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(54) HIGH GAS INLET TEMPERATURE EGR SYSTEM

EGR-SYSTEM MIT HOHER GASEINTRITTSTEMPERATUR

SYSTÈME DE RECIRCULATION DE GAZ D'ÉCHAPPEMENT À TEMPÉRATURE D'ENTRÉE DE
GAZ ÉLEVÉE

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Description

Field of the Invention

[0001] The present invention relates to gas cooling devices, and particularly although not exclusively to exhaust gas re-circulation coolers for use in automotive applications.

Background to the Invention

[0002] There are many applications in which it is desirable to use gas heat exchangers. These include applications where it is desirable to cool down a gas, for example in exhaust gas re-circulation (EGR) coolers.

[0003] Exhaust gas re-circulation cooling is used extensively on diesel engines to aid the reduction of nitrous oxide emissions. To aid overall emissions reduction, the EGR cooling on diesel engines may also be bypassed so that the re-circulated exhaust gas is not subject to additional cooling.

[0004] Under some circumstances heat exchange from the gas may be required, but under other circumstances it may be undesirable. For example in cold engine conditions, it is desirable not to additionally cool the gas so that the engine can heat up more quickly. Under hot engine conditions, it may be desirable to cool the gas.

[0005] Exhaust gas re-circulation and the cooling of re-circulating exhaust gases can also be applied in gasoline (petrol) engines. This is of particular use when downsizing a gasoline engine and utilising turbo charging. Cooled exhaust gas re-circulation can help to significantly improve emissions whilst also reducing fuel consumption. A technical challenge of gasoline exhaust gas re-circulation cooling is that the exhaust gas at the inlet to the exhaust gas re-circulation system is much hotter than in the comparable situation with diesel engines. For example, the temperature of re-circulated exhaust gas in a gasoline engine can be up to 1100 °C, but more typically up to around 1000 °C, compared to the equivalent situation in a diesel engine, where the gas temperature at the inlet to the EGR system is typically of the order of up to 650 °C.

[0006] A common failure mode of diesel exhaust gas re-circulation coolers is that thermal loading causes high stress at the gas inlet interface.

[0007] Referring to figure 1 herein, there is illustrated schematically in cut away view the inlet of a known exhaust gas re-circulation cooling device. The device comprises an outer casing 1 having a bulkhead 2 which extends across a width of the outer casing, the bulkhead contains a plurality of gas conduits 3.

[0008] When gas flows the gas conduits expand due to their increased temperature from the gas, the outer casing 1 also expands but at a slower rate and has a thermal expansion which is less than the thermal expansion of the gas conduits, resulting in high stresses in the bulkhead and the gas conduits, for example as shown at

position A in figure 1. The result can include failure of the bulkheads, failure of the joints between the conduit tubes and the bulkhead, failure of tube to tube joints, and collapse of gas tubes.

[0009] A typical failure of a tube to bulkhead joint may comprise a crack through the tubular conduit wall, at the position of the weld/braze between the tubular conduit wall and the bulkhead, resulting in mixture of coolant with the exhaust gas re-circulation path.

[0010] For diesel engines, other common problems with exhaust gas re-circulation systems include:

- Where the cooled gas inlet temperature is too high, this causes damage to components on the normally cool induction side of the engine.
- Exhaust gas re-circulation valves tend to stick due to being at the cold side, which causes "excessive wet" soot fouling on the valve.
- The exhaust gas re-circulation valve control system gets too hot

[0011] EP1,770,250 discloses an exhaust gas cooler having inner and outer corrugated tubes forming a cavity there between in which liquid coolant flows to cool a gas flow through the inner tube. The problem addressed in EP1,770,250 is to replace prior art coolers for diesel engines, having a construction of a plurality of inner tubes and an outer casing, with a simpler structure. The solution presented in EP 1.770.250 is a concentric tube arrangement with a plurality of spacers to keep the tubes apart.

[0012] In the device of EP 1,770,250 the inner tube has a frusto - conical section joining the inner tube to the outer tube at the inlet end, The inlet ends of the inner and outer tubes do not coincide, and the Inlet of the outer tube extends beyond and upstream in the gas flow compared to the inlet end of the inner tube. The outer tube is not in contact with coolant up to the extremity of its inlet end, and therefore heats up due to the high temperatures of the inlet gas. EP1,770,250 does not address the problem of reliability of an exhaust gas cooler used for the hotter exhaust gases which occur in a gasoline engine exhaust system.

Summary of the Invention

[0013] Specific embodiments herein aim to provide an exhaust gas re-circulation system which is capable of being robust against the thermal loadings caused by high inlet gas temperatures, whilst giving improved heat exchange.

