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(54) **NOZZLE FOR AN EXHAUST GAS RECIRCULATION SYSTEM AND EXHAUST GAS RECIRCULATION SYSTEM COMPRISING SAID NOZZLE**

(57) The present invention relates to a nozzle (20) for injecting a mist of a liquid into exhaust gas of an internal combustion engine, the nozzle (1) comprising a cylindrical body (100), comprising a through-hole (104b) extending axially at least partly through the cylindrical body (100) and being arranged to receive a shaft (600) for guiding the liquid into said nozzle (20) in use of the nozzle (20), said cylindrical body (100) comprises: a plurality of elongated channels (106, 206) extending from the through-hole (104b) to a cylindrical envelope surface (109) of the cylindrical body (100), each elongated channel (106, 206) in the plurality of elongated channels (106, 206) comprises: an inlet (110) having an inlet area (A_{inlet}) for the liquid to enter the respective elongated channel

(106, 206) of the plurality of elongated channels (106, 206) from said through-hole (104b), and an outlet (120) having an outlet area (A_{outlet}) for the liquid to be ejected from the nozzle (20), wherein the outlet (120) of each elongated channel (106, 206) is formed such that in use of the nozzle (20) the mist of the liquid is arranged to be ejected from said nozzle (20) in an ejecting direction defined by a first angle (α_1), measured from a tangent of the cylindrical envelope surface (109) of the cylindrical body (2), said first angle (α_1), being less than 80 degrees. The present invention also relates to an exhaust gas recirculation system (10) for a power generation plant or ICE (1), comprising said nozzle (20).

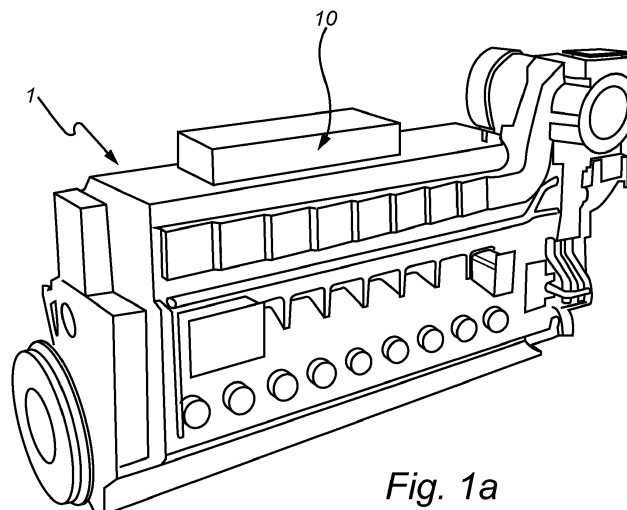


Fig. 1a

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Description

Technical field

[0001] The present disclosure relates to a nozzle for injecting a mist of a liquid into exhaust gas of an internal combustion engine. The present disclosure also relates to an exhaust gas recirculation system.

Background

[0002] The general use of exhaust gas recirculation (EGR) in internal combustion engines is commonly applied in both vehicles and commercial products, vessels, power plants, etc. Exhaust gases may then be recirculated in connection to an internal combustion engine by displacing an amount of the combustible gases from at least one prechamber of e.g. an engine cylinder or a location for a pre-mixture back to the air inlet manifold, for instance located before a turbo device. In diesel engines the exhaust gases may displace excess oxygen of the pre-combustion mixture back to the inlet manifold in a similar way. The exhaust gas recirculation (EGR) provides improvements in a lower combustion temperature and is effective in reducing the nitrogen oxides (NOx-emissions). In practise the recirculated exhaust gases replace the amount of intake air and decrease the charge density through heating of the intake air. These combined effects contribute to reduce pumping losses, resulting in an increase in engine efficiency, and thereby reduced required input power. Therefor EGR is an effective method for reducing nitrogen oxides and so called NOx emissions. From WO09030213 A1, thermodynamically stable fuel- and water microemulsions are moreover known, such as aqueous emulsions, applied into the exhaust gases during recirculation led back to the air inlet manifold as described above, having the advantage to decrease the amount of formation of NOx emissions in comparison to conventional exhaust gas recirculation (EGR). But there is still a need for improvements and also for decreasing the formation of soot particles and the formation of NOx further.

Summary

[0003] It is an object of the present invention to provide an improved solution that alleviates the mentioned drawbacks of present solutions. A first object of the invention is to provide an arrangement implemented in an exhaust recirculation system for providing an increase in engine efficiency, and thereby reduced required power. This object is solved by the invention according to claim 1. A second object of the invention is to provide an arrangement implemented in an exhaust gas recirculation system for decreasing the amount of soot particles and NOx formation. This object is also solved by the invention according to claim 1. A third object of the invention is to provide an exhaust recirculation system which provide

such an increase in engine efficiency, and thereby reduced required power at the same time as a decreased level of soot particles and NOx-formation. This object is solved by the invention according to claim 11.

[0004] According to a first aspect of the invention, a nozzle for injecting a mist of a liquid into exhaust gas of an internal combustion engine, the nozzle comprising a cylindrical body, comprising a through-hole extending axially at least partly through the cylindrical body and being arranged to receive a shaft for guiding the liquid into said nozzle in use of the nozzle,

said cylindrical body comprises:

a plurality of elongated channels extending from the through-hole to a cylindrical envelope surface of the cylindrical body,
each elongated channel in the plurality of elongated channels comprises:

an inlet having an inlet area for the liquid to enter the respective elongated channel of the plurality of elongated channels from said through-hole, and

an outlet having an outlet area for the liquid to be ejected from the nozzle,

wherein the outlet of each elongated channel is formed such that in use of the nozzle the mist of the liquid is arranged to be ejected from said nozzle in an ejecting direction defined by a first angle, measured from a tangent of the cylindrical envelope surface of the cylindrical body, said first angle, being less than 80 degrees. By providing said nozzle to an exhaust recirculation system in an internal combustion engine, an increase in engine efficiency may be provided, and thereby reduced required power at the same time as a decreased level of soot particles and NOx-formation may be provided.

