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(54) Mixing pipe for recirculated exhaust gas and air
Mischrohr für rückgeführtes Abgas und Luft
Conduite de mélange pour gaz d'échappement de recirculation et air

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Description

Technical Field

[0001] The present disclosure generally refers to a mixing pipe for mixing recirculated exhaust gas and air and supplying the mixture of the exhaust gas and the air to a plurality of combustion chambers of the internal combustion engine, e.g., a large internal combustion engine configured to burn heavy fuel oil. The present disclosure also refers to a mixing pipe segment configured to be connected to another mixing pipe segment for forming a mixing pipe of the type mentioned herein. Finally, the present disclosure refers to a method for repairing a mixing pipe consisting of a plurality of mixing pipe segments.

Background

[0002] Exhaust gas recirculation systems (also referred to as EGR systems) are employed by internal combustion engines to help reduce various engine emissions. A typical EGR system may include a conduit, or other structure, fluidly connecting some portion of the exhaust path of an engine with some portion of the air intake system of the engine to thereby form an EGR path. Different amounts of exhaust gas recirculation may be desirable under different engine operating conditions. In order to regulate the amount of exhaust gas recirculation, such systems typically employ an EGR valve that is disposed at some point in the EGR path.

[0003] Systems have been developed to control EGR flow by regulating the amount of exhaust gases that are recirculated under various operating conditions, e.g., by controlling the position of an EGR valve. Some systems include an actuator for opening and closing the EGR valve, wherein the actuator is controlled by software-implemented control logic. Depending on the operating conditions of the engine, the control logic may position the EGR valve to allow varying amounts of exhaust gases to be recirculated.

[0004] While larger amounts of exhaust gas recirculation (i.e., higher EGR flow rates) may, under certain engine operating conditions, reduce emissions, various components may be affected by the EGR flow rate and, as such, may be taxed beyond their operating limits if EGR flow rates get too high. Exemplary components and/or engine operating parameters that can be affected by EGR flow rate may include turbochargers, engine temperature, exhaust temperature, exhaust pressure, catalytic converters, particulate traps, air-to-air after coolers (ATAAC), EGR coolers, etc. In addition, condensation of gases in the air intake track of the engine may also become problematic at higher EGR flow rates.


[0006] In particular, EGR systems have been developed that are configured to improve the level of mixture of recirculated exhaust gas and air. The air may be supplied by a compressor, e.g., a high pressure compressor.

[0007] For example, DE 10 2005 019 776 A1, discloses an exhaust gas recirculation device configured to recirculate an exhaust gas from an exhaust gas duct to a suction duct. A recirculated exhaust gas discharging area is arranged in a mixing pipe in the flow direction of fresh air, before an air manifold. The pipe has a curvature ranging between 215° and 340° before an inlet in the air manifold, with respect to an axis that is arranged parallel to a longitudinal axis of the engine. Such an arrangement shall improve the mixing ratio of the exhaust gas and the fresh air so that the mixture of the recirculated exhaust gas and the fresh air and its mixing ratio is for all cylinders of the internal combustion engine the same before the mixture enters the various combustion chambers of the internal combustion engine. The disclosed exhaust gas recirculation device is disclosed for internal combustion engines configured to be used in motor vehicles and the exhaust gas recirculating device may need a considerable space which may not be available, in particular at large internal combustion engines configured to burn heavy fuel oils.

[0008] US 6,032,634 A discloses a mixing pipe for mixing re-circulated exhaust gas and air and supplying a mixture of the exhaust gas and the air to a plurality of combustion chamber of an internal combustion engine. The mixing pipe comprises a first mixing pipe section having a mixing pipe inlet and a mixing pipe outlet, wherein the predetermined length of the first mixing pipe section is configured to achieve a defined mixing ratio of the exhaust gas and the air at the mixing pipe outlet. Furthermore, the mixing pipe comprises a second mixing pipe section coupled to the mixing pipe outlet, wherein the second mixing pipe section is provided with a plurality of outlets, each outlet being configured to be coupled to a duct supplying a portion of the gas mixture to an associated combustion chamber of the plurality of combustion chambers. The first mixing pipe section and the second mixing pipe section extend substantially parallel to each other.

[0009] US 2002/043234 A1 discloses an intake manifold, which comprises a plurality of individual pipe sections connected to each other.

[0010] US 2406/185639 A1 discloses a modular air intake system, which comprises a variety of modular components coupled together by separate connecting segments.

[0011] WO 2005/057002 A2 discloses an induction device including a collecting housing with at least two collecting spaces. A group of intake manifolds leading to inlet ports of cylinders emanates from each collecting space. An induction line section leads into each collecting...
space, whereby the induction line sections emanate from a common induction line. At least in a first section of the induction line there is provided an exhaust recycling means.

