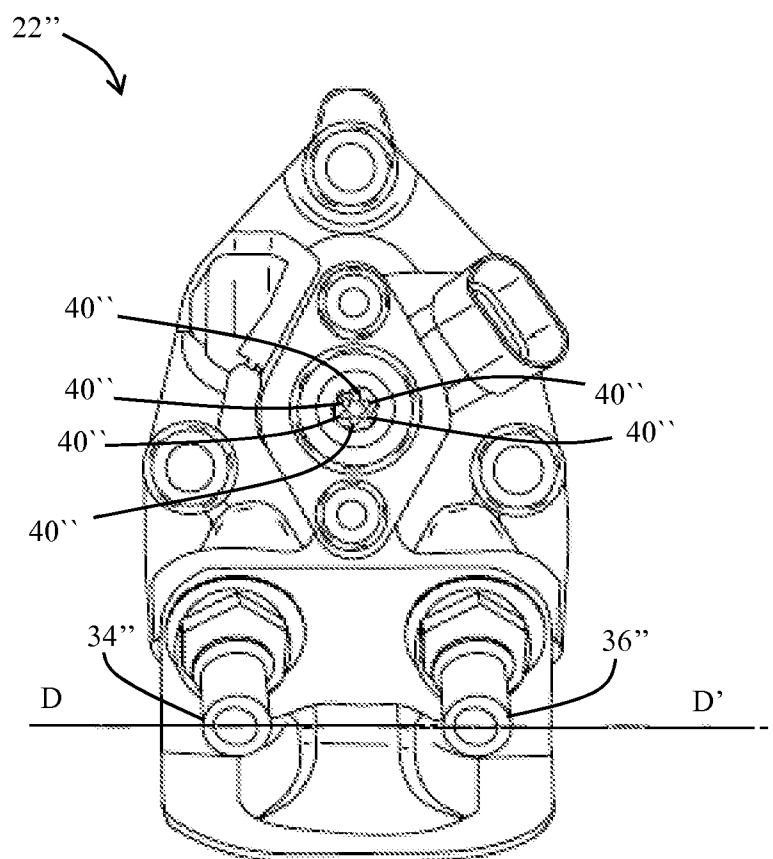


FIG. 6C

INJECTOR UNIT FOR AFTER-TREATMENT SYSTEM

TECHNICAL FIELD

[0001] The present disclosure relates generally to an after-treatment system for engines. More specifically, the present disclosure relates to the positioning of an injector unit in the after-treatment system.

BACKGROUND

[0002] After-treatment systems are generally employed in an internal combustion engine of a machine for treatment of exhaust gases. An after-treatment system commonly includes a number of injector units that inject a reductant fluid into a stream of exhaust gas. During operations, an injector tip of an injector unit is subjected to considerably high temperature conditions by the exhaust gas, which may damage the injector tip. Therefore, the after-treatment system generally employs a cooling circuit around the injector tip to inhibit the effects of such high temperatures. The cooling circuit commonly includes a coolant tank and a fluid pump and is adapted to circulate coolant within the injector unit. For this purpose, the injector unit includes a first port in fluid communication with the coolant tank and a second port in fluid communication with the fluid pump.

[0003] In conventional after-treatment systems, the injector unit is mounted on the after-treatment system, such that the first port and the second port are at a same height in reference to a horizontal axis of the engine. During hot engine shutdowns, the fluid pump may be inoperative (the fluid pump runs via the engine, therefore the fluid pump stops operation, when engine speed reaches 0 rpm) and the flow of coolant to the injector unit may temporarily cease, which may cause the coolant left in the injector units to evaporate. As a result, the vaporized coolant may flow through the first port to the coolant tank, exert vapor pressure on the condensed coolant of the coolant tank, and may cause the condensed coolant to replenish the fluid within the injector unit. However, in certain conditions, such as an operation of the machine on unlevelled terrains, the second port may be tilted upwards relative to the first port. In such conditions, a considerable amount of vaporized coolant may unfavorably flow out or escape through the second port towards the fluid pump, while a relatively lesser quantity of vaporized coolant may flow to the coolant tank. As a result, a reverse flow of vaporized coolant is minimized, substantially reducing the capacity to cool the fuel injectors during a hot engine shutdown. This may result in heat up and damage to the injector tip of the injector unit.