[0014] According to a first aspect there is provided an exhaust gas cooling device comprising:

an inner tubular member (501) having an inlet end and an outlet end, said inner tubular member forming a gas passage; and

an outer tubular member (500), surrounding an outer

portion of said inner tubular member and forming a cavity there between for containing a liquid coolant,

wherein said inner tubular member (501) comprises a plurality of corrugations (504) for absorbing thermal expansion and/or contraction of said inner member; and

wherein said outer tubular member (500) comprises a plurality of corrugations (505) for absorbing thermal expansion and/or contraction of said outer member;

characterised in that said inner and outer tubular members are joined at the inlet end by a member (508) extending between the walls of the respective inner and outer tubular members; and

said inner and outer tubular members do not contact each other at said inlet end except where they are connected together by said member (508) thereby allowing said inlet end to be liquid cooled.

[0015] Other aspects are as recited in the claims herein.

Brief Description of the Drawings

[0016] For a better understanding of the invention and to show how the same may be carried into effect, there will now be described by way of example only, specific embodiments, methods and processes according to the present invention with reference to the accompanying drawings In which:

Figure 1 illustrates schematically a known exhaust gas cooler device having a plurality of gas conduits arranged between a pair of bulkheads within an external casing;

Figure 2 illustrates schematically an exhaust gas re-circulation cooler according to a specific implementation.

Figure 3 illustrates schematically a first exhaust gas re-circulation system according to a second specific embodiment;

Figure 4 illustrates schematically a second exhaust gas re-circulation system according to a further specific embodiment; and

Figure 5 illustrates schematically the second exhaust gas re-circulation system in a second mode of operation.

Detailed Description

[0017] There will now be described by way of example a specific mode contemplated by the inventors. In the following description numerous specific details are set

forth in order to provide a thorough understanding. It will be apparent however, to one skilled in the art, that the present invention may be practiced without limitation to these specific details. In other instances, well known methods and structures have not been described in detail so as not to unnecessarily obscure the description.

[0018] Referring to figure 2 herein, there is illustrated schematically a high temperature exhaust gas cooler according to a specific embodiment. The exhaust gas re-circulation cooler 200 comprises a metallic inner tubular substantially cylindrical member 201, and a co-axially aligned substantially cylindrical tubular outer member 202, surrounding the inner member and spaced apart therefrom, providing a sealed cavity between the inner and outer members, which provides a fluid fillable jacket around a central passage 503 through the inner tubular member, for cooling hot exhaust gases which pass through the cooling device.

[0019] The inner tubular member 201 comprises a plurality of annular or helical corrugations 203.

[0020] The primary purpose of the corrugations is for absorbing expansion and contraction stresses in a direction axially of the inner tubular member, thereby enabling the inner tubular member to operate with an elevated temperature gradient along the cooler, between an inlet temperature of 1100°C maximum and an outlet temperature of around 700 °C maximum. Similarly, the outer tubular member 202 is also provided with a plurality of annular or helical corrugations 505 for a similar purpose, that is, to absorb axial expansion and contraction and axial stresses and strains between the two ends of the cooler, and to enable the cooler to operate over a temperature gradient between a maximum of around 1100 °C at one end and a maximum temperature of around 700 °C at the other end. The outer tubular member 202 is provided with a fluid inlet tube 506, and a fluid outlet tube 207 for entry and outlet of a liquid coolant which fills the cavity between the inner and outer tubular members.

[0021] The corrugations also have the effect of increasing the surface area in contact with the hot exhaust gases flowing through the inner tube, and coating local turbulence at the interface between the gas and the tube wall, thereby increasing the heat transfer rate between the gas and the tubular wall.

[0022] The inner and outer tubular members are joined at the inlet end by a first annular plate member 508 extending between the substantially parallel cylindrical walls of the respective inner and outer tubular members 202, 205. Similarly, at the outlet end of the cooler, a second annular plate member 209 joins the other ends of the inner and outer tubular members. Said annular plates may be formed as part of the gas conduit. Alternatively, said annular platens may be formed as part of the coolant conduit.

[0023] In the embodiments shown, there are no internal bulkheads in the gas flow path, and the ends of the cooler are liquid cooled. The interface components to this embodiment would have a gas path diameter not greater

than the diameter of the gas conduit ends, such that said annular plates are not in the gas flow path. The inner tubular member and the outer tubular member do not contact each other, except at their respective corresponding ends, where they are connected together

[0024] Referring to figure 3 herein, there is illustrated schematically an arrangement of an engine and a first exhaust gas re-circulation bypass system according to a second specific embodiment herein.