[0005] According to one embodiment, in the nozzle each elongated channel comprises a channel wall which is configured to guide the liquid adjacent the outlet in the ejecting direction. An extension of the channel wall may have a direction corresponding to the ejecting direction of said mist and/or liquid.

[0006] According to one embodiment, in the nozzle a ratio of an inlet area to an outlet area of each elongated channel is at least two. By means of said ratio, the liquid may be pressurized and a mist of said liquid may be formed. Alternatively, a mixture of liquid and mist may be formed. Alternatively, the liquid may be water.

[0007] According to one embodiment, in the nozzle the first angle is in the range of 20 - 80 degrees, preferably in the range of 35 - 55 degrees. The first angle in a range of 20 - 80 degrees, preferably in the range of 35 - 55 degrees, may provide an improved ejecting efficiency of the mist, which mist may be ejected out of each elongated channel in an preferred ejection direction. The mist

may thereby be adapted to be injected into the exhaust gases.

[0008] According to one embodiment, the outlet of each elongated channel is formed such that the ejecting direction is defined by a second angle, measured from a normal to the cylindrical envelope surface of the cylindrical body and in plane formed by the normal to the cylindrical envelope surface of the cylindrical body adjacent the respective outlet and an axial direction of the cylindrical body, the second angle, being at least 5 degrees. The second angle of at least 5 degrees may provide a more improved ejecting efficiency out of the outlet of the elongated channels and thereby optimised injection of said mist into the opposite flowing exhaust gases.

[0009] According to one embodiment, in the nozzle said second angle, is preferably at least 20 degrees, and is preferably less than 40 degrees. When the second angle is at least 20 degrees, and preferably less than 40 degrees a more improved ejecting direction out of the elongated channels and injection efficiency into the exhaust gases may be provided.

[0010] According to one embodiment, in the nozzle the through-hole comprises a widening section within the cylindrical body, said widening section and being in direct fluid connection with the plurality of channels. The through-hole may guide liquid from an inlet to the nozzle for providing liquid into said nozzle. The widening section may provide an accumulation of the incoming liquid which subsequently may be distributed into the elongated channels so that an increase in pressure may be provided and a formation from liquid to mist may occur.

[0011] According to one embodiment, in the nozzle the cylindrical body comprise a first cylindrical body part comprising a first circular surface, a second cylindrical body part comprising a second circular surface, wherein the first cylindrical body part is fixed to said second cylindrical body part such that the first and second circular surfaces face each other, and wherein the through-hole extends at least partly through the second cylindrical body part, and the second circular surface comprises a first set of elongated recesses extending from the through-hole to the envelope surface of the second cylindrical body part such that, when the first and second cylindrical body parts are fixed to each other, the plurality of channels are formed by the first set of elongated recesses and a respective surface area of the first circular surface being exposed by a spacing to the respective elongated recess in the first set of elongated recesses.

[0012] The first set of elongated recesses may provide a corresponding set of elongated channels for guiding the liquid. By means of the spacing in each respective elongated recess of the first set of recesses provided into the second circular surface, a respective elongated channel may be formed when the second circular surface is attached to the first circular surface. Preferably, the first circular surface may be substantially flat. Alternatively, the first circular surface may be provided with another surface structure or texture. Initially, the liquid may be

provided in the inlet to the through-hole, which through-hole extends through the first cylindrical body part and at least partly through the second cylindrical body part, and the liquid may be distributed through said through-hole(s) and thereafter enter into the elongated channels.

[0013] According to one embodiment, in the nozzle the second circular surface comprises a circular recess having a second radius being larger than said first radius, such that the widening section of the through-hole is formed by said circular recess when said first and second circular sections are fixed together. The widening section may provide an accumulation of the incoming liquid which subsequently may be distributed into the elongated channels so that an increase in pressure may be provided and a formation from liquid to mist may occur.

[0014] According to one embodiment, in the nozzle the respective surface area of the first circular surface being exposed by a spacing to the respective elongated recess in the first set of elongated recesses are formed by a projection of each elongated recess onto the first circular surface. The spacing formed between a circular surface and a set of elongated recesses may form the elongated channels for transporting the liquid and creating mist.

[0015] According to one embodiment, in the nozzle the second cylindrical body part comprises a third circular surface arranged on the opposite side of the second cylindrical body part with respect to the second circular surface, and the cylindrical body further comprises a third cylindrical body part having a fourth circular surface, wherein the third cylindrical body part is fixed to said second cylindrical body part such that said third and fourth circular surfaces face each other and wherein said through-hole further extends at least partly through said third cylindrical body part. The fixation of the described third and fourth circular surfaces face each other may be advantageous. Either the third or the fourth circular surfaces may be provided with a second or further set of recesses. Alternatively, the third or the fourth circular surfaces may be substantially flat.

[0016] According to one embodiment, in the nozzle the third circular surface comprises a second set of elongated recesses extending from the through-hole to the envelope surface of the second circular body part such that, when the second and third cylindrical body parts are fixed to each other, the plurality of channels are further formed by the second set of elongated recesses and a respective surface area of the fourth circular surface being exposed by a spacing to the respective elongated recess in the second set of elongated recesses. A second and further sets of elongated recesses may form further sets of elongated channels for transporting liquid and forming mist out of the nozzle. A second and further sets of elongated channels may improve the efficiency of the injection of mist into the exhaust gases, whereby both the efficiency and the decrease of soot particles may be improved.