SUMMARY OF THE INVENTION

[0004] Various aspects of the present disclosure illustrate an after-treatment system for an engine. The engine has a horizontal axis and a vertical axis. The after-treatment system includes a housing assembly, a coolant circuit with a coolant tank, and at least one injector unit. The injector unit includes a first port and a second port. The first port is in fluid communication with the coolant tank of the cooling circuit. The second port is in fluid communication with the first port. Moreover, the injector unit is mounted on the housing assembly, such that the first port is positioned substantially vertically above the second port, along the vertical axis. In addition, the injector unit includes a datum line that passes through the first port and the second port. An included angle

defined by the datum line relative to the horizontal axis is generally about 60 degrees, when a width of the housing assembly is parallel to the horizontal axis.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] FIG. 1 is a schematic view of a cooling circuit applied in an after-treatment system of an internal combustion engine, in accordance with the concepts of the present disclosure;

[0006] FIG. 2 is a side view of a housing assembly of the after-treatment system of FIG. 1, assembled with an injector unit, in accordance with the concepts of the present disclosure;

[0007] FIG. 3 is an enlarged view of the injector unit of FIG. 2 that illustrates an orientation of the injector unit when the housing assembly is parallel to a horizontal axis, in accordance with the concepts of the present disclosure;

[0008] FIG. 4 is an enlarged view of the injector unit of FIG. 2 that illustrates an orientation of the injector unit when the housing assembly is inclined at 45 degree angle in a clockwise direction relative to the horizontal axis, in accordance with the concepts of the present disclosure;

[0009] FIG. 5 is an enlarged view of the injector unit of FIG. 2 that illustrates an orientation of the injector unit when the housing assembly is inclined at 45 degree in a counter-clockwise direction relative to the horizontal axis, in accordance with the concepts of the present disclosure;

[0010] FIG. 6A is an enlarged view of the injector unit of FIG. 2 that illustrates an embodiment of the injector unit with three injector jets, in accordance with the concepts of the present disclosure;

[0011] FIG. 6B is another embodiment of the injector unit with a single injector jet, in accordance with the concepts of the present disclosure; and

[0012] FIG. 6C is yet another embodiment of the injector unit with six injector jets, in accordance with the concepts of the present disclosure.

DETAILED DESCRIPTION

[0013] Referring to FIG. 1, there is shown a block diagram of an exemplary after-treatment system 10. The after-treatment system 10 facilitates treatment of exhaust gases from an engine 12 of a machine (not shown). The after-treatment system 10 works in conjunction with a cooling circuit 14. The after-treatment system 10 includes a diesel particulate filter (DPF) 16 and a selective catalyst reduction module 18 (referred to as SCR 18) for the treatment of the exhaust gases prior to emission into the environment. The DPF 16 and the SCR 18 are in fluid communication via an exhaust conduit 20. The exhaust conduit 20 includes a mixing chamber 21, which accommodates at least one injector unit 22. Although, four injector units 22 are shown as an embodiment in FIG. 1, accommodation of any number of injector units 22 in the exhaust conduit 20 may be contemplated. Accommodation of a singular injector unit on the exhaust conduit 20 may also be contemplated. The injector units 22 are fluidly connected to a Diesel Emission Fluid (DEF) tank 24, which holds DEF.

[0014] The engine 12 may be a multi-cylinder engine adapted to be employed in the machine (not shown), such as but not limited to, a construction machine, a marine machine, and/or a forest machine. For example, off-highway trucks, mining trucks, skid steer loaders, wheel loaders, track-type tractors, excavators, dozers, wheel loaders, and/or the like.

Although the present disclosure proposes the deployment of a multi-cylinder diesel engine, an equivalent application to other engine types may also be contemplated.