[0025] An internal combustion engine 300 comprises an inlet manifold 301 for drawing air into the combustion chambers of the engine, and an outlet manifold 302 for channeling exhaust gases out of the engine. Air being input into the inlet manifold may be compressed by a compressor 303. Additionally and optionally, a turbo 304 may be fitted after the exhaust manifold to an exhaust channel 305 of the engine.

[0026] To improve combustion efficiency and reduce harmful emissions, the engine may be fitted with an exhaust gas re-circulation EGR system. The EGR system comprises a first exhaust gas cooler 306 through which exhaust gases flow, and a second exhaust cooler 307, the first and second exhaust coolers being connected in series.

[0027] A high pressure exhaust gas re-circulation circuit takes high pressure exhaust gas from the outlet manifold 302, through a feed pipe 308 to the inlet of the first EGR cooler 306, and from an outlet of the second EGR cooler 307, directly to the inlet manifold 301 via a second feed pipe 309. High pressure recirculated exhaust gas is cooled, but does not pass through the compressor 303 or the turbo 304.

[0028] An alternative low pressure EGR system takes the exhaust gas downstream of the turbo 304 and feeds it via a third feed pipe 310 to the inlet of the first EGR cooler 306, through the first EGR cooler 306 via a connecting pipe 311 to the inlet of the second EGR cooler 307, and from the outlet of the second EGR cooler 307, to an air channel inlet upstream of compressor 303, via a fourth feed pipe 312.

[0029] The purpose of the first EGR cooler 306 is to cool the high temperature exhaust gases from a temperature of 1000 to 1100 °C down to a temperature of around 650 °C prior to entry to the second EGR cooler 307. Gas is entering the second EGR cooler 307 at an inlet temperature of around 650 °C may exit the second EGR cooler at a reduced temperature of around 150 °C.

[0030] By using a single gas conduit first EGR cooler 306 in the hot exhaust gas, before a multi gas conduit EGR cooler 307, the first EGR cooler can be used to cool the exhaust gas from a relatively higher temperature having a maximum temperature in the range 1000 °C - 1100 °C. to a relatively lower temperature of the order of 650 °C. Since the exhaust gas has been cooled prior to entry on the multi gas conduit EGR cooler 307. the multi gas conduit EGR cooler will not suffer cracking of the gas conduits where they connect to the bulkhead inside the EGR cooler.

[0031] It will be appreciated by the person skilled in the art that variations on the high pressure EGR and the low pressure EGR may be provided.

[0032] In a first variation, the exhaust gas is taken at a relatively lower pressure, after the turbo 304 and via the second feed pipe 310, through the first and second EGR coolers, and through the second feed pipe 309 directly into the inlet without going through the compressor. In a second variation, high pressure exhaust gas may be taken by the first feed pipe 308 through the first and second EGR coolers 306, 307, and fed into the compressor 303 via fourth feed pipe 312.

[0033] The exhaust gas re-circulation system may operate to cool gas from a maximum inlet temperature of 1100 °C, to a maximum temperature of around 300 °C at the outlet of the first cooler device. This may not be a highly effective cooler. The first cooler device may be robust so as to withstand thermal shock, thermal loading and thermal growth as experienced in automotive applications. The gas may be cooled from an inlet temperature of the second cooler device of around 700 °C to around 150 °C. with a thermal effectiveness of at least 80%. Preferably, the thermal effectiveness of the second cooler section is in the range 90% to 95%.

[0034] The exhaust gas re-circulation system may be fully integrated as a set of connecting pipes and cooler devices being of welded, brazed or soldered construction, without the need for being joined by fasteners, external dams or other additional mechanical fixings.

[0035] Referring to figure 4 herein, there is illustrated schematically a second EGR system.

[0036] The second system for re-circulating exhaust gas from an internal combustion engine 400 having an inlet manifold 401 and an outlet manifold 402, an inlet air compressor 403 and a turbo 404 operating of the exhaust gas, and comprises a first EGR cooler 405, an inlet of which is supplied with exhaust gas from the exhaust manifold 402 of the internal combustion engine via an exhaust feed pipe 806, the first EGR cooler receiving high temperature exhaust gas at a temperature in the range 1000 °C - 1100 °C; and a second EGR cooler 407 which receives relatively lower temperature exhaust gas typically at a maximum inlet temperature of around 650 °C, and which cools the gas down to a temperature around 150 °C. The cooled exhaust gas being fed through the outlet of the second EGR cooler directly into the inlet manifold 401.

[0037] Referring to figure 5 herein, the system of fig 4 is shown during a warm up phase of the engine, when the engine has just been started and is raising towards its normal operating temperature.