[0017] According to one embodiment, an exhaust gas recirculation system for an internal combustion engine comprises a nozzle according to any one of the preceding

claims, and a shaft for guiding liquid to said nozzle, said shaft is received by at least one bearing in said nozzle, wherein said nozzle is arranged to rotate with respect to the shaft by the liquid being ejected from the nozzle. Such a vehicle may provide an increase in engine efficiency and thereby reduce the required power at the same time as a decreased level of soot particles and NO_x-formation may be provided.

[0018] According to one embodiment, the exhaust gas recirculation system further comprises a compartment, said compartment is arranged to transport exhaust gas in an exhaust gas flow direction wherein said nozzle unit is arranged to eject liquid in a direction partly opposite to said gas flow direction. The compartment may arrange so that nozzle ejects liquid in a direction opposite the gas flow direction.

[0019] According to one embodiment, the exhaust gas recirculation system wherein said nozzle is arranged within said compartment and said shaft is arranged to guide liquid from outside of said compartment to said nozzle.

[0020] According to one embodiment, a vehicle comprises an exhaust gas recirculation system as described above. According to one embodiment, a power generator arrangement comprises an exhaust gas recirculation system implementing a nozzle as described above. The power generator may be a part of a ship, a vessel, a plant, an internal combustion engine or the like. Said vehicle and said power generator arrangement may provide all separate described advantages.

Brief description of the drawings

[0021] These and other aspects of the present invention will now be described in more detail, with reference to the appended drawings showing currently preferred embodiments of the invention.

Fig. 1a is a overview of a power generator arrangement provided with an exhaust gas recirculation system comprising at least one nozzle unit according to one embodiment,

Fig. 1b is a schematic sketch of a basic nozzle unit,

Fig. 1c is a principal sketch of a nozzle unit arranged in an opposite exhaust gas recirculation flow,

Fig. 2a is a schematic exploded perspective sketch of the nozzle unit according to a preferred embodiment,

Fig 2b is a a plane view of an intermediate cylindrical body part of the nozzle unit according to a preferred embodiment, and

Fig. 3 is a schematic sketch of a mounted nozzle unit according to Fig 2a.

Detailed description of the embodiments

[0022] The present invention will be described more fully hereinafter with reference to the accompanying

drawings, in which preferred embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. In the drawings, like numbers refer to like elements.

[0023] Fig. 1a shows a schematic illustration of a power generator arrangement 1 in a power plant, a vessel or a vehicle, etcetera provided with an exhaust gas recirculation system 10 according to one preferred embodiment.

[0024] Fig. 1b shows a schematic illustration of the nozzle unit 20 for injecting a mist of a liquid into the exhaust gas recirculation system 10 of the power generator arrangement 1. The nozzle unit 20 is preferably constituted of at least one cylindrical body 100, see Fig. 1c.

[0025] In Fig. 2a a preferred embodiment of the nozzle arrangement 20 is shown, wherein said arrangement 20 comprises a first, a second and a third cylindrical body part 101, 102, 103 each having an envelope surface 109. The cylindrical body parts 101, 102, 103 are arranged along a central axis E, extending in the axial direction through said cylindrical body parts 101, 102, 103 so that said first 101 and third 103 cylindrical parts constitute the outermost located cylindrical body parts 101, 103 and the second cylindrical body part 102 is arranged immediately in between. A first bearing 300 having a through hole with a radius r1 is fixedly arranged into said first cylindrical body part 101. The second cylindrical body part 102 is arranged with a centrally arranged through-hole 104 b. A second bearing 300 may be fixedly arranged in the third cylindrical body part 103 in similarity to the first cylindrical body part 101. A shaft 600 is running through the first bearing 300, the through hole 104b and the second bearing 300. In this way, the nozzle unit 20 is adapted to be rotated around said shaft 600 running along said central axis E thereof. The shaft 600 is also provided with at least one opening 650, which is substantially positioned in the second intermediate body part 102 in the longitudinal direction of the central axis E. Said opening 650 may distribute the liquid internally to the nozzle unit 20.

[0026] In greater detail, the nozzle 20 comprises said first cylindrical body part 101, which in turn comprises a first circular surface 101a. The nozzle 20 further comprises said second cylindrical body part 102, which in turn comprises a second circular surface 102b. The first cylindrical body part 101 is connected to said second cylindrical body part 102 so that said first and said second circular surfaces 101a, 102b are adjacently located and face each other as they are fixedly attached.

[0027] The first cylindrical body part 101 is further provided with a bearing 300 having a through-going hole with a radius r1. In a corresponding way, the second cylindrical body part 102 comprises a circular recess 104b having a second radius, r2, see Fig 2b, being larger than said first radius, r1. Thereby, a widening section 107 is

formed by said radiuses r_1 r_2 when said first and second cylindrical body parts 101, 102 are fixedly attached together.

[0028] The second cylindrical body part 102 comprises a third circular surface 102c arranged on the rear side of the second cylindrical body part 102 with respect to the second circular surface 102b. The cylindrical body 100 further comprises a third cylindrical body part 103 having a fourth circular surface 103d. In one preferred embodiment, both said third and fourth circular surfaces 102c and 103d are provided substantially flat. The second cylindrical body part 102 is connected to said third cylindrical body part 103 in such a way that said third and fourth circular surfaces 102c and 103d are adjacently located and face each other when said second cylindrical body part 102 is fixedly attached to the third cylindrical body part 103.

[0029] As is shown in Fig 2a, the first, the second and third cylindrical body parts 101, 102, 103 may be fixedly attached by means of attachment means 500 for jointly attach said cylindrical body parts 101, 102, 103. For instance, the cylindrical body parts 101, 102, 103 may be jointly attached by a number of through-going holes 400 provided therein and a corresponding number of screwing means 500.

