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(54) **EXHAUST ADDITIVE SUPPLY ARRANGEMENT, INTERNAL COMBUSTION ENGINE, AND VEHICLE**

(57) An exhaust additive supply arrangement (1) is disclosed configured to supply an exhaust additive to a stream of exhaust gas of an internal combustion engine (40). The supply arrangement (1) comprises a nozzle (3) with a nozzle body (5) forming a chamber (7) and a number of supply holes (8). The nozzle body (5) is configured to rotate around a rotation axis (Ax) during operation of the supply arrangement (1). The nozzle (3) comprises a valve arrangement (9) controllable between a first and a second state to open and close a fluid connection between the chamber (7) and a first set (S1) of supply holes (8). The present disclosure further relates to an internal combustion engine (40) and a vehicle (2) comprising an internal combustion engine (40).

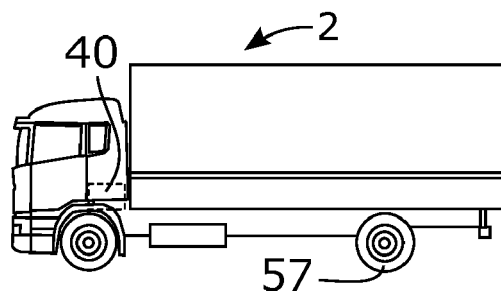


Fig. 1

Description

TECHNICAL FIELD

[0001] The present disclosure relates to an exhaust additive supply arrangement configured to supply an exhaust additive to a stream of exhaust gas of an internal combustion engine. The present disclosure further relates to an internal combustion engine comprising an exhaust system and an exhaust additive supply arrangement. Moreover, the present disclosure relates to a vehicle comprising an internal combustion engine.

BACKGROUND

[0002] Environmental concerns, as well as emissions standards for motor vehicles, have led to the development of internal combustion engines using exhaust additives, such as reducing agents for diesel, and/or ethanol, exhaust gases. Reducing agents may comprise an aqueous urea solution and may be used as a consumable in a Selective Catalytic Reduction SCR in order to lower nitrogen oxides NO_x concentration in exhaust emissions from the internal combustion engine. A Selective Catalytic Reduction SCR system is a type of engine exhaust catalyst arrangement configured to convert the nitrogen oxides of exhaust gases into diatomic nitrogen and water using a reduction agent. The exhaust additive is usually injected directly upstream of a SCR catalyst.

[0003] The use of exhaust additives is associated with some problems and design difficulties. One problem is that the flowrate of exhaust gas through an exhaust system of an internal combustion engine varies to a great extent. Moreover, different amounts of particular exhaust substances are produced at different operational conditions of an internal combustion engine. Therefore, the needed flowrate of exhaust additive into the stream of exhaust gas also varies to a great extent. For example, in order to produce the quantities of ammonia required to reduce substantially all NO_x in a stream of exhaust gas, large quantities of urea solution must occasionally be injected into the exhaust stream. Moreover, high temperatures are needed to evaporate the exhaust additive. Furthermore, the temperature needed for evaporation depends on the injected mass flow of exhaust additive, i.e., the greater the mass flow, the higher the temperature required.

[0004] If the exhaust additive is not fully evaporated, the exhaust additive may deposit onto surfaces of the exhaust system. Such deposits of exhaust additives can be corrosive and can damage components of the exhaust system. Moreover, the reduction efficiency of the exhaust additive is significantly reduced if the exhaust additive is not fully evaporated.

[0005] A further problem with the use of exhaust additives, partly linked to the problems specified above, is the requirement for efficient mixing between exhaust additive and the stream of exhaust gas in order to achieve

uniform distribution of exhaust additive. The space available for mixing is limited and the exhaust additive is commonly injected into the exhaust stream shortly upstream of a catalyst substrate.

SUMMARY

[0006] It is an object of the present invention to overcome, or at least alleviate, at least some of the above-mentioned problems and drawbacks.

[0007] According to a first aspect of the invention, the object is achieved by an exhaust additive supply arrangement configured to supply an exhaust additive to a stream of exhaust gas of an internal combustion engine. The supply arrangement comprises a nozzle with a nozzle body forming a chamber and a number of supply holes. The nozzle body is configured to rotate around a rotation axis during operation of the supply arrangement. The nozzle comprises a valve arrangement controllable between a first state in which the valve arrangement closes a fluid connection between the chamber and a first set of supply holes of the number of supply holes and a second state in which the valve arrangement opens the fluid connection between the chamber and the first set of supply holes.

[0008] Since the nozzle body is configured to rotate around the rotation axis during operation of the supply arrangement, a more efficient mixing is provided between exhaust additive and the stream of exhaust gas. In this manner, the risk of formation of deposits of exhaust additive onto various parts of an exhaust system of the internal combustion engine is reduced.

[0009] Moreover, since the nozzle comprises the valve arrangement controllable between the first and second states to open and close the fluid connection between the chamber and the first set of supply holes, the injected amount of exhaust additive can be controlled to a greater extent. Moreover, conditions are provided for an increase in the maximum flow rate of exhaust additive through the nozzle while still obtaining an efficient mixing between exhaust additive and the stream of exhaust gas due to the rotation of the nozzle body. Furthermore, in this manner, conditions are provided for an increase in total evaporation of exhaust additive while the nozzle has conditions for an efficient supply of exhaust additive also at lower flow rates of exhaust additive through the nozzle.

[0010] Accordingly, an exhaust additive supply arrangement is provided overcoming, or at least alleviating, at least some of the above-mentioned problems and drawbacks. As a result, the above-mentioned object is achieved.

[0011] Optionally, the number of supply holes comprises a second set of supply holes, and wherein a fluid connection between the chamber and the second set of supply holes is open when the valve arrangement is in the first state. Thereby, conditions are provided for a further improved control of the spray of exhaust additive from the nozzle which can reduce the risk of formations of

deposits onto parts of an exhaust system of the internal combustion engine.

[0012] Optionally, the valve arrangement is configured to close the fluid connection between the chamber and the second set of supply holes when the valve arrangement is in the second state. Thereby, a further improved control of the spray of exhaust additive from the nozzle can be provided which can reduce the risk of formations of deposits onto parts of an exhaust system of the internal combustion engine.