[0038] In these circumstances, the second EGR cooler 407 is bypassed, but the first EGR cooler 406 remains in the EGR circuit. Under warm up conditions, a temperature at the inlet of the first EGR cooler 406 may be of the order of 400 °C, and gradually rises as the engine warms up, towards a maximum temperature in the range 1000 °C - 1100 °C. As long as the exhaust gas at the

outlet of the EGR system remains at a maximum temperature in the range 150 °C or less, then the second EGR cooler 407 can be bypassed, thereby enabling the engine to heat up to its optimum running temperature more quickly, improving efficiency of the engine.

[0039] However, once the engine gets up to operating temperature, and the temperature of the exhaust gas at the outlet of the first EGR cooler rises above around 150 °C, then the second EGR cooler 407 is switched into circuit via a valve mechanism to provide further cooling of the exhaust gas before it is fed back into the inlet manifold 401.

[0040] It will be appreciated by those skilled in the art that although annular corrugations have been shown for the inner and outer tubular members of the pre-cooler device, the corrugations could be made helical as an alternative embodiment. The corrugations extend in either case around a circumference of the inner tubular member, and similarly for the outer tubular member.

[0041] A high gas inlet temperature cooler as described herein may be designed to function with relatively high inlet gas temperatures (up to 1100 °C) and be able to withstand the associated thermal shock loading by using a single gas tube to form the gas conduit. The gas conduit may be substantially concentric within an outer cooler conduit, and an annular space between said gas tube and said outer cool tube may form a cavity for a coolant fluid. The cooler may avoid having any bulkhead interfacing between the gas conduit and any other component within the cooler.

[0042] In the exhaust gas re-circulation systems described herein, a high gas inlet temperature cooler may be used to cool an EGR valve, thus enabling the EGR valve to be located after the high gas inlet temperature cooler and therefore upstream of a relatively lower temperature gas cooler, operating typically at a maximum temperature of around 700 °C.

[0043] The relatively higher gas inlet temperature cooler may be used to cool an exhaust gas re-circulation valve, which enables a lower temperature cooler to be located after the EGR valve.

[0044] The relatively high gas inlet temperature cooler may have a gas inlet interface joint between a gas conduit and the rest of the cooler, which is substantially cooled by the cooler coolant.

[0045] The EGR system may be used for "high pressure" exhaust gas recirculation, i.e. taking gas from pre turbo in the gas flow through an internal combustion engine.

[0046] The EGR system may also be used for "low pressure" exhaust gas recirculation, i.e. taking exhaust gases after passing through a turbo.

[0047] The lower gas inlet temperature cooler may have a bypass valve-such-that gas can bypass the cooler without being significantly cooled. The whole of the EGR system may not be bypassed as this would cause the gas inlet to the induction side to be too hot.

[0048] The lower gas inlet temperature cooler, may

have an internal gas conduit which is flexible along its axis and have either annular or helical corrugations along its walls. The corrugations may be present substantially all the way along the internal gas conduit, or in a restricted section of the gas conduit.

[0049] An outer casing of the lower temperature gas cooler may have annular or helical corrugations to allow flexibility along the length of the casing. The corrugations may be present along substantially the entire outer cooler conduit, or may be restricted to a section of its length.

[0050] The embodiments disclosed above may provide an EGR system capable of cooling re-circulated exhaust gas from a maximum temperature of around 1100 °C at a gas inlet to the system, down to a first stage of cooling at a maximum temperature of around 700 °C within a specially designed section which is robust against thermal shock, thermal loading and thermal growth. The gas may then be further cooled down from a maximum temperature of around 700 °C within a second cooling section which has a thermal effectiveness of at least 90%, and preferably at least 95%.

[0051] In the EGR system embodiment shown above, the whole system may be fully integrated, without the use of additional fasteners or connectors between the tubes and sections, to form a unitary welded, brazed or soldered construction.

Claims

1. An exhaust gas cooling device comprising:

an inner tubular member (201) having an inlet end and an outlet end, said inner tubular member forming a gas passage; and
an outer tubular member (200), surrounding an outer portion of said inner tubular member and forming a cavity there between for containing a liquid coolant,
wherein said inner tubular member (201) comprises a plurality of corrugations (504) for absorbing thermal expansion and/or contraction of said inner member; and
wherein said outer tubular member (200) comprises a plurality of corrugations (205) for absorbing thermal expansion and/or contraction of said outer member;

characterised in that said inner and outer tubular members are joined at the inlet end by a member (208) extending between the walls of the respective inner and outer tubular members; and
at said inlet end, said inner and outer tubular members do not contact each other except where they are connected together by said member (208) thereby allowing said inlet end to be liquid cooled.