[0012] DE 3501067 A1 discloses an induction system including a mixing pipe with a first mixing pipe section for mixing a part of a fresh air with re-circulated exhaust gas and a second mixing pipe section being parallel to the first mixing pipe section for mixing the gas exiting from the first mixing pipe section with additional fresh air and supplying this gas to a plurality of combustion chambers of an internal combustion engine.

[0013] WO 94/04815 discloses an internal combustion engine air-aspiration system which includes an enclosure with an inlet pipe and the separate suction pipes which are connected to individual cylinders.

[0014] The present disclosure is directed, at least in part, to improving or overcoming one or more aspects of prior systems.

Summary of the Disclosure

[0015] In a first exemplary aspect of the present disclosure a mixing pipe is provided. The mixing pipe is configured to mix recirculated exhaust gas and air and supplying the mixture to a plurality of combustion chambers of an internal combustion engine. The mixing pipe may comprise a first mixing pipe section having a mixing pipe inlet and a mixing pipe outlet. The distance between the mixing pipe inlet and the mixing pipe outlet may have a predetermined length. The predetermined length of the first mixing pipe section may be configured to achieve a defined mixing ratio of the exhaust gas and the air at the mixing pipe outlet. The mixing pipe further may comprise a second mixing pipe section coupled to the mixing pipe outlet of the first mixing pipe section. The second mixing pipe section may be provided with a plurality of outlets, each outlet may be configured to be coupled to a duct supplying a portion of the gas mixture to an associated combustion chamber of the plurality of combustion chambers. In addition, the first mixing pipe section and the second mixing pipe section may extend substantially parallel to each other. The defined mixing ratio of the mixture of the recirculated exhaust gas and the air may be set such that it may not substantially vary after entering in the second mixing pipe section, and, consequently, the mixing ratio may be substantially the same before the mixture enters into the various combustion chambers. The mixing pipe contains or is covered with a mineral to neutralize sulfur acid contained in the recirculated exhaust gas flow, in particular CaO, BaO, or MgO, at least at portions which may come into contact with the recirculated exhaust gas flow.

[0016] In another exemplary aspect of the present disclosure a mixing pipe segment for forming a mixing pipe may be configured to be connected to another mixing pipe segment. Accordingly, a plurality of mixing pipe segments may form a mixing pipe of the type disclosed here-
angle in a range of 70°-120°.

[0029] In addition the terminology "large internal combustion engine" used herein may refer to internal combustion engines which may be used as main or auxiliary engines of ships/vessels such as cruiser liners, cargo ships, container ships, and tankers, or in power plants for production of heat and/or electricity, or the like. In particular, large internal combustion engines may be configured to burn at least one fuel selected from the group consisting of diesel and heavy fuel oil (HFO).

[0030] Referring to Fig. 1, an internal combustion engine 5 extending along a longitudinal direction is shown, for example a large internal combustion engine configured to burn inter alia heavy fuel oil or their like is shown. On a front side of the internal combustion engine 5 a low pressure compressor 20 may be located, low pressure compressor 20 may being connected to an intake air cooler 25. Intake air cooler 25 in turn is connected to an inlet of a duct 30 extending from the front end to another opposite front end of internal combustion engine 5.

[0031] At the opposite front end of internal combustion engine 5 a high pressure compressor 40 may be arranged. High pressure compressor 40 may be connected to an outlet of duct 30 located at the opposite front end of internal combustion engine 5. High pressure compressor 40 may also be connected to a further cooler 35 in which compressed intake air supplied by compressor 40 may be cooled.

[0032] Cooler 35 may be connected to a mixing pipe 100. Mixing pipe 100 may be located at an upper side of internal combustion engine 5, e.g. adjacent to duct 30. Alternative locations for mixing pipe 100 are possible, e.g. between cylinders of V-type internal combustion engine. Mixing pipe 100 may comprise a first mixing pipe section 102 and a second mixing pipe section 106. First mixing pipe section 102 may include a mixing pipe inlet 103 and a mixing pipe outlet 104. Mixing pipe inlet 103 may be connected to an outlet 36 of cooler 35. A pipe 95 may also be connected to mixing pipe inlet 103. The pipe 95 may be connected to an exhaust gas recirculation system for recirculating exhaust gas 46 from an exhaust side of internal combustion engine 5.

[0033] The distance between mixing pipe inlet 103 and mixing pipe outlet 104 may have a predetermined length L so that the exhaust gas 46 and the air 45 leaving cooler 35 mix with each other so that a defined mixing ratio may be achieved at the area of mixing pipe outlet 104. First mixing pipe section 102 may extend at least over half or about the whole length of the internal combustion engine 5 or its engine block.