[0015] As part of the after-treatment system **10**, the DPF **16** may be selected from one of widely available DPF's in the market. The DPF **16** is connected to an exhaust port of the engine **12** and is configured to receive exhaust gas from the engine **12** in a raw, untreated state. Upon reception, the DPF **16** is adapted to filter or separate diesel particulate matter from the inflowing exhaust gas.

[0016] The exhaust conduit **20** is fluidly connected to the DPF **16** and is positioned downstream of the DPF **16** (along a gas flow direction, S). The exhaust conduit **20** may be shaped and structured as conventionally known and is adapted to receive a filtered exhaust gas from the DPF **16**. The exhaust conduit **20** includes the mixing chamber **21**, which typically facilitates a mixing of the filtered exhaust gases from the DPF **16** with a reductant fluid, such as the DEF. Although not limited, typical reductant fluids or DEFs may include anhydrous ammonia, aqueous ammonia, and/or urea.

[0017] The SCR **18** is fluidly connected downstream to the exhaust conduit **20** (along the gas flow direction, S). The SCR **18** includes a catalyst (not shown), such as titanium oxide, and other active catalytic components of oxides of base metals to convert nitrogen oxides in the exhaust gases into diatomic nitrogen and water. Base metals may include, but are not limited to, vanadium, molybdenum, and/or tungsten. As with the DPF **16**, the SCR **18** may also be chosen from among the widely known SCR units available in the art.

[0018] The injector units **22** are arranged along a length of the exhaust conduit **20** and are adapted to periodically inject a predetermined quantity of DEF into the exhaust conduit **20**. For this purpose, the injector units **22** are fluidly connected to the DEF tank **24**. The injector units **22** include an injector tip **26** that injects the DEF to the exhaust conduit **20**. Exhaust gas that flows through the exhaust conduit **20** may heat the injector tip **26** of each of the injector units **22**. Therefore, the after-treatment system **10** employs the cooling circuit **14** to cool the injector tip **26** of each of the injector units **22**.

[0019] The cooling circuit **14** is adapted to facilitate a flow of coolant (along a coolant flow direction, B) through the injector units **22**, when actuated. The cooling circuit **14** includes a coolant reservoir **28**, a fluid pump **30**, and a coolant tank **32**. The coolant reservoir **28** may be a storage tank that stores the coolant in liquid form. The fluid pump **30** is fluidly connected to the coolant reservoir **28** and is disposed downstream of the coolant reservoir **28** (along the coolant flow direction, B). The injector units **22** are further in fluid communication with the fluid pump **30** and are disposed downstream to the fluid pump **30** (along the coolant flow direction, B). The coolant tank **32** may be a phase separation tank connected to the injector units **22** and disposed downstream to the injector units **22** (along the coolant flow direction, B).

[0020] Referring to FIG. 2, there is shown an arrangement of the injector unit **22** relative to a housing assembly **38** of the after-treatment system **10**, to facilitate the flow of coolant from the cooling circuit **14**. For ease in understanding, the forthcoming description is focused towards a single injector unit **22**. However, it may be contemplated that this description is equivalently applicable when multiple injector units are employed. The injector unit **22** includes a first port **34** and a second port **36**. The first port **34** is in fluid communication with the second port **36**, via coolant jackets (not shown) that are structured around the injector tip **26** to temporarily

accommodate a quantity of coolant. The first port **34** is fluidly connected to the coolant tank **32**. The second port **36** is fluidly connected to the fluid pump **30** of the cooling circuit **14**. As the fluid pump **30** is actuated, a flow of coolant in the cooling circuit **14** is facilitated in the coolant flow direction, B (as shown in FIG. 1).

[0021] During hot engine shutdowns, the fluid pump **30** is deactivated and a coolant flow (along the coolant flow direction, B) is halted (shown in FIG. 1). As a result, the coolant in the injector unit **22** may boil. As a resulting vaporized coolant requires to be delivered to the coolant tank **32**, the first port **34** is maintained above the second port **36** of the injector unit **22**.