2. The cooling device as claimed in claim 1, wherein

said cavity extends substantially a full length along said inner (201) and outer (200) tubular members, such that first and second end extremities of said cooling device are cooled in use by a coolant fluid flowing through said cavity formed between said inner and outer tubular members.

3. The cooling device as claimed in claim 1 or 2, wherein the inner (201) and outer (200) tubular members are arranged so as not to contact each other, other than at first ends of the inner and outer members, and at second ends of the inner and outer tubular members.
4. The cooling device as claimed in any one of the preceding claims, wherein said cooling device has no bulkhead component to join the inner tubular member (201) to the outer tubular member (202).
5. The cooling device as claimed in any one of the preceding claims, wherein said inner tubular member comprises a plurality of annular or helical corrugations (203).
6. The cooling device as claimed in claim 5, wherein said corrugations (203) on said inner tubular member extend over a length of between 10% and 85% of an overall length of said inner tubular member.
7. The cooling device as claimed in any one of the preceding claims, wherein said outer tubular member has a set of corrugations (205) which extend over a proportion of between 10% and 100% of the length of the outer tubular member.
8. The cooling device as claimed in any one of the preceding claims, wherein a main central axis of an inlet end of said inner tubular member lies at an angle with respect to a main central axis of an outlet of said inner tubular member, and said inner and outer members are bent, such that the cooling device forms a curved or bent component.
9. The cooling device as claimed in any one of the preceding claims, capable of operating in a temperature range of -60°C to 1100°C.
10. The cooling device as claimed in any one of the preceding claims, wherein said outer tubular member comprises a plurality of annular or helical corrugations (205).
11. The cooling device as claimed in any one of the preceding claims, wherein said inner tubular member comprises;
a first type of corrugation having a peak to peak spacing between adjacent corrugations in a direction along the main length of the inner tubular member

of a distance corresponding to 16% to 20% of the distance across the tubular member.

12. The cooling device as claimed in any one of the preceding claims, comprising a first type of corrugation, having a peak to trough distance in the radial direction in the range of 6% to 8% of the internal radial distance of the inner tubular member.
13. The cooling device as claimed in any one of the preceding claims, having a second type of corrugation comprising a substantial toroidal surface.
14. The cooling device as claimed in claim 13, wherein said corrugations of said second type have a peak to trough radial distance in the range of 10% to 14% of a maximum radius of the inner tubular member.
15. The cooling device as claimed in any one of the preceding claims, comprising at least one elongate indent, said elongate indent extending along a main axial direction of said inner tubular member.
16. The cooling device as claimed in any one of the preceding claims, comprising at least one elongate indent, said elongate indent extending along a main axial length of said inner tubular member; said indent comprising a wall portion which extends in to a main inner passage of said inner tubular member to a distance in the range 15% - 90% of a distance across said inner tubular member.
17. The cooling device as claimed in claim 16, comprising a plurality of said elongate indents, said plurality of indents opposing each other, such that an internal cross sectional profile of an internal passage of inner tubular member forms a substantially butterfly or double mushroom shape.
18. The cooling device as claimed in claim 16 or 17, wherein each said elongate indent has superimposed a plurality of corrugations extending circumferentially around said inner tubular member.
19. The cooling device as claimed in any one of the preceding claims, comprising a second tubular end piece in to which connects a second end of said inner tubular member and a second end of said outer tubular member, such that said inner and outer tubular members are spaced apart from each other with the cavity there between, and do not touch each other.
20. The cooling device as claimed in any one of the preceding claims, wherein said inner tubular member and said outer tubular member are constructed so as not to contact each other except at said inlet end and said outlet end.

21. The cooling device as claimed in any one of the preceding claims, wherein said first cooling device is capable of cooling said exhaust gas from a maximum inlet temperature of 1100°C, to a maximum outlet temperature of 700°C.

22. An exhaust gas re-circulation system for an internal combustion engine, said system comprising:

a first cooling device as claimed in any one of claims 1 to 21, configured for receiving exhaust gas from said internal combustion engine; and a second cooling device connected in series with said first cooling device and arranged for receiving cooled exhaust gas from an outlet of said first cooler device, an outlet of said second cooling device being connected to an inlet of said internal combustion engine.