[0034] Second mixing pipe section 106 may be coupled to mixing pipe outlet 104 via a coupling segment 105 and may be provided with a plurality of outlet 120. Each outlet 120 may be configured to be coupled to a duct 15 of a plurality of ducts 15. Each duct 15 may be connected to a combustion chamber 16 (see e.g. Fig. 3) of a plurality of combustion chambers 16 of internal combustion engine 5. Second mixing pipe section 106 may include a closed end part on the front end opposite to coupling segment 105.

[0035] Coupling segment 105 may be configured to turn or divert the mixture of exhaust gas 46 and intake air 45 discharged at mixing pipe outlet 104 by an angle ranging between about 160° to 200°, in particular about 180°, to an inlet of second mixing pipe section 106. In other words: a longitudinal direction of the first mixing pipe section 102 and a longitudinal direction of second mixing pipe section 106 may insert an angle of about 0° to 40°.

[0036] Fig. 2a shows a schematic cross sectional view of mixing pipe 100 along line II-II of Fig. 1. Mixing pipe 100 may comprise first mixing pipe section 102 and second mixing pipe section 106. Both may have identical, similar, or different cross sectional shapes. In the exemplary embodiment of mixing pipe 100 shown in Fig. 2a first mixing pipe section 102 and second mixing pipe section 106 have identical cross sectional shapes and may be arranged adjacent to each other. Second mixing pipe section 106 may be located above first mixing pipe section 102. However, in other exemplary embodiments of mixing pipe 100 first mixing pipe section 102 and second mixing pipe section 106 may be arranged side by side, or in any another configuration.

[0037] Referring to Fig. 2b another exemplary embodiment of mixing pipe 100’ is shown. Contrary to the exemplary embodiment of mixing pipe 100 shown in Fig. 2a mixing pipe 100’ shown in Fig. 2b may have another cross sectional shape. In particular, first mixing pipe section 102 may have a cross sectional shape other then circular, e.g. elliptic, oval, block shaped etc. The second mixing pipe section 106 may also have a cross sectional shape which is not circular, for example elliptic, oval, block shaped etc.

[0038] Both embodiment of mixing pipe 100, 100’ shown in Figs. 2a and 2b may be formed in one piece, but it is also possible, to provide each mixing pipe segment 102 and 106 separate and connect them by welding, bolting, clamping etc. This may also apply to the further exemplary embodiments of mixing pipes shown in the other Figs. It may also appropriate to provide a plurality of mixing pipe segments each comprising a portion of first mixing pipe section 102 and second mixing pipe section 106. For example, a mixing pipe segment may have a predetermined length so that one mixing pipe segment may be associated to one (ore more) duct(s) and combustion chamber(s). Alternatively, a mixing pipe segment may comprise only a portion of first mixing pipe section 102 and second mixing pipe section 106. For more details see Fig. 6 and the accompanying description.

[0039] Fig. 3 shows a schematic sectional view of an internal combustion engine 5 which may comprise a plurality of cylinders 18. Each cylinder 18 may comprise one of the plurality of combustion chambers 16. Each combustion chamber 16 may be defined by a piston 17. On the side of cylinders 18 mixing pipe 100” may be located.
Mixing pipe 100" may have another configuration as mixing pipes 100 shown in Figs. 1-2b. Further details of mixing pipe 100" are shown in Figs. 4 and 5.

[0040] Above mixing pipe 100" a high pressure exhaust gas duct 43 may be located. High pressure exhaust gas duct 43 may be connected to duct 95 shown in Fig. 1.

[0041] A low pressure exhaust gas duct 42 may be arranged above high pressure exhaust gas duct 43. Low pressure exhaust gas duct 42 may be connected to a turbine (not shown) configured to pressurize the low pressure exhaust gas. Duct 30 for the low pressure exhaust gas (see Fig. 1) may be located below mixing pipe 100".

[0042] Figs. 4 and 5 show another exemplary embodiment of a mixing pipe 100" as already schematically shown in Fig. 3. This exemplary embodiment of mixing pipe 100" may comprise a first mixing pipe section 102" and a second mixing pipe section 106". First mixing pipe section 102" may be housed within the interior 111" of second mixing pipe section 106". First mixing pipe section 102" may be connected to an inlet portion 107 which in turn may be connected to duct 95 and cooler 35. Second mixing pipe section 106" may comprise a closed end part 105" and another closed end part 112" opposite closed end part 105". Closed end part 112" may be penetrated by inlet part 107. First mixing pipe section 102" may be mounted within the interior 111" of second mixing pipe section 106" via the end of end part 112" and struts 130".

[0043] First mixing pipe section 102" may be located within second mixing pipe section 106" so that mixture of the exhaust gas 46 and the intake air 45 discharged at the outlet of first mixing pipe section 102 may flow around at least part of the outer surface of first mixing pipe section 102". As indicated in Fig. 4, ducts 15 may be connected to outlets 15 of second mixing pipe section 106".