[0013] Optionally, the valve arrangement is controllable to a third state in which the valve arrangement opens the fluid connection between the chamber and each of the first and second sets of supply holes. Thereby, conditions are provided for an increase in the maximum flow rate of exhaust additive through the nozzle while still obtaining an efficient mixing between exhaust additive and the stream of exhaust gas due to the rotation of the nozzle body. Moreover, in this manner conditions are provided for an increase in total evaporation of exhaust additive while the nozzle has conditions for an efficient supply of exhaust additive also at lower flow rates of exhaust additive through the nozzle.

[0014] Optionally, the second set of supply holes is configured to provide a different injection characteristic than the first set of supply holes. Thereby, a further improved control of the spray of exhaust additive from the nozzle can be provided which can reduce the risk of formations of deposits onto parts of an exhaust system of the internal combustion engine. That is, due to the different injection characteristic of the second set of supply holes as compared to the first set of supply holes, the valve arrangement can be controlled to open and close the first and second sets of supply holes respectively at various operational states of an internal combustion engine comprising the exhaust additive supply arrangement to obtain efficient evaporation of exhaust additive at the various operational states of the internal combustion engine.

[0015] Optionally, the different injection characteristic is obtained by at least one of a different nozzle diameter, a different nozzle placement, and a different nozzle shape. Thereby, the different injection characteristic is obtained in a simple and cost-efficient manner to improve the control of the spray of exhaust additive from the nozzle of the exhaust additive supply arrangement.

[0016] Optionally, the first set of supply holes is configured to inject the exhaust additive at a first injection angle relative to the rotation axis, and wherein the second set of supply holes is configured to inject the exhaust additive at a second injection angle relative to the rotation axis, wherein the second injection angle is different from the first injection angle. Thereby, a further improved control of the spray of exhaust additive from the nozzle of the exhaust additive supply arrangement is provided in a simple and cost-efficient manner. Moreover, since the second injection angle is different from the first injection angle, the risk of formations of deposits of exhaust addi-

tive onto various parts of an exhaust system of an internal combustion engine comprising the exhaust additive supply arrangement is further reduced. This is because the valve arrangement can be controlled to open and close the first and second sets of supply holes respectively at various operational states of an internal combustion engine comprising the exhaust additive supply arrangement to obtain different evaporation characteristics of exhaust additive at the various operational states of the internal combustion engine.

[0017] Optionally, the supply arrangement comprises an actuator configured to control the valve arrangement between at least the first and second states. Thereby, the valve arrangement can be controlled in a simple, efficient, and accurate manner.

[0018] Optionally, the actuator comprises a solenoid or a piezoelectric element. Thereby, the valve arrangement can be controlled in a simple, efficient, and accurate manner.

[0019] Optionally, the valve arrangement is configured to be controlled between at least the first and second states based on a pressure of exhaust additive supplied to the chamber. Thereby, the valve arrangement can be controlled in a further simpler and more cost-efficient manner.

[0020] Optionally, the supply arrangement comprises a motor configured to rotate the nozzle body around the rotation axis during operation of the supply arrangement. Thereby, the rotation of the nozzle body can be controlled to a great extent which provides conditions for an improved mixing between exhaust additive and the stream of exhaust gas at various operational states of an internal combustion engine comprising the exhaust additive supply arrangement.

[0021] Optionally, the nozzle body is configured to be rotated around the rotation axis by the stream of exhaust gas of the internal combustion engine. Thereby, a simple and cost-efficient solution for rotating the nozzle body is provided. Moreover, a simple and cost-efficient solution is provided for varying the rotational speed of the nozzle body in an advantageous and automatic manner. This is because an increase in the flow rate of the stream of exhaust gas of the internal combustion engine normally increases the need for exhaust additive to be injected and decrease in the flow rate of the stream of exhaust gas of the internal combustion engine normally decreases the need for exhaust additive to be injected. Thus, since the nozzle body is configured to be rotated around the rotation axis by the stream of exhaust gas of the internal combustion engine, an increase in the flow rate of exhaust gas can increase the rotational speed of the nozzle body, and a decrease in the flow rate of exhaust gas can decrease the rotational speed of the nozzle body. In this manner, an efficient mixing can be obtained between exhaust additive and the stream of exhaust gas at various operational states of an internal combustion engine comprising the exhaust additive supply arrangement

[0022] Optionally, the nozzle body is configured to be

rotated around the rotation axis by reaction forces obtained from the flow of exhaust additive through the number of supply holes. Thereby, a simple and cost-efficient solution for rotating the nozzle body is provided. Moreover, a simple and cost-efficient solution is provided for varying the rotational speed of the nozzle body in an advantageous and automatic manner. This is because an increase in the flow rate of exhaust additive through the number of supply holes can increase the rotational speed of the nozzle body, and a decrease in the flow rate of exhaust additive through the number of supply holes can decrease the rotational speed of the nozzle body. In this manner, an efficient mixing can be obtained between exhaust additive and the stream of exhaust gas at various operational states of an internal combustion engine comprising the exhaust additive supply arrangement.

[0023] According to a second aspect of the invention, the object is achieved by an internal combustion engine comprising an exhaust system and a supply arrangement according to some embodiments of the present disclosure, wherein the supply arrangement is configured to supply an exhaust additive to a stream of exhaust gas in the exhaust system.

[0024] Since the internal combustion engine comprises an exhaust additive supply arrangement according to embodiments herein, an internal combustion engine is provided having conditions for a more efficient mixing between exhaust additive and the stream of exhaust gas which reduces the risk of formations of deposits of exhaust additive onto various parts of an exhaust system of the internal combustion engine.

[0025] Moreover, an internal combustion engine is provided having conditions for an increase in the maximum flow rate of exhaust additive into the stream of exhaust gas in the exhaust system thereof, while still obtaining an efficient mixing between exhaust additive and the stream of exhaust gas due to the rotation of the nozzle body of the exhaust additive supply arrangement. Moreover, in this manner, conditions are provided for an increase in total evaporation of exhaust additive as well as conditions for an efficient supply of exhaust additive also at lower flow rates of exhaust gas through an exhaust system of the internal combustion engine.