[0030] If turning now to Fig. 2b, the second circular surface 102b of the second cylindrical body part 102 is provided with a first set or number of elongated recesses 105, which extend from the interior through-hole or interior circular recess 104b in a substantially radial direction to the exterior envelope surface 109 of the second cylindrical body 102. However, there are deviations to the mentioned substantially radial direction of the through-going running elongated recesses 105. The characteristics of the elongated recesses 105 are to be described in more detail later in the following.

[0031] The first circular surface 101a is provided substantially flat relative to the respective elongated recess 105 of the first set of elongated recesses 105 of second circular surface 102b. The surface of the first circular surface 101a is then exposed by a spacing to the respective elongated recess 105 in the first set of elongated recesses 105 of the second circular surface 102b. Thereby a corresponding first number of elongated channels 106 are formed as the first circular cylindrical body 101 is fixedly attached to the second circular cylindrical body part 102. The elongated recesses 105 and thereby the elongated channels 106 may preferably have a similar shape and appearance, see Fig. 3.

[0032] In one preferred embodiment there is preferably six (6) elongated recesses 105 arranged in the described way on the circular surface 102b of the intermediate second cylindrical body 102 as shown in Fig. 3. Consequently, there is the same number of elongated channels 106 formed in the nozzle unit 20. Alternatively, there may be 4, 8, 10, n of elongated recesses 106 arranged in said circular surface 102b for obtaining a desired level of injection of mist into the exhaust gases.

[0033] Hereinafter, the characteristics of the elongated channels 106 are to be described in further detail according to Fig. 3. In one preferred embodiment, each of the first number of elongated channels 106 have the same shape and appearance. As is shown in Fig. 3, each elongated channel 106 is then provided with an inlet 110 into which the liquid is configured to enter from the widening section 107, see Fig. 2b, into the elongated channels 106. The widening section 107 is provided with an interior envelope surface 108 wherein each said inlet 110 is provided. Each of the said inlets 110 has an cross-sectional inlet area, A_{inlet} .

[0034] Each of the first number of elongated channels 106 is provided with an outlet 120 out of the exterior envelope surface 109 of the nozzle unit 20. Each outlet 120 has an cross-sectional area, A_{outlet} , from which the liquid are ejected out of all the elongated channels 106. The ratio of A_{inlet} to A_{outlet} is preferably at least two.

[0035] Further characteristics of the elongated channels 106 are that the nozzle unit 20 is configured so that the mist of the liquid in use are to be ejected from said nozzle 100 in an ejecting direction defined by a first angle, α_1 , which is measured from a tangent t of the exterior cylindrical envelope surface 109 of the cylindrical body 100 to a surface normal n . In more detail, each of the first number of the elongated channels 106 comprises a channel wall 115 configured to guide the liquid, in the ejecting direction, an ejecting angle α_1 , particularly adjacent each outlet 120. The respective channel wall 115 is formed such that an extension of the channel wall 115 has a direction corresponding to the ejecting direction, α_1 . The first angle α_1 , which constitutes the ejecting angle, is preferably less than 80 degrees. Alternatively, the first angle, α_1 may be in the range of 20 - 80 degrees, preferably in the range of 35 - 55 degrees.

[0036] Furthermore, the outlet 120 of each of the first number of elongated channels 105 is formed such that the ejecting direction is also defined by a second angle, α_2 . The second angle α_2 is measured from a normal N , to the cylindrical envelope surface 109 of the cylindrical body 100, 101, 102, 103 and in a plane formed by the normal N to the cylindrical envelope surface 109 of the cylindrical body 100, 101, 102, 103 adjacent the respective outlet 120 and an axial direction E of the cylindrical body 100, the second angle, α_2 , being at least 5 degrees. In that way the direction of the ejected mist out of the outlet(s) is in opposite to the direction of the exhaust gas flow.

[0037] According to drawing Fig. 3, the bearing 300 of the first cylindrical body part 101 is provided with the shaft 600 therein for guiding liquid into said nozzle unit 20. Thus, the inlet pipe for liquid inlet is a part of the shaft 600. However, there may be a separately arranged inlet pipe for distributing liquid into the nozzle unit 20. Furthermore, the shaft 600 may be connected to liquid filling arrangements outside of the compartment 5 and the nozzle unit 20, see Fig 1c. The liquid is preferably constituted of water.

[0038] According to Fig. 1c, the power generating plant 1 further comprises at least one compartment 5, which may be a part of the exhaust gas recirculation system 10, which then may be arranged to transport exhaust gases in a gas flow direction from a location positioned before the cylinder of an internal combustions engine in a by-pass direction back to an air inlet manifold, in which exhaust gas recirculation system 10 said nozzle 20 may be arranged to eject liquid in a direction, at least partly, opposite to the exhaust gas flow direction of the exhaust gas recirculation system located in said compartment 5. As mentioned above, the ejecting direction is defined by a second angle, α_2 , which is at least 5 degrees.

[0039] The nozzle unit 20 is configured to work in the following way.

[0040] The nozzle 20 rotates around the shaft 600 arranged along the axis E in an exhaust gas recirculation flow inside the compartment 5.

[0041] The shaft 600 guides the liquid into the through-hole 104b and further to the widening section 107. As the nozzle unit 20 rotates around the shaft 600 the liquid flows further from the widening section 107 and enters each inlet 110 of the elongated channels 106 wherein each respective channel wall 115 guides the liquid through the elongated channels 106 to the respective outlet 120 thereof. The nozzle 20 ejects the liquid, preferably as mist, from the outlets 120 of the elongated channels 106 in the directions α_1 into the, at least partly, opposite flowing exhaust gas recirculation flow. The mist injected into the exhaust gas flow forming fuel- and water microemulsions such as aqueous emulsions, which contributes to improve the engine efficiency and reduce the required power and also decreases the level of soot particles and the NOx-formation.