[0044] Fig. 5 shows a schematical cross section view along line V-V of Fig. 4. Two struts 130" mount the open end of first mixing pipe section 102" within the interior 111" of second mixing pipe section 162". In other exemplary embodiments different struts or another number of struts may be provided for mounting the first mixing pipe section 102" within second mixing pipe section 106".

[0045] Referring to Fig. 6 another exemplary embodiment of a mixing pipe 100" is shown. Here, mixing pipe 100" may comprise a first mixing pipe segment 305 and a second mixing pipe segment 310. Adjacent first and second mixing pipe segments 305, 310 may be coupled via a connector segment 315.

[0046] Connecting segments 315 may be fixed in longitudinal direction of mixing pipe 100" via, for example, a locking ring 320. Other mechanical locking means may be contemplated, for example screws, bolts etc. Locking rings 320 may be placed within a groove 325 formed at the outer surface of segments 305, 310. Each segment 305, 310 may be provided with a further groove 330 in which a seal ring, for example a O-ring, is inserted. Sealing rings 335 may contact an inner surface of connecting segments 315 for providing a fuel between the two segments 305, 310 so that no gas of the gas mixture flowing within interior 110" may leak from the interior 110".

[0047] If the temperature of the gas mixture of exhaust gas and air flowing within interior 110" may fall below dew point sulfur acid may be generated. Sulfur acid may be problematic with respect to corrosion of segments 305, 310 and other parts like a segment 315.

[0048] In the exemplary embodiment of a mixing pipe 100" shown in Fig. 6 mixing pipe segment 310 may be provided with a step 340 shaped for receiving a ring 345 which may contain or is made of alkaline earth oxides, e.g. selected from the group consisting of CaO, BaO, and MgO. The alkaline earth oxide of ring 345 may be configured to neutralize sulfur acid which may condensate in interior 110", if the temperature falls below a specific temperature, e.g. the dew point of sulfur acid. As ring 345 may be able to absorb or bind sulfur acid, corrosion within mixing pipe 100" may be reduced. As the absorption capacity of ring 345 may be limited, ring 345 may be fitted in an exchangeable manner on or at step 340.

[0049] Alternatively, ring 345 may be configured to line the inner surface of segments 305, 310, 315 at least in part. In another exemplary embodiment of a mixing pipe 100, 100" the mineral may be sputtered or painted on at least portions of surfaces of segments 305, 310, 315 etc. Accordingly, corrosion of these parts may be reduced.

Industrial Applicability

[0050] Referring to Figs. 1 and 2a, the basic principle of operation of the EGR system of internal combustion engine 5 is explained in the following.

[0051] Intake air may be supplied to low pressure compressor 20. In low pressure compressor 20 intake air may be pressurized and discharged to cooler 25. In cooler 25 the compressed intake air may be cooled to a defined temperature. Cooled and compressed intake air leaving cooler 25 may enter into duct 30 and may flow from one front end to another front end of internal combustion engine 5.

[0052] Intake air flow may enter into high pressure compressor 40. In high pressure compressor 40 the intake air may be further compressed up to a defined pressure level. The high pressure intake air discharged by high pressure compressor 40 may be supplied to cooler 35. In cooler 35 the high pressure intake air may be cooled down to a defined temperature. The high pressure intake air having a reduced defined temperature may be discharged into mixing pipe inlet 103.

[0053] Recirculated exhaust gas may also be supplied into mixing pipe inlet 103. Accordingly, the recirculated exhaust gas 46 and high pressure intake air having a reduced temperature may flow from mixing pipe inlet 103 to mixing pipe outlet 104 in interior 110 of mixing pipe 100 (or 100"). In interior 110 further mechanical means for increasing mixing of the two gas flows 45, 46 may be provided.
[0054] As the intake air 45 and exhaust gas 46 may flow along first mixing pipe section 102 over a distance L which may extend for at least half of the length of the engine 5 the two gas flows 45, 46 may sufficiently mix so that a defined mixing ratio of the two gas flows 45, 46 may be achieved at the end at mixing pipe outlet 104. The gas mixture having a defined mixing ratio may then deflect into second mixing pipe section 106 and flow in each duct 15 and further to the associated combustion chambers 16.

[0055] As a predefined mixing ratio may already be achieved at mixing pipe outlet 104 the mixing ratio may be roughly similar or identical in each duct 15. The space occupied by first mixing pipe section 102 and second mixing pipe section 106 may be reduced due to the specific arrangement of the two sections 102, 106 to each other.

[0056] According to the present disclosure mixing pipes 100, 100° may take advantage of the longitudinal dimension of engine 5 for providing a sufficient mixture of the two gas flows 45, 46.