Patentansprüche

1. Abgaskühlvorrichtung umfassend:

ein inneres Rohrelement (201) mit einem Einlassende und einem Auslassende, wobei das innere Rohrelement einen Gaskanal bildet; und ein äusseres Rohrelement (200) um einen äusseren Abschnitt des inneren Rohrelements, wobei das äussere Rohrelement bildet einen Hohlraum dazwischen zur Aufnahme eines flüssigen Kühlmittels, wobei das innere Rohrelement (201) eine Vielzahl von Wellungen (504) für die Aufnahme von thermischen Expansion und/oder Kontraktion des inneren Elements umfasst; wobei das äussere Rohrelement (200) eine Vielzahl von Wellungen (205) für die Aufnahme von thermischen Expansion und/oder Kontraktion des äusseren Elements umfasst;

dadurch gekennzeichnet, dass die innere und äussere Rohrelemente bei dem Einlassende mit einem Element (208), das zwischen den Wänden der inneren und äusseren Rohrelemente spannt, verbunden sind; und

bei dem Einlassende, die innere und äussere Rohrelemente berühren nicht einander, ausser wo sie mit dem Element (208) verbunden sind, damit das Einlassende mit der Flüssigkeit kühlen lassen.

2. Die Kühlvorrichtung nach Anspruch 1, wobei der Hohlraum im wesentlichen die ganze Länge des inneren (201) und äusseren (200) Rohrelemente spannt, so dass die erste und zweite Ende des Kühlvorrichtunges mit einer Kühlflüssigkeit, die durch den Hohlraum zwischen den inneren und äusseren Rohrelementen fliesst, gekühlt werden.

3. Die Kühlvorrichtung nach Anspruch 1 oder 2, wobei das innere (201) und das äussere (200) Rohrelemente so angeordnet werden, einander nicht, ausser an ersten Enden der inneren und äusseren Rohrelemente und an zweiten Enden der inneren und äusseren Rohrelemente zu kontaktieren.

4. Die Kühlvorrichtung nach einem der vorhergehenden Ansprüche, wobei die Kühlvorrichtung keine Trenwand Komponente, um das innere Rohrelement (201) und das äussere Rohrelement (202) zu verbinden, umfasst.

5. Die Kühlvorrichtung nach einem der vorhergehenden Ansprüche, wobei das innere Rohrelement eine Vielzahl von Ring- oder Spiralwellungen (203) umfasst.

6. Die Kühlvorrichtung nach Anspruch 5, wobei die Wellungen (203) auf dem inneren Rohrelement zwischen 10% und 85% der gesamten Länge des inneren Rohrelements spannen.

7. Die Kühlvorrichtung nach einem der vorhergehenden Ansprüche, wobei das äussere Rohrelement eine Reihe von Wellungen (205) umfasst, die zwischen 10% und 100% der Länge des inneren Rohrelements spannen.

8. Die Kühlvorrichtung nach einem der vorhergehenden Ansprüche, wobei eine Hauptmittelachse eines Einlassendes des inneren Rohrelements in einem Winkel in Bezug auf eine Hauptmittelachse eines Auslassendes des inneren Rohrelements liegt und die innere- und äussere Elemente gebogen sind, so dass die Kühlvorrichtung eine gekrümmte oder gebogene Komponente bildet.

9. Die Kühlvorrichtung nach einem der vorhergehenden Ansprüche, geeignet zum Betrieb in einem Temperaturbereich -60 ° C bis 1100 ° C.

10. Die Kühlvorrichtung nach einem der vorhergehenden Ansprüche, wobei das äussere Rohrelement eine Vielzahl von Ring- oder Spiralwellungen (205) umfasst.

11. Die Kühlvorrichtung nach einem der vorhergehenden Ansprüche, wobei das innere Rohrelement umfasst:

die erste Sorte von Wellungen, die von Höhepunkt bis Höhepunkt Fugen zwischen anschliessenden Wellungen haben, längs der Hauptlänge des inneren Rohrelements, mit der Distanz gemäss von 16% bis 20% von dem Distanz über das Rohrelement.