[0026] Accordingly, an internal combustion engine is provided overcoming, or at least alleviating, at least some of the above-mentioned problems and drawbacks. As a result, the above-mentioned object is achieved.

[0027] According to a third aspect of the invention, the object is achieved by a vehicle comprising an internal combustion engine according to some embodiments of the present disclosure. Since the vehicle comprises an internal combustion engine according to some embodiments, a vehicle is provided overcoming, or at least alleviating, at least some of the above-mentioned problems and drawbacks. As a result, the above-mentioned object is achieved.

[0028] Further features of, and advantages with, the present invention will become apparent when studying

the appended claims and the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] Various aspects of the invention, including its particular features and advantages, will be readily understood from the example embodiments discussed in the following detailed description and the accompanying drawings, in which:

Fig. 1 schematically illustrates a vehicle according to some embodiments,

Fig. 2 schematically illustrates an internal combustion engine of the vehicle illustrated in Fig. 1,

Fig. 3 schematically illustrates an exhaust additive supply arrangement according to embodiments of the internal combustion engine illustrated in Fig. 2,

Fig. 4a schematically illustrates a nozzle of the exhaust additive supply arrangement according to the embodiments illustrated in Fig. 2 and 3,

Fig. 4b illustrates the nozzle illustrated in Fig. 4a in which a valve arrangement has been controlled to a second state,

Fig. 4c illustrates the nozzle illustrated in Fig. 4a and Fig. 4b in which the valve arrangement has been controlled to a third state, and

Fig. 5 schematically illustrates a cross section of a nozzle body of the nozzle according to the embodiments illustrated in Fig. 4a - Fig. 4c.

DETAILED DESCRIPTION

[0030] Aspects of the present invention will now be described more fully. Like numbers refer to like elements throughout. Well-known functions or constructions will not necessarily be described in detail for brevity and/or clarity.

[0031] Fig. 1 schematically illustrates a vehicle 2 according to some embodiments. According to the illustrated embodiments, the vehicle 2 is a truck, i.e., a type of heavy vehicle. According to further embodiments, the vehicle 2, as referred to herein, may be another type of heavy or lighter type of manned or unmanned vehicle for land or water-based propulsion such as a lorry, a bus, a construction vehicle, a tractor, a car, a ship, a boat, or the like.

[0032] The vehicle 2 comprises an internal combustion engine 40. According to the illustrated embodiments, the internal combustion engine 40 is configured to provide motive power to the vehicle 2 via wheels 57 of the vehicle 2.

[0033] Fig. 2 schematically illustrates the internal combustion engine 40 of the vehicle 2 illustrated in Fig. 1. The internal combustion engine 40 is in some places herein referred to as the "combustion engine 40", or simply "the engine 40", for reasons of brevity and clarity. Below, simultaneous reference is made to Fig. 1 and Fig.

2, if not indicated otherwise.

[0034] The vehicle 2 may comprise one or more electric propulsion motors in addition to the internal combustion engine 40 for providing motive power to the vehicle 2. Thus, the vehicle 2, as referred to herein, may comprise a so-called hybrid electric powertrain comprising one or more electric propulsion motors in addition to the combustion engine 40 for providing motive power to the vehicle 2.

[0035] According to the illustrated embodiments, the internal combustion engine 40 comprises six cylinders 10 arranged in one row. The internal combustion engine 40 according to the illustrated embodiments may therefore be referred to an inline-six engine. However, according to further embodiments, the internal combustion engine 40, as referred to herein, may comprise another number of cylinders 10. Moreover, the cylinders 10 of the internal combustion engine 40 may be arranged in another configuration than in one row, such as in two or more rows. Each cylinder 10 of the internal combustion engine 40 comprises a piston connected to a crankshaft of the internal combustion engine 40.

[0036] According to embodiments herein, the internal combustion engine 40 is a four-stroke internal combustion engine. Moreover, according to the illustrated embodiments, the internal combustion engine 40 is a diesel engine, i.e., a type of compression ignition engine. The internal combustion engine 40 may thus be a compression ignition engine configured to operate on diesel or a diesel-like fuel, such as biodiesel, biomass to liquid (BTL), or gas to liquid (GTL) diesel. Diesel-like fuels, such as biodiesel, can be obtained from renewable sources such as vegetable oil which mainly comprises fatty acid methyl esters (FAME). Diesel-like fuels can be produced from many types of oils, such as rapeseed oil (rapeseed methyl ester, RME) and soybean oil (soy methyl ester, SME).

[0037] According to further embodiments, the internal combustion engine 40, as referred to herein, may be an Otto engine with a spark-ignition device, wherein the Otto engine may be configured to run on petrol, alcohol, similar volatile fuels, or combinations thereof. Alcohol, such as ethanol, can be derived from renewable biomass.

[0038] Moreover, according to some embodiments, the internal combustion engine 40, as referred to herein, may be arranged to power another type of device or system than a vehicle, such as for example an electric generator.

[0039] The internal combustion engine 40 comprises an exhaust system 30. The exhaust system 30 is configured to transfer exhaust gas from exhaust valves of the cylinders 10 of the internal combustion engine 40 to the surroundings. According to the illustrated embodiments, the exhaust system 30 comprises a particulate filter 32, a diesel oxidation catalyst 33 and a selective catalytic reduction catalyst 34. As an alternative, or in addition, the exhaust system 30 may comprise one or more other types of exhaust after treatment arrangements, such as

for example a Lean NO_x Trap (LNT), a Three-Way Catalyst (TWC), or another type of catalytic converter.

[0040] The exhaust system 30 of the internal combustion engine 40 comprises an exhaust additive supply arrangement 1. The exhaust additive supply arrangement 1 is configured to supply an exhaust additive to a stream of exhaust gas inside the exhaust system 30 of the internal combustion engine 40.

[0041] According to the illustrated embodiments, the exhaust additive supply arrangement 1 is positioned between the diesel oxidation catalyst 33 and the selective catalytic reduction catalyst 34. In other words, according to the illustrated embodiments, the exhaust additive supply arrangement 1 is positioned downstream of the diesel oxidation catalyst 33 and upstream of the selective catalytic reduction catalyst 34 as seen relative to an intended flow direction of exhaust gas through the exhaust system 30 during operation of the internal combustion engine 40. According to further embodiments, the exhaust additive supply arrangement 1 may have another position in an exhaust system 30 than depicted in Fig. 2.