[0057] As indicated in Fig. 1, mixing pipe 100 may be assembled from a plurality of mixing pipe segments 110. The segments 110 may be connected with each other via a connecting segment as for example shown in Fig. 6. However, other ways for connecting two adjacent segments 110 are possible. For example, segments 110 may be welded, bolted, or connected via other mechanical means, e.g. positive locking engagement means.

[0058] In case of corrosion generated by sulfur acid contained within the gas mixture one or more segments 110 may have to be replaced after a defined time period. In this case, the connection between two adjacent segments may be released and a new segment 110 may be inserted.

[0059] In case of connecting means designed as a connecting means 315 of Fig. 6 locking rings 320 may be removed. Afterwards, ring 315 may be shifted in a longitudinal direction (to the left side in Fig. 6). Afterwards, segment 310 may be replaced by a new segment 310. In case that ring 345 has to be replaced only, ring 345 may be removed from step 340 and replaced by a new ring. Afterwards, connecting segment 315 may be shifted in the opposite direction and fixed by new rings 320. If necessary or appropriate, sealing rings 330 may be replaced, too.

[0060] Accordingly, a simple but efficient manner for replacing parts of mixing pipe 100, 100° may be provided. In addition, corrosion of parts or portions of mixing pipe 100, 100° may be reduced.

[0061] It will be apparent to those skilled in the art that various modifications and variations can be made to the disclosed mixing pipes and methods without departing from the scope of the present invention as defined by the appended claims.

[0062] For example, in addition or supplementary to the exemplary embodiments disclosed above, according to an exemplary embodiment of a mixing pipe of the present disclosure the second mixing pipe section may have a length measured from a first outlet to a last outlet along a longitudinal direction of the second mixing pipe section and this length of the second mixing pipe section may being at least more than half of the predetermined length of the first mixing pipe section. The length of the first mixing pipe section may be at least half of the length of the engine or the engine block, e.g. the first mixing pipe section may have a length nearly identical with the length of the engine block.

[0063] According to another exemplary embodiment of a mixing pipe of the present disclosure the second mixing pipe section may have a first end and a second end. The first end may be open and the second end may be closed. The first mixing pipe section may be housed within the second mixing pipe section.

[0064] According to another exemplary embodiment of a mixing pipe of the present disclosure the mixing pipe may further comprise an exhaust gas inlet configured to induce the recirculated exhaust gases into the air at the pipe inlet.

[0065] According to another exemplary embodiment of a mixing pipe of the present disclosure the first mixing pipe section may be configured to be connected to an outlet of a high pressure compressor configured to discharge compressed air.

[0066] According to another exemplary embodiment of a mixing pipe of the present disclosure the mixing pipe may further comprise a cooling water passage arranged in parallel to at least of the first mixing pipe section and the second mixing pipe section.

[0067] According to another exemplary embodiment of a mixing pipe of the present disclosure the mixing pipe may be configured to be used in an internal combustion engine configured to burn heavy fuel oil.

[0068] According to another exemplary embodiment of a mixing pipe of the present disclosure the first mixing pipe section and/or the second mixing pipe section may consist of a plurality of separate mixing pipe segments configured to be connected to each other. The mixing pipe segments may be replaceable connected so that a plurality of mixing pipe segments may form a mixing pipe of the type disclosed herein.

[0069] According to another exemplary embodiment of the mixing pipe segment a separate connecting segment may be configured to connect two adjacent mixing pipe segments.

[0070] According to another exemplary embodiment of a mixing pipe consisting of a plurality of mixing pipe segments at least two mixing pipe segments may be identical constructed.

[0071] According to another exemplary embodiment of a mixing pipe the two passages formed within the mixing pipe may be arranged side by side or above each other.
1. A mixing pipe (100) for mixing recirculated exhaust gas and air (45) and supplying a mixture of the exhaust gas (46) and the air (45) to a plurality of combustion chambers (16) of an internal combustion engine (5), the mixing pipe (100) comprising:

   a first mixing pipe section (102) having a mixing pipe inlet (103) and a mixing pipe outlet (104), the distance between the mixing pipe inlet (103) and the mixing pipe outlet (104) having a predetermined length, wherein the predetermined length of the first mixing pipe section (102) is configured to achieve a defined mixing ratio of the exhaust gas (46) and the air (45) at the mixing pipe outlet (104);
   a second mixing pipe section (106) coupled to the mixing pipe outlet (104) and extending substantially parallel to the first mixing pipe section (102), the second mixing pipe section (106) being provided with a plurality of outlets (120), each outlet (120) being configured to be coupled to a duct (15) supplying a portion of the gas mixture (47) to an associated combustion chamber (16) of the plurality of combustion chambers (16);

   characterized in that the mixing pipe (100) contains or is covered with a mineral to neutralize sulfur acid contained in the recirculated exhaust gas flow (46), in particular CaO, BaO, or MgO, at least at portions which may come into contact with the recirculated exhaust gas flow (46).