[0022] The mounting and arrangement of the injector unit **22** relative to a housing assembly **38** of the after-treatment system **10** will now be explained in detail. The engine **12** includes a horizontal axis X-X' and a vertical axis Y-Y', relative to which the mount and arrangement of the injector unit **22** is described. The after-treatment system **10** includes the housing assembly **38** that houses the DPF **16**, the SCR **18**, and the exhaust conduit **20** (as shown in FIG. 1) of the after-treatment system **10**. The housing assembly **38** provides a mounting base for the injector unit **22** of the after-treatment system **10**. The injector unit **22** includes a datum line D-D', which passes through the first port **34** and the second port **36**. The injector unit **22** is mounted on the housing assembly **38**, such that the first port **34** is positioned substantially vertically above the second port **36**, along the vertical axis Y-Y'. For this purpose, the injector unit **22** is mounted to the housing assembly **38**, such that an included angle, A defined by the datum line D-D' relative to the horizontal axis X-X' is generally about 60 degrees in a clockwise direction, when a width, W of the housing assembly **38** is parallel to the horizontal axis X-X'. Notably, the included angle, A is maintained substantially 60 degrees to maintain the first port **34** vertically above the second port **36**, during a tilt of the machine (not shown) at a tilt angle of 45 degrees. Although, in the present disclosure, the included angle, A is 60 degrees, however the included angle, A may be any angle greater than the tilt angle of the machine (not shown). The specific arrangement of the injector unit **22**, relative to the housing assembly **38**, facilitates the first port **34** to be positioned vertically above the second port **36** in general level (tilt) conditions of the machine (not shown).

[0023] Referring to FIGS. 3, 4, and 5, three exemplary orientations of the injector unit **22**, is shown. These orientations correspond to three separate level (tilt) conditions during operation and shutdown of the machine (not shown).

[0024] Referring to FIG. 3, there is shown the injector unit **22**, when the machine (not shown) is on a level terrain and the housing assembly **38** is parallel to the horizontal axis X-X'. In such situations, the width, W, of the housing assembly **38** is parallel to the horizontal axis X-X'. Additionally, the injector unit **22** is oriented, such that the included angle, A (defined between the datum line D-D' and the horizontal axis X-X') is substantially 60 degrees vertically above, in the clockwise direction. Therefore, the first port **34** is maintained above the second port **36**, when the machine (not shown) operates on level terrain. This facilitates a relative ease in a reverse flow of coolant (along the direction, C) from the coolant tank **32** to the injector unit **22**, during engine shutdowns and the machine (not shown) operated on the levelled terrain.

[0025] Referring to FIG. 4, there is shown the injector unit **22**, when the machine (not shown) is on an unlevelled terrain and the housing assembly **38** is at a 45 degrees inclination in

a clockwise direction relative to the horizontal axis X-X'. In such operating conditions, the width, W, of the housing assembly 38 is also inclined at an angle of 45 degrees in the clockwise direction, to the horizontal axis X-X'. In such situations, the injector unit 22 is oriented, such that the included angle, A (defined between the datum line D-D' and the horizontal axis X-X'), is substantially about 105 degrees vertically above, in the clockwise direction. Therefore, the first port 34 is maintained above the second port 36. This facilitates ease in the reverse flow of coolant (along the direction, C) from the coolant tank 32 to the injector unit 22, during engine shutdowns and the machine (not shown) on the unlevelled terrain with 45 degrees clockwise inclination of the machine (not shown).

[0026] Referring to FIG. 5, there is shown the injector unit 22, when the machine (not shown) is on an unlevelled terrain and the housing assembly 38 is at a 45 degrees inclination in counter-clockwise direction relative to the horizontal axis X-X'. In such operating conditions, the width W of the housing assembly 38 is inclined at an angle of 45 degrees in the counter-clockwise direction, to the horizontal axis X-X'. In such situations, the injector unit 22 is oriented, such that the included angle, A (defined between the datum line D-D' and the horizontal axis X-X'), is substantially about 15 degrees vertically above, in the clockwise direction. Therefore, the first port 34 is maintained above the second port 36, at 45 degrees inclination in the counter-clockwise direction of the machine (not shown). This facilitates the reverse flow of coolant (along the direction, C) from the coolant tank 32 to the injector unit 22, during engine shutdowns at 45 degrees counter-clockwise inclination of the machine (not shown).