[0042] Furthermore, according to some embodiments, the exhaust system 30 may comprise a particulate filter 32, a diesel oxidation catalyst 33, and/or a selective catalytic reduction catalyst 34, wherein the particulate filter 32, the diesel oxidation catalyst 33, and/or the selective catalytic reduction catalyst 34 are arranged in another order, as seen relative to an intended flow direction of exhaust gas through the exhaust system 30, than depicted in Fig. 2. Furthermore, as indicated above, the exhaust system 30 may lack a particulate filter 32 and/or a diesel oxidation catalyst 33.

[0043] For reasons of brevity and clarity, the exhaust additive supply arrangement 1 is in some places herein referred to as the "supply arrangement".

[0044] Fig. 3 schematically illustrates the exhaust additive supply arrangement 1 according to the embodiments illustrated in Fig. 2. Below, simultaneous reference is made to Fig. 1 - Fig. 3, if not indicated otherwise.

[0045] The supply arrangement 1 comprises a nozzle 3 with a nozzle body 5. The nozzle body 5 forms a chamber and a number of supply holes 8 fluidly connected to the chamber 7.

[0046] The nozzle body 5 is configured to rotate around a rotation axis Ax during operation of the supply arrangement 1. According to the illustrated embodiments, the supply arrangement 1 comprises a motor 15 configured to rotate the nozzle body 5 around the rotation axis Ax during operation of the supply arrangement 1. The motor 15 is connected to the nozzle body 5 via a hollow shaft 16.

[0047] According to further embodiments, the nozzle body 5 may be configured to be rotated around the rotation axis Ax by the stream of exhaust gas of the internal combustion engine 40. According to such embodiments, the nozzle body 5 may be provided with a shape and/or a number of elements causing rotation of the nozzle body 5 around the rotation axis Ax when a stream of exhaust gas is flowing around the nozzle body 5.

[0048] As an alternative, or in addition, the nozzle body 5 may be configured to be rotated around the rotation axis Ax by reaction forces obtained from the flow of exhaust additive through the number of supply holes 8. According to such embodiments, at least a number of the supply holes 8 may be angled such that the injection direction thereof is transversal to the rotation axis Ax of the nozzle body 5 to obtain a reaction torque onto the nozzle body 5 when exhaust additive flows through the number of supply holes 8.

[0049] The exhaust additive supply arrangement 1 further comprises a tank unit 18, a pump 22, and a dosage unit 24. The pump 22 is configured to pump exhaust additive from the tank unit 18 to the nozzle 3 via the dosage unit 24 and the hollow shaft 16. The dosage unit 24 is configured to control the amount of exhaust additive pumped to the nozzle 3 of the exhaust additive supply arrangement 1.

[0050] Fig. 4a schematically illustrates the nozzle 3 of the exhaust additive supply arrangement 1 according to the embodiments illustrated in Fig. 2 and 3. Below, simultaneous reference is made to Fig. 1 - Fig. 4a, if not indicated otherwise.

[0051] As is indicated in Fig. 4a, the nozzle body 5 forms a chamber 7 and a number of supply holes 8 fluidly connected to the chamber 7. The chamber 7 is also fluidly connected to the hollow shaft 16 and is configured to receive exhaust additive therefrom during operation of the exhaust additive supply arrangement 1.

[0052] Moreover, as is indicated in Fig. 4a, the nozzle 3 comprises a valve arrangement 9. In Fig. 4a, the valve arrangement 9 is illustrated in dotted lines. The valve arrangement 9 is controllable between a first state and a second state. In Fig. 4a, the valve arrangement 9 is illustrated in the first state in which the valve arrangement 9 closes a fluid connection between the chamber 7 and a first set S1 of supply holes 8 of the number of supply holes 8.

[0053] That is, as can be seen in Fig. 4a, the number of supply holes 8 comprises a first set S1 of supply holes 8 and a second set S2 of supply holes 8. Moreover, according to the illustrated embodiments, the valve arrangement 9 comprises a valve body provided with a first set of blocking elements 39 configured to close the fluid connection between the chamber 7 and the first set S1 of supply holes 8 when the valve arrangement 9 is in the first state.

[0054] Fig. 4b illustrates the nozzle 3 illustrated in Fig. 4a in which the valve arrangement 9 has been controlled to the second state. Below, simultaneous reference is made to Fig. 1 - Fig. 4b, if not indicated otherwise. In the second state, the valve arrangement 9 opens the fluid connection between the chamber 7 and the first set S1 of supply holes 8.

[0055] According to the illustrated embodiments, the valve arrangement 9 is movably arranged inside the chamber 7 in directions parallel to the rotation axis Ax of the nozzle body 5. In other words, according to the illus-

trated embodiments, the valve arrangement 9 is controllable between the first and second states by being displaced inside the chamber 7 of the nozzle body 5 between different positions.

[0056] As seen in Fig. 4b, according to the illustrated embodiments, the first set of blocking elements 39 of the valve arrangement 9 are moved to positions in which they unblock the first set S1 of supply holes to open the fluid connection between the chamber 7 and the first set S1 of supply holes 8 when the valve arrangement 9 is in the second state.

[0057] As seen in Fig. 4a and 4b, according to the illustrated embodiments, the valve arrangement 9 comprises a second set of blocking elements 39'. According to these embodiments, as seen in Fig. 4a, the valve arrangement 9 is configured to open the fluid connection between the chamber 7 and the second set S2 of supply holes 8 when the valve arrangement 9 is in the first state. As seen in Fig. 4a, according to the illustrated embodiments, this is achieved by the second set of blocking elements 39' assuming unblocking positions to open the fluid connection between the chamber 7 and the second set S2 of supply holes 8 when the valve arrangement 9 is in the first state.