2. The mixing pipe of claim 1, wherein:

   the second mixing pipe section (106) has a length measured from a first outlet (120) to a last outlet (120) along a longitudinal direction of the second mixing pipe section (106); and
   the length of the second mixing pipe section (106) is at least more than half of the predetermined length of the first mixing pipe section (102).

3. The mixing pipe of claim 1 or 2, wherein:

   the second mixing pipe section (106) has a first end and a second end, the first end being open and the second end being closed; and
   the first mixing pipe section (102) is housed within the second mixing pipe section (106).

4. The mixing pipe of any one of the preceding claims, further comprising:

   an exhaust gas inlet (95) configured to induce the recirculated exhaust gases (46) into the air (45) at the mixing pipe inlet (103).

5. The mixing pipe of any one of the preceding claims, wherein the first mixing pipe section (102) is configured to be connected to an outlet of a high pressure compressor (40) configured to discharge compressed air (46).

6. The mixing pipe of any one of the preceding claims, further comprising:

   a cooling water passage arranged in parallel to at least one of the first mixing pipe section (102) and the second mixing pipe section (106).

7. The mixing pipe of any one of the preceding claims, wherein the mixing pipe (100; 100") is configured to be used in an internal combustion engine (5) configured to burn heavy fuel oil.

8. The mixing pipe of any one of the preceding claims, wherein the first mixing pipe section (102) and/or the second mixing pipe section (106) are consisting of replaceable section segments (305, 310) configured to be connected to each other.

9. A mixing pipe segment (305, 310) configured to be connected to another mixing pipe segment (305, 310), wherein the mixing pipe segments are configured to constitute replaceable section segments of the first mixing pipe section (102) and/or the second mixing pipe section (106) of a mixing pipe according to claim 8 so that a plurality of mixing pipe segments (305, 310) form a mixing pipe (100; 100") of any one of the preceding claims.

10. The mixing pipe segment (305, 310) of claim 9, wherein the mixing pipe segment (305, 310) includes a first front end and a second front end opposite the first front end and a second front end opposite the first front end, the first front end being configured to get into releasable engagement with a second front end of another mixing pipe segment (305, 310).

11. The mixing pipe segment (305, 310) of claim 9 or 10, further comprising:

   a separate connecting segment (315) configured to connect two adjacent pipe section segments (305, 310).

12. The mixing pipe segment (305, 310) of any one of claims 9-11, wherein at least a portion or part of the mixing pipe segment (305, 310) contains or is covered with a material for neutralizing sulfur acid, in particular the material being CaO or BaO.

13. A method for repairing a mixing pipe (100; 100") of claim 8, the method comprising:
disconnecting a mixing pipe segment (305, 310) of the plurality of mixing pipe segments (305, 310) forming the mixing pipe (100; 100°); and replacing the disconnected mixing pipe segment (305, 310) by a new mixing pipe segment.

Patentansprüche

1. Mischrohr (100) zum Mischen von rückgeführttem Abgas und Luft (45) und Zuführen eines Gemisches des Abgases (46) und der Luft (45) zu einer Mehrzahl von Brennkammern (16) einer Brennkraftmaschine (5) mit innerer Verbrennung, welches Mischrohr (100) enthält:

- einen ersten Mischrohrabschnitt (102), der einen Mischrohreinlass (103) und einen Mischrohrauslass (104) enthält, wobei der Abstand zwischen dem Mischrohreinlass (103) und dem Mischrohrauslass (104) eine vorbestimmte Länge hat, wobei die vorbestimmte Länge des ersten Mischrohrabschnitts (102) derart bemessen ist, dass an dem Mischrohrauslass (104) ein vorbestimmtes Mischungsverhältnis des Abgases (46) und der Luft (45) erreicht wird;
- einen zweiten Mischrohrabschnitt (106), der an den Mischrohrauslass (104) gekoppelt ist und sich im Wesentlichen parallel zu dem ersten Mischrohrabschnitt (102) erstreckt, wobei der zweite Mischrohrabschnitt (106) mit einer Mehrzahl von Auslässen (120) versehen ist, wobei jeder Auslass (120) derart konfiguriert ist, dass er an eine Leitung (15) gekoppelt ist, die einen Teil des Gasgemisches (47) einer zugehörigen Brennkammer (16) der Mehrzahl von Brennkammern (16) zuführt;

dadurch gekennzeichnet, dass das Mischrohr (100; 100°) ein Mineral enthält oder mit einem Mineral bedeckt ist, um in der rückgeführtten Abgasströmung (46) enthaltene Schwefelsäure zu neutralisieren, insbesondere CaO, BaO, oder MgO zumindest an Bereichen, die in Berührung mit der rückführten Abgasströmung (46) kommen können.