[0027] Therefore, one can understand that, even when the machine (not shown) is operated in a tilted position of 45 degrees (in the clockwise direction and/or the counter-clockwise direction, relative to the horizontal axis X-X') in side-to-side direction, the first port 34 is always maintained substantially vertically above the second port 36. This would ensure, that during the hot shutdowns of the machine (not shown), the hot coolant around the injector tip 26 is replaced by a cooler coolant and the vaporized hot coolant is expanded in the coolant tank 32.

[0028] Furthermore, the present disclosure contemplates mounting of the injector unit 22, such that the included angle, A (when the width, W, of the housing assembly 38 is parallel to the horizontal axis X-X') is 60 degrees in the clockwise direction. However, a wide range of the included angle, A, may be contemplated. The injector unit 22 generally includes injector jets 40 that facilitates injection of the DEF into the exhaust conduit 20. The included angle, A (when the width, W, of the housing assembly 38 is parallel to the horizontal axis X-X') is dependent on the number on injector jets 40 of the injector unit 22.

[0029] Referring to FIGS. 6A, 6B, and 6C, three exemplary embodiments of the injector unit 22, 22', 22'' are explained that includes different number of injector jets 40, 40', 40''. Additionally, the included angle, A (when the width, W, of the housing assembly 38 is parallel to the horizontal axis X-X') corresponding to the injector unit 22, 22', 22'' is described.

[0030] Referring to FIG. 6A, there is shown an embodiment of the injector unit 22 that includes three injector jets 40, to inject the DEF into the exhaust conduit 20. The three injector jets 40 are equilaterally placed, such that an exemplary mounting of the injector unit 22 on the housing assembly 38, may vary in steps of 120 degrees, from one application to

other. In each variation, the coolant flow from the coolant tank 32 to the injector unit 22 is facilitated, while the injector dosing performance may remain unaffected.

[0031] Referring to FIG. 6B, there is shown another embodiment of the injector unit 22' that includes singular injector jet 40', to inject the DEF into the exhaust conduit 20. Notably, a first port 34' and a second port 36' respectively of the injector unit 22' are similar in form and construction to the first port 34 and the second port 36 of the injector unit 22. The singular injector jet 40' is centrally positioned, such that an exemplary mounting of the injector unit 22' on the housing assembly 38, may vary in a range of 45 degrees to 135 degrees, from one application to other. In each variation, the coolant flow from the coolant tank 32 to the injector unit 22 is facilitated, while the injector dosing performance may remain unaffected.

[0032] Referring to FIG. 6C, there is shown another embodiment of the injector unit 22'' that includes six injector jets 40'', to inject the DEF into the exhaust conduit 20. Notably, a first port 34'' and a second port 36'' respectively of the injector unit 22'' are similar in form and construction to the first port 34 and the second port 36 of the injector unit 22. The six injector jets 40'' are equilaterally placed, such that an exemplary mounting of the injector unit 22'' on the housing assembly 38, may vary in steps of 60 degrees, from one application to other. In each variation, the coolant flow from the coolant tank 32 to the injector unit 22'' is facilitated, while the injector efficiency may remain unaffected.

INDUSTRIAL APPLICABILITY

[0033] In operation, the fluid pump 30 circulates the coolant through the injector unit 22, 22', 22'' (in the coolant flow direction, B). More specifically, the fluid pump 30 supplies the coolant to the injector unit 22, 22', 22'' via the second port 36, 36', 36''. As the second port 36, 36', 36'' is in fluid communication with the first port 34, 34', 34'', through the coolant jackets (not shown), a flow of coolant through the injector unit 22, 22', 22'' (in the coolant flow direction, B) is facilitated.