[0058] Moreover, as seen in Fig. 4b, according to these embodiments, the valve arrangement 9 is configured to close the fluid connection between the chamber 7 and the second set S2 of supply holes 8 when the valve arrangement 9 is in the second state. As seen in Fig. 4b, according to the illustrated embodiments, this is achieved by the second set of blocking elements 39' assuming blocking positions to close the fluid connection between the chamber 7 and the second set S2 of supply holes 8 when the valve arrangement 9 is in the second state.

[0059] Fig. 4c illustrates the nozzle 3 illustrated in Fig. 4a and Fig. 4b in which the valve arrangement 9 has been controlled to a third state. Below, simultaneous reference is made to Fig. 1 - Fig. 4c, if not indicated otherwise. According to the illustrated embodiments, the valve arrangement 9 is controllable to a third state in which the valve arrangement 9 opens the fluid connection between the chamber 7 and each of the first and second sets S1, S2 of supply holes 8.

[0060] As seen in Fig. 4c, according to the illustrated embodiments, the third state constitutes a state in which the first and second sets of blocking elements 39, 39' assume unblocking positions to open the fluid connection between the chamber 7 and the first and second set S1, S2 of supply holes 8.

[0061] For reasons of brevity and clarity, in Fig. 4a - 4c, only one blocking element of the first set of blocking elements 39 has been provided with the reference sign "39". Likewise, in Fig. 4a-4c, only one blocking element of the second set of blocking elements 39' has been provided with the reference sign "39'". However, the first set of blocking elements 39 may comprise the same number of blocking elements as the number of supply holes 8 of the first set S1 of supply holes 8. Likewise, the second

set of blocking elements 39' may comprise the same number of blocking elements as the number of supply holes 8 of the second set S2 of supply holes 8.

[0062] Moreover, in the schematic illustration of the nozzle 3 in Fig. 4a - Fig. 4c, the first set S1 of supply holes 8, as well as the second set S2 of supply holes 8, is illustrated as comprising three supply holes 8. However, the first and second sets S1, S2 of supply holes 8 may each comprise another number of supply holes 8, such as a number between one and twenty.

[0063] According to embodiments herein, the second set S2 of supply holes 8 is configured to provide a different injection characteristic than the first set S1 of supply holes 8. The different injection characteristic may be obtained by at least one of a different nozzle diameter, a different nozzle placement, and a different nozzle shape. That is, each supply hole 8 of the second set S2 of supply holes 8 may comprise least one of a different nozzle diameter, a different nozzle placement, and a different nozzle shape than a supply hole 8 of the first set S1 of supply holes 8.

[0064] In this manner, the valve arrangement 9 can be controlled to open and close the first and second sets S1, S2 of supply holes 8 respectively at various operational states of an internal combustion engine 40 comprising the exhaust additive supply arrangement 1 to obtain efficient evaporation of exhaust additive at the various operational states of the internal combustion engine 40.

[0065] Fig. 5 schematically illustrates a cross section of the nozzle body 5 of the nozzle 3 according to the embodiments illustrated in Fig. 4a - Fig. 4c. In the cross section of Fig. 5, one supply hole 8 of the first set S1 of supply holes 8 and one supply hole 8 of the second set S2 of supply holes 8 can be seen.

[0066] According to these embodiments, the first set S1 of supply holes 8 is configured to inject the exhaust additive at a first injection angle α_1 relative to the rotation axis Ax. In Fig. 5, the first injection angle α_1 is indicated between a main flow direction 51 of exhaust additive through the supply hole 8 of the first set S1 of supply holes 8 and a line Ax' being parallel to the rotation axis Ax of the nozzle body 5. The main flow direction 51 of exhaust additive through the supply hole 8 of the first set S1 of supply holes 8 may coincide with a main extension direction of the supply hole 8 of the first set S1 of supply holes 8.

[0067] Moreover, as indicated in Fig. 5, according to these embodiments, the second set S2 of supply holes 8 is configured to inject the exhaust additive at a second injection angle α_2 relative to the rotation axis Ax, wherein the second injection angle α_2 is different from the first injection angle α_1 . In Fig. 5, the second injection angle α_2 is indicated between a main flow direction 52 of exhaust additive through the supply hole 8 of the second set S2 of supply holes 8 and a line Ax' being parallel to the rotation axis Ax of the nozzle body 5. The main flow direction 52 of exhaust additive through the supply hole

8 of the second set S2 of supply holes 8 may coincide with a main extension direction of the supply hole 8 of the second set S2 of supply holes 8.

[0068] According to the illustrated embodiments, the difference between the first and second injection angles α_1 , α_2 is approximately 18 degrees. However, according to further embodiments, the difference between the first and second injection angles α_1 , α_2 may be within the range of 1 - 160 degrees, or may be within the range of 5 - 60 degrees.

[0069] In Fig. 2, walls 55 of the exhaust system 32 adjacent to the nozzle of the exhaust additive supply arrangement 1 are indicated. Below, simultaneous reference is made to Fig. 1 - Fig. 5, if not indicated otherwise. Due to the difference between the first and second injection angles α_1 , α_2 , a further improved control of the spray of exhaust additive from the nozzle 3 of the exhaust additive supply arrangement 1 is provided with a reduced risk of formations of deposits of exhaust additive onto the walls 55 of the exhaust system 30. This is because the valve arrangement 9 can be controlled to open and close the first and second sets S1, S2 of supply holes respectively at various operational states of the internal combustion engine 40 to obtain different evaporation characteristics of exhaust additive at the various operational states of the internal combustion engine 40.

[0070] Moreover, since the valve arrangement 9 is controllable to the third state in which all supply holes 8 of the nozzle 3 are open, conditions are provided for an increase in total evaporation of exhaust additive while the nozzle 3 has conditions for an efficient supply of exhaust additive also at lower flow rates of exhaust additive through the nozzle 3.

[0071] As is indicated in Fig. 3, according to the illustrated embodiments, the supply arrangement 1 comprises an actuator 13 configured to control the valve arrangement 9 between the first, second, and third states. According to the illustrated embodiments, the actuator 13 is operably connected to the valve arrangement 9 via a control rod 57 extending through the supply tube 16. The actuator 13 may comprise a solenoid or a piezoelectric element.