12. Die Kühlvorrichtung nach einem der vorhergehenden Ansprüche, umfassend die erste Sorte von Wellungen, die einen Höhenpunkt in einem Talabstand in einer Radialrichtung, von 6% bis 8% von dem inneren radialen Abstand des inneren Rohrelements. 5
13. Die Kühlvorrichtung nach einem der vorhergehenden Ansprüche, umfassend die zweite Sorte von Wellungen umfassend eine im wesentlichen ringförmige Oberfläche. 10
14. Die Kühlvorrichtung nach Anspruch 13, wobei die Wellungen von der zweiten Sorte einen Höhenpunkt in einem Talabstand von 10% bis 14 % von maximalem Radius des inneren Rohrelements umfassen. 15
15. Die Kühlvorrichtung nach einem der vorhergehenden Ansprüche, umfassend mindestens eine gezogene Einkerbung, die gezogene Einkerbung spannt die Hauptmittellachse von dem inneren Rohrelement. 20
16. Die Kühlvorrichtung nach einem der vorhergehenden Ansprüche, umfassend mindestens eine gezogene Einkerbung, die gezogene Einkerbung spannt die Hauptmittellachse des inneren Rohrelements; Die Einkerbung umfasst eine Wandportion, die bis die haupt innere Passage des inneren Rohrelements spannt, von 15% bis 90% von dem Abstand über das innere Rohrelement. 25 30
17. Die Kühlvorrichtung nach Anspruch 16, umfassend eine Vielzahl der gezogenen Einkerbungen, die Vielzahl der gezogenen Einkerbungen entgegen einander, so dass die innere entgegen Sektionsprofile der inneren Passage des inneren Rohrelements eine im wesentlichen Falten- oder Pilzdoppelform bildet. 35
18. Die Kühlvorrichtung nach Anspruch 16 oder 17, wobei die gezogene Einkerbung eine Vielzahl von Wellungen super installiert umfasst, die im Umfang das innere Rohrelement spannt. 40
19. Die Kühlvorrichtung nach einem der vorhergehenden Ansprüche, umfassend ein zweites Rohrende, wobei das zweite Ende des inneren Rohrelements und das zweite Ende des äußeren Rohrelements verbunden sind, so dass das innere und äußere Rohrelemente mit dem Hohlraum getrennt sind, nicht berührend sich einander. 45 50
20. Die Kühlvorrichtung nach einem der vorhergehenden Ansprüche, wobei das innere Rohrelement und das äußere Rohrelement so konstruiert sind, dass sie sich einander nicht berühren, ausser dem Einlassende und dem Auslassende. 55

21. Die Kühlvorrichtung nach einem der vorhergehenden Ansprüche, wobei die erste Kühlvorrichtung ist fähig das Abgas von einer Einlassstemperatur maximum von 1100 °C zu einer Auslassstemperatur maximum von 700 °C, zu kühlen.

22. Abgas re-zirkulierung System für einen inneren Verbrennungsmotor, das System umfassend:

die erste Kühlvorrichtung nach Ansprüche 1 bis 21, für eine Abgaseinnahme von dem inneren Verbrennungsmotor konfiguriert werden; und die zweite Kühlvorrichtung verbunden in Serien mit der ersten Kühlvorrichtung und eingerichtet für eine Kühlabgaseinnahme von dem Auslass der ersten Kühlvorrichtung, ein Auslass der zweiten Kühlvorrichtung mit dem Einlass des inneren Verbrennungsmotors verbunden werden.

Revendications

1. Dispositif de refroidissement des gaz d'échappement comprenant:

un membre tubulaire interne (201) possédant une extrémité d'admission et une extrémité de sortie, ledit membre tubulaire interne formant un passage de gaz; et

un membre tubulaire externe (200) entourant une portion externe dudit membre tubulaire interne et formant une cavité entre les membres pour contenir un réfrigérant liquide, dans lequel ledit membre tubulaire interne (201) comprend plusieurs ondulations (504) pour absorber l'expansion ou la contraction thermique dudit membre interne; et dans lequel ledit membre tubulaire externe (200) comprend plusieurs ondulations (205) pour absorber l'expansion ou la contraction thermique dudit membre externe;

caractérisé en ce que lesdits membres tubulaires interne et externe sont joints au niveau de l'extrémité d'admission par un membre (208) s'étendant entre les parois des membres tubulaires interne et externe respectifs; et au niveau de ladite extrémité d'admission, lesdits membres tubulaires interne et externe ne se contactent pas, à l'exception de leur point de jonction formé par ledit membre (208), permettant ainsi le refroidissement de ladite extrémité d'admission par réfrigération liquide.

2. Dispositif de refroidissement selon la revendication 1, dans lequel ladite cavité s'étend sur essentiellement une longueur entière le long desdits membres tubulaires interne (201) et externe (200), de sorte

que des première et deuxième extrémités dudit dispositif de refroidissement soient refroidies en cours d'usage par un liquide réfrigérant qui s'écoule au travers de ladite cavité formée entre lesdits membres tubulaires interne et externe.