[0034] During hot engine shutdowns, the fluid pump 30 temporarily halts a coolant supply to the injector unit 22, 22', 22''. Therefore, an amount of coolant left in the injector unit 22, 22', 22'' heats up. In such situations, the resulting vaporized coolant is required to be drawn through the first port 34, 34', 34'' to the coolant tank 32, to facilitate the reverse flow of the condensed coolant of the coolant tank 32 (along the flow direction, C). For this purpose, the first port 34, 34', 34'' is required to be kept vertically above the second port 36, 36', 36''. Although, the embodiment of the injector unit 22 with three injector jets 40 is described in the forthcoming disclosure, similar description for various other embodiments of the injector units 22', 22'' may also be contemplated. In the current embodiment, the first port 34 of the injector unit 22 is required to be kept vertically above the second port 36, along the vertical axis Y-Y'.

[0035] In situations, when the machine (not shown) is on level terrain and the engine 12 is shutdown, the included angle, A (between the datum line D-D' and the horizontal axis X-X'), is about 60 degrees in the clockwise direction. This facilitates the first port 34 to be maintained above the second port 36. Such an arrangement may cause the vaporized coolant to flow through the first port 34 to the coolant tank 32. Therefore, a resulting reverse flow of the coolant (in the flow direction, C) from the coolant tank 32 to the injector unit 22,

is facilitated. This allows for cooling of the injector unit **22**, when the engine **12** is shutdown and the machine (not shown) is on a levelled terrain.

[0036] In situations, such as when the machine (not shown) is on an unlevelled terrain and the housing assembly **38** is at an inclination of **45** degrees in clockwise direction, and the engine **12** is shutdown, the included angle, A is about 105 degrees vertically above, in the clockwise direction. This facilitates the first port **34** to be vertically above the second port **36**, along the vertical axis Y-Y'. Such an arrangement may cause the vaporized coolant to flow through the first port **34** to the coolant tank **32**. This facilitates the reverse flow (in the flow direction, C) of coolant in liquid form in the coolant tank **32**, to flow to the injector unit **22**, which results in cooling of the injector unit **22**.

[0037] In yet other situations, when the machine (not shown) is on unlevelled terrain, the housing assembly **38** makes an inclination of 45 degrees in the counter-clockwise direction, and the engine **12** is shutdown, the included angle, A, is about **15** degrees vertically above, in the clockwise direction. This facilitates the first port **34** to be above the second port **36**, along the vertical axis Y-Y'. Such an arrangement may cause vaporized coolant to flow through the first port **34** to the coolant tank **32**. This facilitates the reverse flow of the condensed coolant (in the flow direction, C) from the coolant tank **32** to the injector unit **22**. This results in the cooling of the injector unit **22**. Therefore, the mount and arrangement of the injector unit **22**, as disclosed in the present disclosure, maintains the reverse flow (in the flow direction, C) of coolant from the coolant tank **32** to the injector unit **22**

during engine shutdowns. This facilitates cooling of the injector tip **26** of the injector unit **22** and prevention of damage to the injector tip **26**.

[0038] It should be understood that the above description is intended for illustrative purposes only and is not intended to limit the scope of the present disclosure in any way. Thus, those skilled in the art will appreciate that other aspects of the disclosure may be obtained from a study of the drawings, the disclosure, and the appended claim.

What is claimed is:

1. An after-treatment system for an engine, the engine having a horizontal axis and a vertical axis, the after-treatment system comprising:

a housing assembly;

a coolant circuit including a coolant tank; and

at least one injector unit including:

a first port in fluid communication with the coolant tank; and

a second port in fluid communication with the first port, wherein the at least one injector unit is mounted on the housing assembly, such that the first port is positioned substantially vertically above the second port, along the vertical axis,

wherein the at least one injector unit includes a datum line passing through the first port and the second port, such that an included angle defined by the datum line relative to the horizontal axis is generally about 60 degrees, when a width of the housing assembly is parallel to the horizontal axis.

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