[0072] According to further embodiments, the exhaust additive supply arrangement 1 may comprise another type of actuator for controlling the valve arrangement 9 between the different states. Moreover, according to further embodiments, the actuator 13 of the exhaust additive supply arrangement 1 may be operably connected to the valve arrangement 9 in another manner than via a control rod 57 extending through the supply tube 16.

[0073] According to some embodiments of the present disclosure, the valve arrangement 9 may be configured to be controlled between at least the first, second, and third states based on a pressure of exhaust additive supplied to the chamber 7. That is, as schematically indicated in Fig. 4a - Fig. 4c, the nozzle 3 may comprise a spring element 59 configured to bias the valve arrangement 9 towards one of the first, second, and third states, wherein

the valve arrangement 9 is configured to be displaced to the other of the first, second, and third states by the pressure of exhaust additive supplied to the chamber 7.

[0074] As an example, the spring element 59 may be configured to bias the valve arrangement 9 towards the first state, wherein the valve arrangement 9 is configured to be displaced to the second state when the pressure of exhaust additive supplied to the chamber 7 reaches a first threshold pressure. Moreover, the valve arrangement 9 may be configured to be displaced to the third state when the pressure of exhaust additive supplied to the chamber 7 reaches a second threshold pressure being higher than the first threshold pressure.

[0075] In this manner, the valve arrangement 9 can be configured to be controlled between at least the first, second, and third states based on a pressure of exhaust additive supplied to the chamber 7. The pressure of exhaust additive supplied to the chamber 7 may for example be controlled by the dosage unit 24.

[0076] As illustrated in Fig. 1, according to the illustrated embodiments, the internal combustion engine 40 comprises a control arrangement 21. The control arrangement 21 may be operably connected to the dosage unit 24 and may be configured to control the operation thereof based on data from the internal combustion engine 40, and/or data from the exhaust system 30, such as data from a sensor 61 arranged in the exhaust system 30 of the internal combustion engine 40. According to such embodiments, the control arrangement 21 may be configured to control the valve arrangement 9 of the exhaust additive supply arrangement 1 between the first, second, and third states by controlling the dosage unit 24 based on data from the internal combustion engine 40, and/or data from the exhaust system 30, such as data from a sensor 61 arranged in the exhaust system 30 of the internal combustion engine 40.

[0077] Moreover, in embodiments in which the nozzle body 5 is configured to be rotated around the rotation axis Ax by reaction forces obtained from the flow of exhaust additive through the number of supply holes 8, the control arrangement 21 may be configured to control the rotational speed of the nozzle body 5 of the nozzle 3 by controlling dosage unit 24. Also such a control may be based on data from the internal combustion engine 40, and/or data from the exhaust system 30, such as data from a sensor 61 arranged in the exhaust system 30 of the internal combustion engine 40.

[0078] Moreover, the control arrangement 21 may be operably connected to the actuator 13 and may be configured to control the operation thereof based on data from the internal combustion engine 40, and/or data from the exhaust system 30, such as data from a sensor 61 arranged in the exhaust system 30 of the internal combustion engine 40. According to such embodiments, the control arrangement 21 may be configured to control the valve arrangement 9 of the exhaust additive supply arrangement 1 between the first, second, and third states by controlling the actuator 13 based on data from the

internal combustion engine 40, and/or data from the exhaust system 30, such as data from a sensor 61 arranged in the exhaust system 30 of the internal combustion engine 40.

[0079] Moreover, the control arrangement 21 may be operably connected to the motor 15 and may be configured to control the operation thereof based on data from the internal combustion engine 40, and/or data from the exhaust system 30, such as data from a sensor 61 arranged in the exhaust system 30 of the internal combustion engine 40. According to such embodiments, the control arrangement 21 may be configured to control the rotational speed of the nozzle body 5 of the nozzle 3 by controlling the motor 15 based on data from the internal combustion engine 40, and/or data from the exhaust system 30, such as data from a sensor 61 arranged in the exhaust system 30 of the internal combustion engine 40.

[0080] The control arrangement 21 may comprise a calculation unit which may take the form of substantially any suitable type of processor circuit or microcomputer, e.g., a circuit for digital signal processing (digital signal processor, DSP), a Central Processing Unit (CPU), a processing unit, a processing circuit, a processor, an Application Specific Integrated Circuit (ASIC), a microprocessor, or other processing logic that may interpret and execute instructions. The herein utilised expression "calculation unit" may represent a processing circuitry comprising a plurality of processing circuits, such as, e.g., any, some or all of the ones mentioned above.

[0081] The control arrangement 21 may further comprise a memory unit, wherein the calculation unit may be connected to the memory unit, which may provide the calculation unit with, for example, stored program code and/or stored data which the calculation unit may need to enable it to do calculations. The calculation unit may also be adapted to store partial or final results of calculations in the memory unit. The memory unit may comprise a physical device utilised to store data or programs, i.e., sequences of instructions, on a temporary or permanent basis. According to some embodiments, the memory unit may comprise integrated circuits comprising silicon-based transistors. The memory unit may comprise e.g., a memory card, a flash memory, a USB memory, a hard disc, or another similar volatile or non-volatile storage unit for storing data such as e.g., ROM (Read-Only Memory), PROM (Programmable Read-Only Memory), EPROM (Erasable PROM), EEPROM (Electrically Erasable PROM), etc. in different embodiments.

[0082] The control arrangement 21 may be connected to components of the internal combustion engine 40 and/or the exhaust additive supply arrangement 1 for receiving and/or sending input and output signals. These input and output signals may comprise waveforms, pulses, or other attributes which the input signal receiving devices can detect as information and which can be converted to signals processable by the control arrangement 21. These signals may then be supplied to the calculation unit. One or more output signal sending devices may be

arranged to convert calculation results from the calculation unit to output signals for conveying to other parts of the vehicle's control system and/or the component or components for which the signals are intended. Each of the connections to the respective components of the internal combustion engine 40 and/or the exhaust additive supply arrangement 1 for receiving and sending input and output signals may take the form of one or more from among a cable, a data bus, e.g., a CAN (controller area network) bus, a MOST (media orientated systems transport) bus or some other bus configuration, or a wireless connection.