2. Mischrohr nach Anspruch 1, wobei der zweite Mischrohrabschnitt (106) eine von einem ersten Auslass (120) zu einem letzten Auslass (120) längs einer Längsrichtung des zweiten Mischrohrabschnitts (106) gemessene Länge hat; und die Länge des zweiten Mischrohrabschnitts (106) wenigstens größer als die Hälfte der vorbestimmten Länge des ersten Mischrohrabschnitts (102) ist.

3. Mischrohr nach Anspruch 1 oder 2, wobei der zweite Mischrohrabschnitt (106) ein erstes Ende und ein zweites Ende hat, das erste Ende offen ist und das zweite Ende geschlossen ist; und der erste Mischrohrabschnitt (102) innerhalb des zweiten Mischrohrabschnitts (106) aufgenommen ist.

- einen Abgaseinlass (95), der derart konfiguriert ist, dass das rückführte Abgas (46) an dem Mischrohreinlass (103) in die Luft (45) eingeleitet wird.

5. Mischrohr nach einem der vorhergehenden Ansprüche, wobei der erste Mischrohrabschnitt (102) derart konfiguriert ist, dass er an einen Auslass eines Hochdruckkompressors (40) angeschlossen ist, der konfiguriert ist, um komprimierte Luft (46) abzugeben.

6. Mischrohr nach einem der vorhergehenden Ansprüche, weiter enthaltend:

- einen Kühlwasserdurchlass, der parallel zu mindesten einem von erstem Mischrohrabschnitt (102) und zweitem Mischrohrabschnitt (106) angeordnet ist.

7. Mischrohr nach einem der vorhergehenden Ansprüche, wobei das Mischrohr (100; 100°) derart konfiguriert ist, dass es in einer Brennkraftmaschine (5) mit innerer Verbrennung verwendet wird, die zur Verbrennung von Schweröl konfiguriert ist.

8. Mischrohr nach einem der vorhergehenden Ansprüche, wobei der erste Mischrohrabschnitt (102) und/oder der zweite Mischrohrabschnitt (106) aus austauschbaren Abschnittssegmenten (305, 310) bestehen, die aneinander anschließbar konfiguriert sind.

9. Mischrohrsegment (305, 310), das zur Verbindung mit einem anderen Mischrohrsegment (305, 310) konfiguriert ist, wobei die Mischrohrsegmente derart konfiguriert sind, dass sie austauschbare Abschnittssegmente des ersten Mischrohrabschnitts (102) und/oder des zweiten Mischrohrabschnitts (106) eines Mischrohrs nach Anspruch 8 bilden, so dass eine Mehrzahl von Mischrohrsegmenten (305, 310) ein Mischrohr (100; 100°) nach einem der vorhergehenden Ansprüche bildet.

10. Mischrohrsegment (305, 310) nach Anspruch 9, wobei das Mischrohrsegment (305, 310) ein erstes Vorderende und ein zu dem ersten Vorderende entgegengesetztes zweites Vorderende enthält und das erste Vorderende derart konfiguriert ist, dass es in
lösbarer Eingriff mit einem zweiten Vorderende eines anderen Mischrohrsegments (305, 310) gelangt.

11. Mischrohrsegment (305, 310) nach Anspruch 9 oder 10, weiter enthaltend: ein separates Verbindungssegment (315), das zur Verbindung von zwei benachbarten Rohrabschnittssegmenten (305, 310) konfiguriert ist.

12. Mischrohrsegment (305, 310) nach einem der Ansprüche 9 bis 11, wobei wenigstens ein Bereich oder Teil des Mischrohrsegments (305, 310) ein Material enthält oder mit einem Material bedeckt ist, um Schwefelsäure zu neutralisieren, wobei das Material insbesondere CaO oder BaO ist.

13. Verfahren zum Reparieren eines Mischrohrs (100; 100") nach Anspruch 8, welches Verfahren enthält:

   Lösen eines Mischrohrsegments (305, 310) einer Mehrzahl von Mischrohrsegmenten (305, 310), die das Mischrohr (100; 100") bilden; und Ersetzen des gelösten Mischrohrsegments (305, 310) durch ein neues Mischrohrsegment.

Revendications

1. Conduite de mélange (100) pour mélanger du gaz d’échappement remis en circulation et de l’air (45) et fournissant un mélange du gaz d’échappement (46) et de l’air (45) à une pluralité de chambres de combustion (16) d’un moteur à combustion interne (5), la conduite de mélange (100) comprenant :