[0042] There may here may be a number of other embodiments and combinations of the present disclosure. For instance, a second number of recesses 205 may be provided, for instance into a third circular surface 102c of the cylindrical body part 102, which then may extend from an interior through-hole 104b or an interior recess 104c of said cylindrical body part 102 to the envelope surface 109 in a corresponding way as the first number of elongated recesses 105. As the fourth circular surface 103d provided substantially flat, exposed by a spacing to the respective elongated recess 205 in the second number of elongated recesses 205, and the second cylindrical part 102 is subsequently fixedly attached to the third cylindrical body part 103, a second number of elongated channels 206 are formed accordingly. Accordingly, in this second embodiment, the number of elongated channels 106, 206 are twice as many since implemented on both surfaces 102b, 103 of the nozzle unit 20. This disclosure may, however, be embodied in further forms and should not be construed as limited to the embodiments set forth herein. There may be a third circular surface provided with a third number of elongated recesses, and so on.

[0043] In the drawings and specification, there have

been disclosed preferred embodiments and examples of the invention and, although specific terms are employed, they are used in a generic and descriptive sense only and not for the purposed of limitaion, the scope of the invention being set forth in the following claims.

Claims

1. A nozzle (20) for injecting a mist of a liquid into exhaust gas of an internal combustion engine, the nozzle (20) comprising:

a cylindrical body (100), comprising a through-hole (104b,) extending axially at least partly through the cylindrical body (100) and being arranged to receive a shaft (600) for guiding the liquid into said nozzle (20) in use of the nozzle (20),

said cylindrical body (100) comprises:

a plurality of elongated channels (106) extending from the through-hole (104b) to a cylindrical envelope surface (109) of the cylindrical body (100),
each elongated channel (106, 206) in the plurality of elongated channels (106, 206) comprises:

an inlet (110) having an inlet area (A_{inlet}) for the liquid to enter the respective elongated channel (106, 206) of the plurality of elongated channels (106, 206) from said through-hole (104b), and
an outlet (120) having an outlet area (A_{outlet}) for the

liquid to be ejected from the nozzle (20),

wherein the outlet (120) of each elongated channel (106, 206) is formed such that in use of the nozzle (20) the mist of the liquid is arranged to be ejected from said nozzle (20) in an ejecting direction defined by a first angle (α_1), measured from a tangent (t) of the cylindrical envelope surface (109) of the cylindrical body (100), said first angle (α_1), being less than 80 degrees.

2. A nozzle (20) according to claim 1, wherein each elongated channel (106, 206) comprises a channel wall (115) configured to guide the liquid adjacent the outlet (120) in the ejecting direction.
3. A nozzle (20) according to any one of claims 1 or 2, wherein a ratio of an inlet area (A_{inlet}) of the inlet (110) to an outlet area (A_{outlet}) of the outlet (120) of each elongated channel (106, 206) is at least two.

4. A nozzle (20) according to any one of the preceding claims, wherein the first angle, (α_1) is in the range of 20 - 80 degrees.
 5. A nozzle (20) according to any one of the preceding claims, wherein the outlet (120) of each elongated channel (106, 206) is formed such that the ejecting direction is defined by a second angle, (α_2), measured from a normal (n) to the cylindrical envelope surface (109) of the cylindrical body (100) and in a plane formed by the normal (n) to the cylindrical envelope surface (109) of the cylindrical body (100) adjacent the respective outlet (120) and an axial direction (E) of the cylindrical body (100), the second angle, (α_2), being at least 5 degrees.
 6. A nozzle (20) according to any one of the preceding claims, wherein the through-hole (104b) further comprises a widening section (107) within the cylindrical body (100, 101, 102, 103), said widening section (107) being in direct fluid connection with the plurality of channels (106).
 7. A nozzle (20) according to any one of the preceding claims, wherein the cylindrical body (100) comprise,
 - a first cylindrical body part (101) comprising a first circular surface (101a),
 - a second cylindrical body part (102) comprising a second circular surface (102b), wherein the first cylindrical body part (101) is fixed to said second cylindrical body part (102) such that the first and second circular surfaces (101a, 102b) face each other, and
 - wherein the through-hole (104b) extends at least partly through the second cylindrical body part (102) and the second circular surface (102b) comprises a first set of elongated recesses (105) extending from the through-hole (104b) to the envelope surface (109) of the second cylindrical body part (102) such that, when the first and second cylindrical body parts (101, 102) are fixed to each other, the plurality of channels (106, 206) are formed by the first set of elongated recesses (105) and a respective surface area of the first circular surface (101a) being exposed by a spacing to the respective elongated recess (105) in the first set of elongated recesses (105).
 8. A nozzle (20) according to claim 7, wherein the respective surface area of the first circular surface (101a) being exposed by a spacing to the respective elongated recess (105) in the first set of elongated recesses (105) are formed by a projection of each elongated recess (105) onto the first circular surface (101a).
 9. A nozzle (20) according to any one of claims 7-8
- wherein the second cylindrical body part (102) comprises a third circular surface (102c) arranged on the opposite side of the second cylindrical body part (102) with respect to the second circular surface (102b), and the cylindrical body (100) further comprises,
- a third cylindrical body part (103) having a fourth circular surface (103d), wherein the third cylindrical body part (103) is fixed to said second cylindrical body part (102) such that said third and fourth circular surfaces (102c, 103d) face each other and wherein said through-hole (104c) further extends at least partly through said third circular body part (103).
10. A nozzle (20) according to claim 9, wherein the third circular surface (103) comprises a second set of elongated recesses (205) extending from the through-hole (104c) to the envelope surface (109) of the second circular body part (102) such that, when the second and third cylindrical body parts (102, 103) are fixed to each other, the plurality of channels (206) are further formed by the second set of elongated recesses (205) and a respective surface area of the fourth circular surface (103d) being exposed by a spacing to the respective elongated recess (205) in the second set of elongated recesses (205).
 11. An exhaust gas recirculation system (10) for an internal combustion engine (1), comprising:
 - a nozzle (20) according to any one of the preceding claims, and
 - a shaft (600) for guiding liquid to said nozzle (20), said shaft (600) is received by at least one bearing (300) in said nozzle (20), wherein said nozzle (20) is arranged to rotate with respect to the shaft (600) by the water being ejected from the nozzle (20).
 12. A exhaust gas recirculation system (10) according to claim 11, further comprising a compartment (5), said compartment (5) is arranged to transport exhaust gas in an exhaust gas flow direction wherein said nozzle unit (20) is arranged to eject water in a direction partly opposite to said gas flow direction.
 13. A exhaust gas recirculation system (10) according to claim 12, wherein said nozzle (20) is arranged within said compartment (5) and said shaft (600) is arranged to guide water from outside said compartment (5) to said nozzle (20).