[0083] In the embodiments illustrated, the internal combustion engine 40 comprises a control arrangement 21 but might alternatively be implemented wholly or partly in two or more control arrangements or two or more control units. Control systems in modern vehicles generally comprise a communication bus system consisting of one or more communication buses for connecting a number of electronic control units (ECUs), or controllers, to various components on board the vehicle. Such a control system may comprise a large number of control units and taking care of a specific function may be shared between two or more of them. Vehicles and engines of the type here concerned are therefore often provided with significantly more control arrangements than depicted in Fig. 2, as one skilled in the art will surely appreciate.

[0084] As explained above, according to the illustrated embodiments, the valve arrangement 9 of the exhaust additive supply arrangement 1 is controllable between the first, second, and third states. However, according to further embodiments, the valve arrangement 9 of the exhaust additive supply arrangement 1 may be controllable only between the first and second states explained herein.

[0085] Moreover, as explained above, according to the illustrated embodiments, the number of supply holes 8 comprises the first and second sets S1, S2 of supply holes 8, wherein the valve arrangement 9 is configured to control the flow of exhaust additive through the first and second sets S1, S2 of supply holes 8. However, according to further embodiments, the valve arrangement 9 may be configured to control the flow of exhaust additive through only a first set S1 of supply holes 8. According to such embodiments, the number of supply holes 8 may comprise one or more other supply holes 8 which is/are not included in the first set S1 of supply holes 8. In other words, the number of supply holes 8 may comprise one or more other supply holes 8 which is/are not controlled by the valve arrangement 9. Moreover, to such embodiments, the first set S1 of supply holes 8, which is controlled by the valve arrangement 9, may simply be referred to as a set S1 of supply holes 8.

[0086] Furthermore, as explained above, according to the illustrated embodiments, the valve arrangement 9 is controllable between the first and second states by being displaced inside the chamber 7 of the nozzle body 5 between different positions. However, according to further

embodiments, the valve arrangement 9 may be configured to control flow of exhaust additive through different sets S1, S2 of supply holes 8 in another manner.

[0087] It is to be understood that the foregoing is illustrative of various example embodiments and that the invention is defined only by the appended independent claims. A person skilled in the art will realize that the example embodiments may be modified, and that different features of the example embodiments may be combined to create embodiments other than those described herein, without departing from the scope of the present invention, as defined by the appended independent claims.

[0088] As used herein, the term "comprising" or "comprises" is open-ended, and includes one or more stated features, elements, steps, components, or functions but does not preclude the presence or addition of one or more other features, elements, steps, components, functions, or groups thereof.

Claims

1. An exhaust additive supply arrangement (1) configured to supply an exhaust additive to a stream of exhaust gas of an internal combustion engine (40),

wherein the supply arrangement (1) comprises a nozzle (3) with a nozzle body (5) forming a chamber (7) and a number of supply holes (8), wherein the nozzle body (5) is configured to rotate around a rotation axis (Ax) during operation of the supply arrangement (1),

and wherein the nozzle (3) comprises a valve arrangement (9) controllable between a first state in which the valve arrangement (9) closes a fluid connection between the chamber (7) and a first set (S1) of supply holes (8) of the number of supply holes (8) and a second state in which the valve arrangement (9) opens the fluid connection between the chamber (7) and the first set (S1) of supply holes (8).

2. The supply arrangement (1) according to claim 1, wherein the number of supply holes (8) comprises a second set (S2) of supply holes (8), and wherein a fluid connection between the chamber (7) and the second set (S2) of supply holes (8) is open when the valve arrangement (9) is in the first state.
3. The supply arrangement (1) according to claim 2, wherein the valve arrangement (9) is configured to close the fluid connection between the chamber (7) and the second set (S2) of supply holes (8) when the valve arrangement (9) is in the second state.
4. The supply arrangement (1) according to claim 2 or 3, wherein the valve arrangement (9) is controllable

to a third state in which the valve arrangement (9) opens the fluid connection between the chamber (7) and each of the first and second sets (S1, S2) of supply holes (8).

- 5 5. The supply arrangement (1) according to any one of the claims 2 - 4, wherein the second set (S2) of supply holes (8) is configured to provide a different injection characteristic than the first set (S1) of supply holes (8). 10
6. The supply arrangement (1) according to claim 5, wherein the different injection characteristic is obtained by at least one of a different nozzle diameter, a different nozzle placement, and a different nozzle shape. 15
7. The supply arrangement (1) according to any one of the claims 2 - 6, wherein the first set (S1) of supply holes (8) is configured to inject the exhaust additive at a first injection angle (a1) relative to the rotation axis (Ax), and wherein the second set (S2) of supply holes (8) is configured to inject the exhaust additive at a second injection angle (a2) relative to the rotation axis (Ax), wherein the second injection angle (a2) is different from the first injection angle (a1). 20 25
8. The supply arrangement (1) according to any one of the preceding claims, wherein the supply arrangement (1) comprises an actuator (13) configured to control the valve arrangement (9) between at least the first and second states. 30
9. The supply arrangement (1) according to claim 8, wherein the actuator (13) comprises a solenoid or a piezoelectric element. 35
10. The supply arrangement (1) according to any one of the preceding claims, wherein the valve arrangement (9) is configured to be controlled between at least the first and second states based on a pressure of exhaust additive supplied to the chamber (7). 40
11. The supply arrangement (1) according to any one of the preceding claims, wherein the supply arrangement (1) comprises a motor (15) configured to rotate the nozzle body (5) around the rotation axis (Ax) during operation of the supply arrangement (1). 45
12. The supply arrangement (1) according to any one of the preceding claims, wherein the nozzle body (5) is configured to be rotated around the rotation axis (Ax) by the stream of exhaust gas of the internal combustion engine (40). 50 55
13. The supply arrangement (1) according to any one of the preceding claims, wherein the nozzle body (5) is configured to be rotated around the rotation axis (Ax)

by reaction forces obtained from the flow of exhaust additive through the number of supply holes (8).

14. An internal combustion engine (40) comprising an exhaust system (30) and a supply arrangement (1) according to any one of the preceding claims, wherein the supply arrangement (1) is configured to supply an exhaust additive to a stream of exhaust gas in the exhaust system (30).
15. A vehicle (2) comprising an internal combustion engine (40) according to claim 14.