   une première section de conduite de mélange (102) ayant une entrée de conduite de mélange (103) et une sortie de conduite de mélange (104), la distance entre l’entrée de conduite de mélange (103) et la sortie de conduite de mélange (104) ayant une longueur prédéterminée, dans laquelle la longueur prédéterminée de la première section de conduite de mélange (102) est configurée pour obtenir un rapport de mélange défini du gaz d’échappement (46) et de l’air (45) à la sortie de conduite de mélange (104); une seconde section de conduite de mélange (106) couplée à la sortie de conduite de mélange (104) et s’étendant de manière sensiblement parallèle à la première section de conduite de mélange (102), la seconde section de conduite de mélange (106) étant pourvue d’une pluralité de sorties (120), chaque sortie (120) étant configurée pour être couplée à une canalisation (15) fournissant une portion du mélange gazeux (47) à une chambre de combustion associée (16) de la pluralité de chambres de combustion (16); caractérisée en ce que : la conduite de mélange (100 ; 100") contient ou est recouverte d’un minéral pour neutraliser l’acide sulfurique contenu dans l’écoulement de gaz d’échappement remis en circulation (46), en particulier du CaO, du BaO ou du MgO, au moins dans des portions qui peuvent venir en contact avec l’écoulement de gaz d’échappement remis en circulation (46).

2. Conduite de mélange selon la revendication 1, dans laquelle :

   la seconde section de conduite de mélange (106) a une longueur mesurée d’une première sortie (120) à une dernière sortie (120) le long d’une direction longitudinale de la seconde section de conduite de mélange (106); et la longueur de la seconde section de conduite de mélange (106) est au moins supérieure à la moitié de la longueur prédéterminée de la première section de conduite de mélange (102).

3. Conduite de mélange selon la revendication 1 ou 2, dans laquelle :

   la seconde section de conduite de mélange (106) a une première extrémité et une seconde extrémité, la première extrémité étant ouverte et la seconde extrémité étant fermée; et la première section de conduite de mélange (102) est logée à l’intérieur de la seconde section de conduite de mélange (106).

4. Conduite de mélange selon l’une quelconque des revendications précédentes, comprenant en outre :

   une entrée de gaz d’échappement (95) configurée pour induire les gaz d’échappement remis en circulation (46) dans l’air (45) à l’entrée de conduite de mélange (103).

5. Conduite de mélange selon l’une quelconque des revendications précédentes, dans laquelle la première section de conduite de mélange (102) est configurée pour être raccordée à une sortie d’un compresseur haute pression (40) configurée pour décharger de l’air comprimé (46).

6. Conduite de mélange selon l’une quelconque des revendications précédentes, comprenant en outre :

   un passage d’eau de refroidissement aménagé de manière parallèle à la au moins une première section de conduite de mélange (102) et à la seconde section de conduite de mélange (106).
7. Conduite de mélange selon l’une quelconque des revendications précédentes, dans laquelle la conduite de mélange (100 ; 100") est configurée pour être utilisée dans un moteur à combustion interne (5) configuré pour brûler du mazout lourd.

8. Conduite de mélange selon l’une quelconque des revendications précédentes, dans laquelle la première section de conduite de mélange (102) et/ou la seconde section de conduite de mélange (106) sont constituées de segments de section remplaçables (305, 310) configurés pour être raccordés l’un à l’autre.

9. Segment de conduite de mélange (305, 310) configuré pour être raccordé à un autre segment de conduite de mélange (305, 310), dans lequel les segments de conduite de mélange sont configurés pour constituer des segments de section remplaçables de la première section de conduite de mélange (102) et/ou de la seconde section de conduite de mélange (106) d’une conduite de mélange selon la revendication 8, de sorte qu’une pluralité de segments de conduite de mélange (305, 310) forme une conduite de mélange (100 ; 100") selon l’une quelconque des revendications précédentes.

10. Segment de conduite de mélange (305, 310) selon la revendication 9, dans lequel le segment de conduite de mélange (305, 310) comprend une première extrémité avant et une seconde extrémité avant opposée à la première extrémité avant, la première extrémité avant étant configurée pour entrer en engagement amovible avec une seconde extrémité avant d’un autre segment de conduite de mélange (305 ; 310).

11. Segment de conduite de mélange (305, 310) selon la revendication 9 ou 10, comprenant en outre :

   un segment de raccordement séparé (315) configuré pour raccorder deux segments de section de conduite adjacents (305 ; 310).

12. Segment de conduite de mélange (305, 310) selon l’une quelconque des revendications 9 à 11, dans lequel au moins une portion ou une partie du segment de conduite de mélange (305, 310) contient ou est recouverte d’un matériau pour neutraliser l’acide sulfurique, le matériau étant en particulier le CaO ou le BaO.

13. Procédé de réparation d’une conduite de mélange (100 ; 100") selon la revendication 8, le procédé comprenant les étapes consistant à :

   débrancher un segment de conduite de mélange (305, 310) de la pluralité de segments de
dconde de mélange (305, 310) formant la conduite de mélange (100 ; 100") ; et replacer le segment de conduite de mélange débranché (305, 310) par un nouveau segment de conduite de mélange.
REFERENCES CITED IN THE DESCRIPTION

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