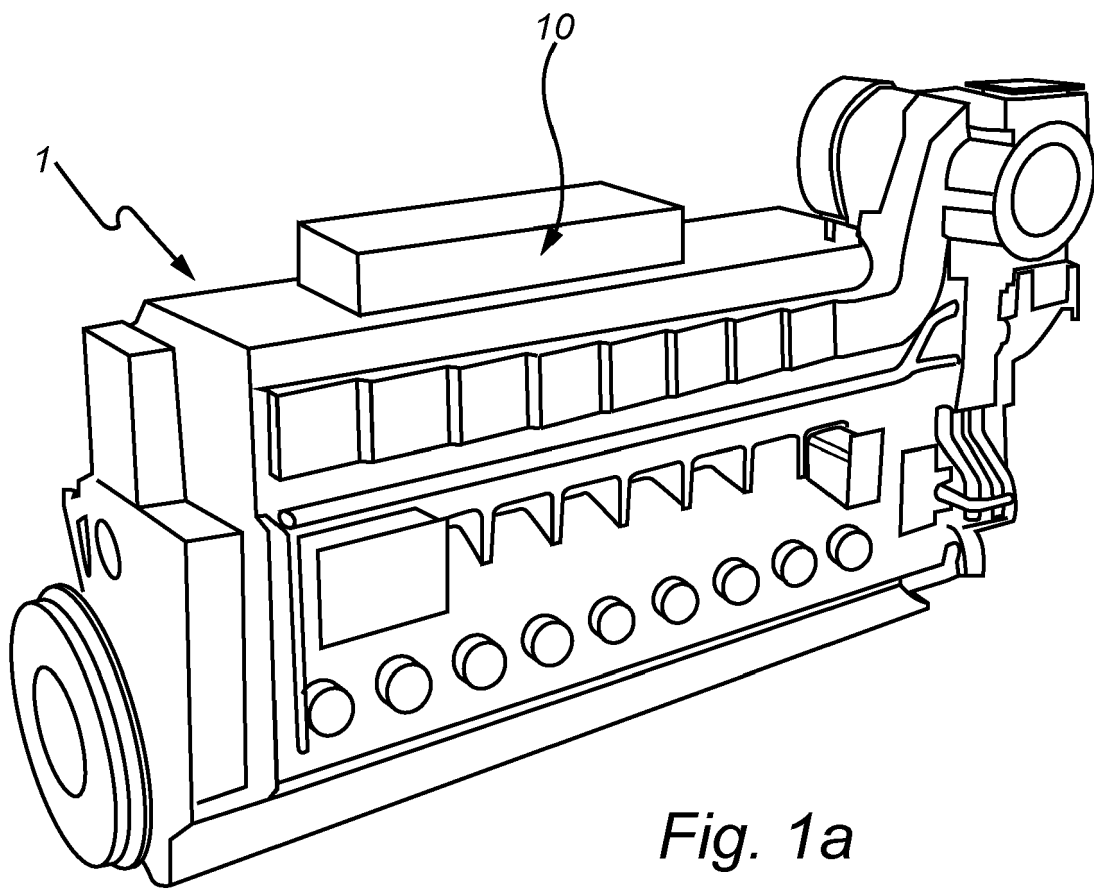


Fig. 1a

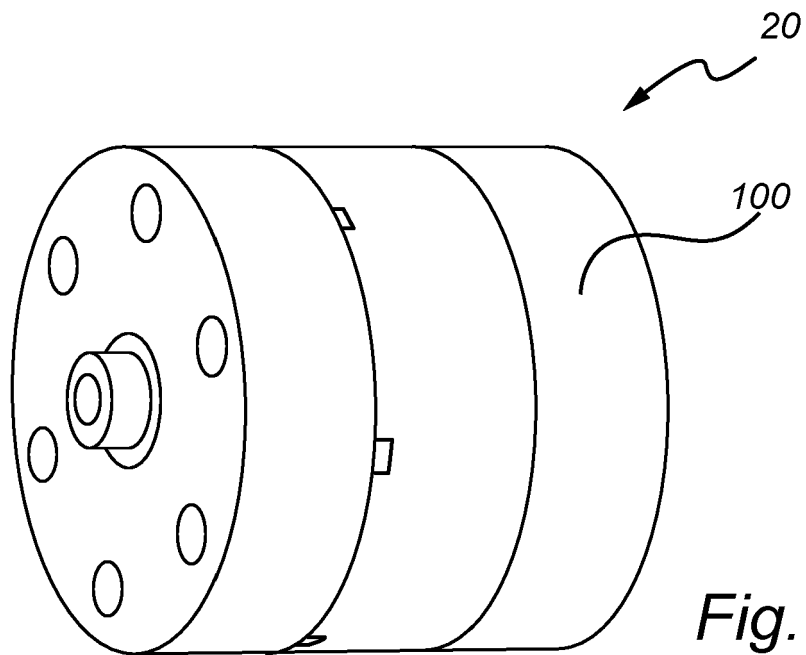


Fig. 1b