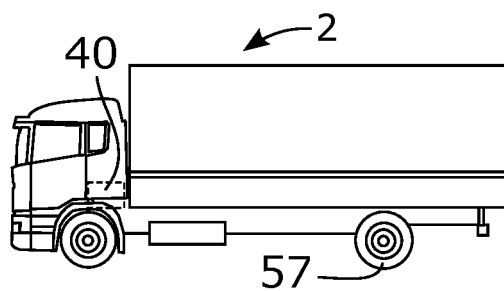


Fig. 1

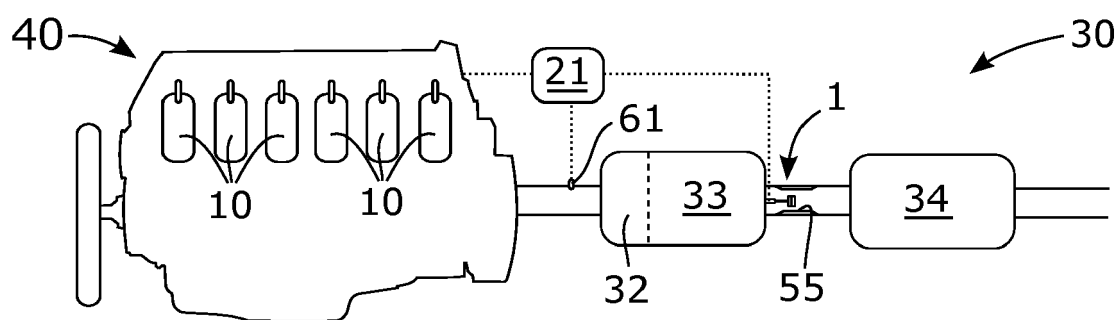


Fig. 2

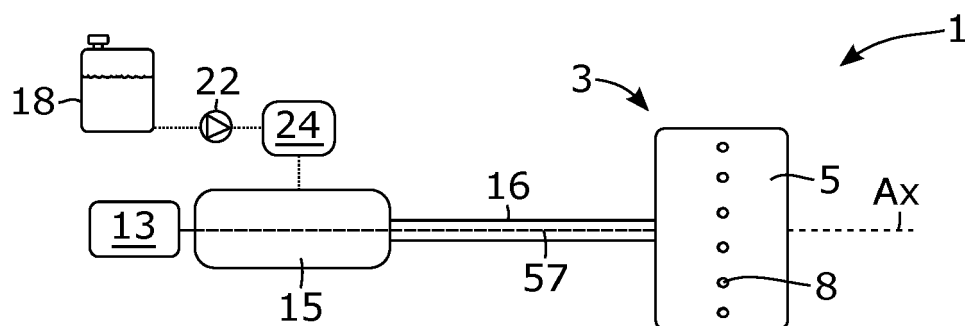


Fig. 3

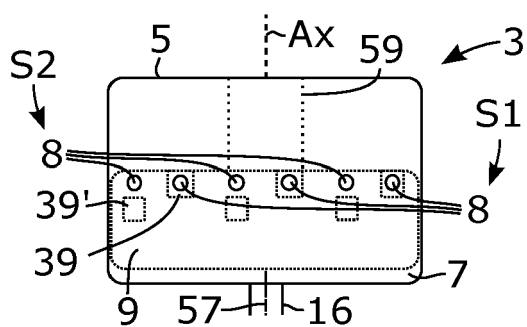


Fig. 4a

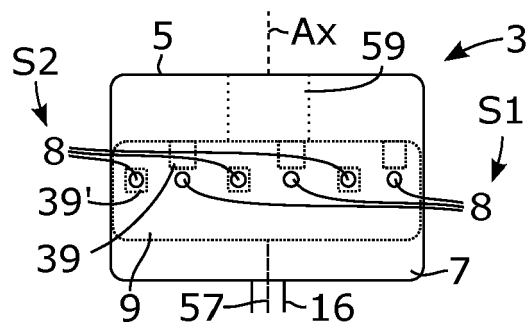


Fig. 4b

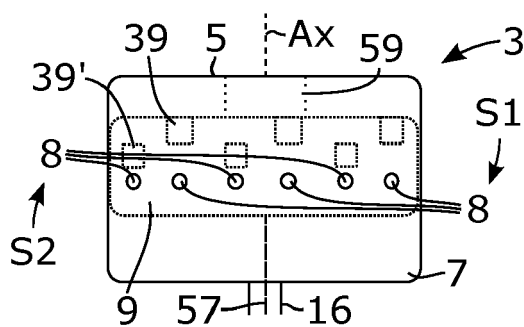


Fig. 4c

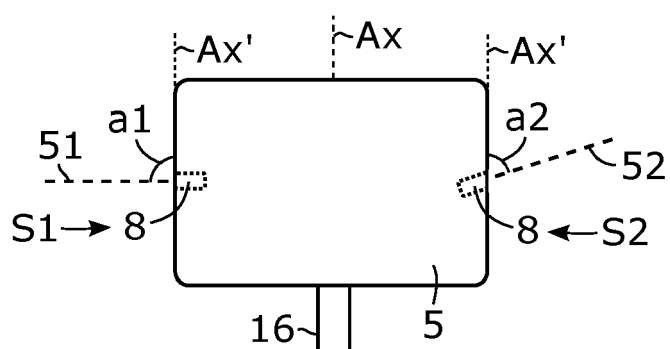


Fig. 5



EUROPEAN SEARCH REPORT

Application Number

EP 22 16 9354

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	CN 113 047 927 A (HENAN DIESEL ENGINE IND CO LTD) 29 June 2021 (2021-06-29) * the whole document *	1-15	INV. F01N3/20
A	US 6 203 770 B1 (PETER-HOBLYN JEREMY D [GB] ET AL) 20 March 2001 (2001-03-20) * column 4, line 64 - column 5, line 26; figures 1,2 *	1-15	
			TECHNICAL FIELDS SEARCHED (IPC)
			F01N
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
Munich		18 October 2022	Zebst, Marc
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			
T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 22 16 9354

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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18-10-2022

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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US 6203770 B1	20-03-2001	US 5968464 A	19-10-1999
		US 6203770 B1	20-03-2001