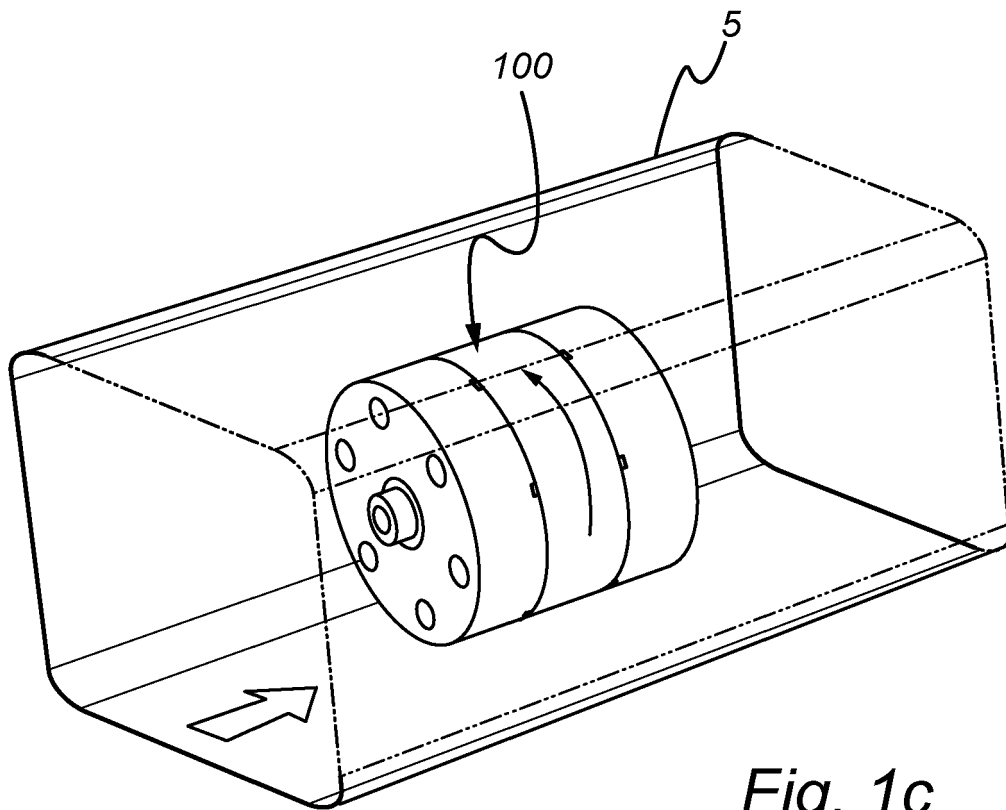
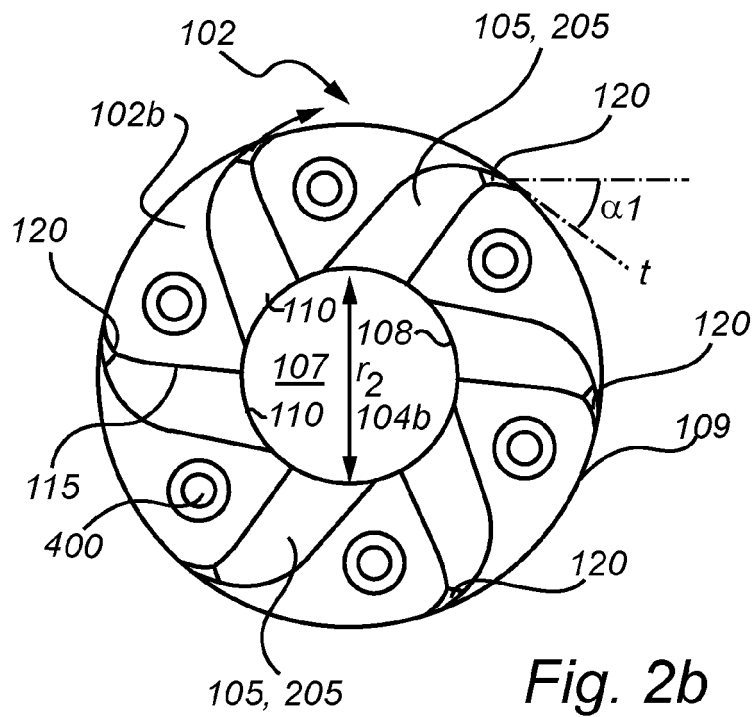
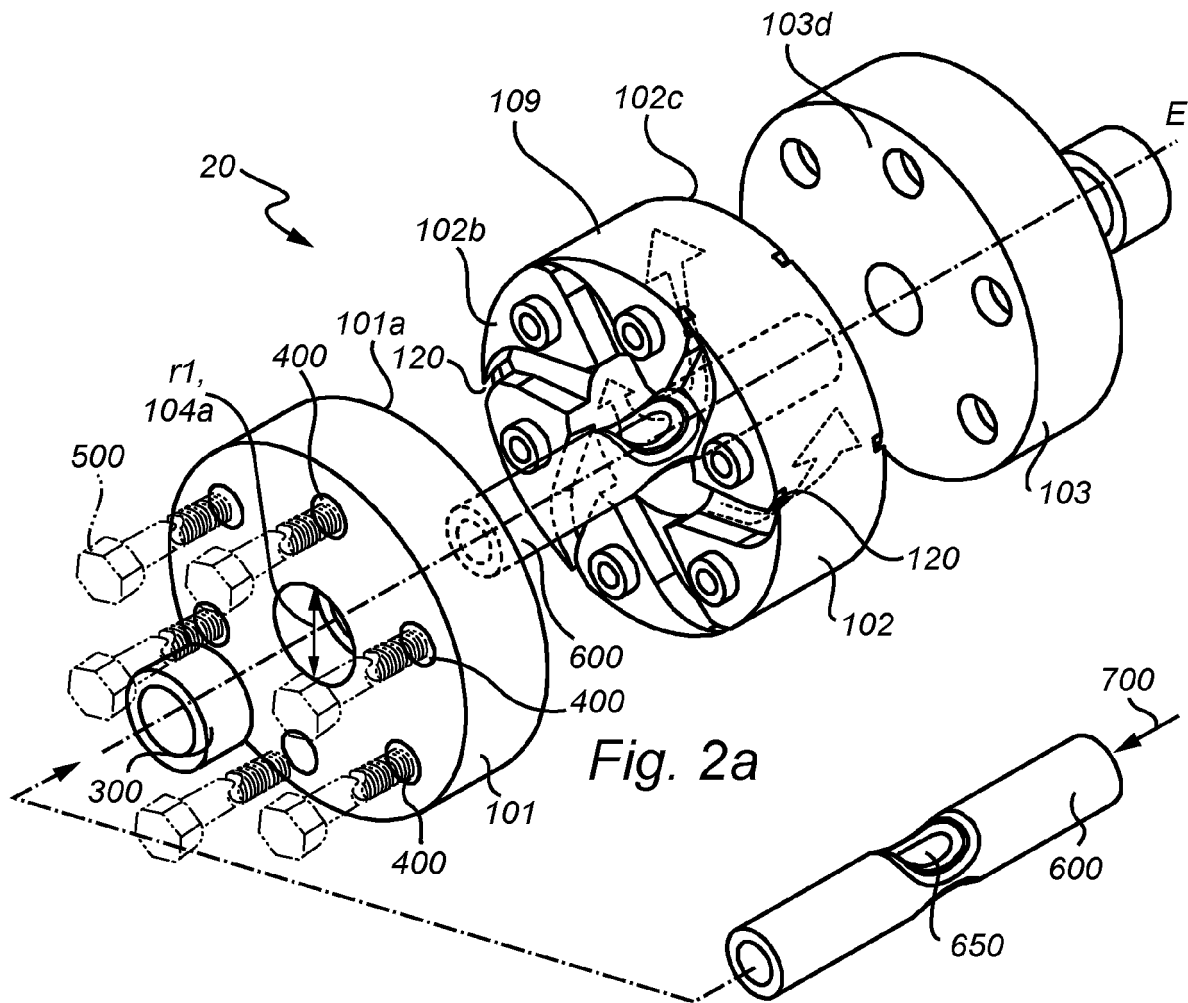


Fig. 1c



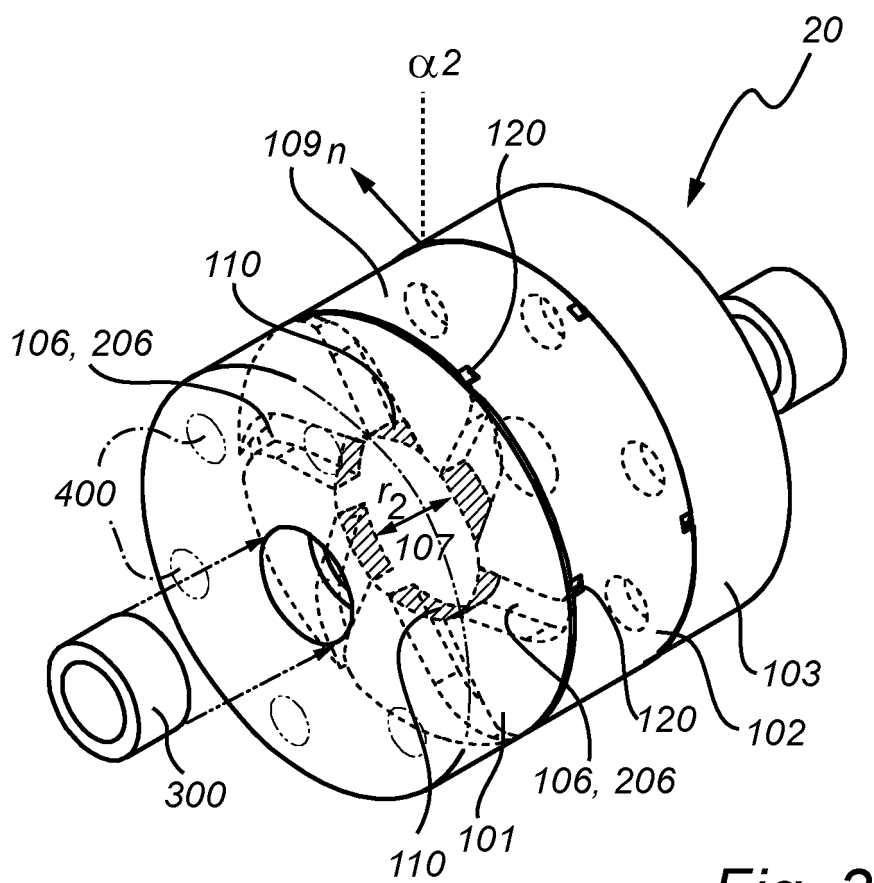


Fig. 3



EUROPEAN SEARCH REPORT

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