3. Dispositif de refroidissement selon la revendication 1 ou 2, dans lequel les membres tubulaires interne (201) et externe (200) sont disposés de sorte à ne pas se contacter l'un avec l'autre, mis à part au niveau des premières extrémités des membres interne et externe, et au niveau des deuxième extrémités des membres tubulaires interne et externe.
4. Dispositif de refroidissement selon l'une des revendications précédentes, dans lequel ledit dispositif de refroidissement ne possède pas d'élément de cloison pour joindre le membre tubulaire interne (201) au membre tubulaire externe (202).
5. Dispositif de refroidissement selon l'une des revendications précédentes, dans lequel ledit membre tubulaire interne comprend plusieurs ondulations (203) annulaires ou hélicoïdales.
6. Dispositif de refroidissement selon la revendication 5, dans lequel lesdites ondulations (203) sur ledit membre tubulaire interne s'étendent sur une proportion de 10% à 85% de la longueur du membre tubulaire externe.
7. Dispositif de refroidissement selon l'une des revendications précédentes, dans lequel ledit membre tubulaire externe possède un ensemble d'ondulations (205) qui s'étendent sur une proportion de 10% à 100% de la longueur du membre tubulaire externe.
8. Dispositif de refroidissement selon l'une des revendications précédentes, dans lequel un axe central principal d'une extrémité d'admission dudit membre tubulaire interne repose à un angle par rapport à un axe central principal d'une sortie dudit membre tubulaire interne, et lesdits membres interne et externe sont cintrés, de sorte que le dispositif de refroidissement forme un élément courbe ou cintré.
9. Dispositif de refroidissement selon l'une des revendications précédentes, capable de fonctionner dans une gamme de températures de - 60°C à 1100°C.
10. Dispositif de refroidissement selon l'une des revendications précédentes, dans lequel ledit membre tubulaire externe possède plusieurs ondulations (205) annulaires ou hélicoïdales.
11. Dispositif de refroidissement selon l'une des revendications précédentes, dans lequel ledit membre tubulaire interne comprend;

un premier type d'ondulation possédant un écart de crête à crête entre ondulations adjacentes, selon une direction suivant la longueur principale du membre tubulaire interne, correspondant à 16% à 20% de la distance transversale du membre tubulaire.

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12. Dispositif de refroidissement selon l'une des revendications précédentes, comprenant un premier type d'ondulation, qui possède une distance de crête à point bas, selon une direction radiale, dans la gamme de 6% à 8% de la distance radiale interne du membre tubulaire interne.
13. Dispositif de refroidissement selon l'une des revendications précédentes, possédant un deuxième type d'ondulation, qui comprend une surface essentiellement toroïdale.
14. Dispositif de refroidissement selon la revendication 13, dans lequel lesdites ondulations dudit deuxième type possèdent une distance radiale de crête à point bas dans la gamme de 10% à 14% d'un rayon maximal du membre tubulaire interne.
15. Dispositif de refroidissement selon l'une des revendications précédentes, comprenant au moins une indentation allongée, ladite indentation allongée s'étendant selon une direction axiale principale dudit membre tubulaire interne.
16. Dispositif de refroidissement selon l'une des revendications précédentes, comprenant au moins une indentation allongée, ladite indentation allongée s'étendant selon une longueur axiale principale dudit membre tubulaire interne; ladite indentation comprenant une portion de paroi qui s'étend dans un passage interne principal dudit membre tubulaire interne sur une distance dans la gamme 15% - 90% d'une distance transversale dudit membre tubulaire interne.
17. Dispositif de refroidissement selon la revendication 16, comprenant plusieurs indentations allongées, lesdites indentations allongées s'opposant les unes aux autres, de sorte qu'un profil interne de section en coupe d'un passage interne du membre tubulaire interne prenne une forme essentiellement de papillon ou de double - champignon.
18. Dispositif de refroidissement selon la revendication 16 ou 17, dans lequel chaque indentation allongée superpose plusieurs ondulations en extension circconférentielle autour dudit membre tubulaire interne.
19. Dispositif de refroidissement selon l'une des revendications précédentes, comprenant une deuxième pièce d'extrémité tubulaire, dans laquelle se connectent une deuxième extrémité dudit membre tubulaire

interne et une deuxième extrémité dudit membre tubulaire externe, de sorte que lesdits membres tubulaires interne et externe soient distancés l'un de l'autre avec la cavité entre les membres, et ne se touchent pas.

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20. Dispositif de refroidissement selon l'une des revendications précédentes, dans lequel ledit membre tubulaire interne et ledit membre tubulaire externe sont construits de sorte à ne pas se contacter l'un avec l'autre, mis à part au niveau de ladite extrémité d'admission et au niveau de ladite extrémité de sortie.
21. Dispositif de refroidissement selon l'une des revendications précédentes, dans lequel ledit premier dispositif de refroidissement est capable de refroidir lesdits gaz d'échappement depuis une température maximale d'admission de 1100°C jusqu'à une température maximale de sortie de 700°C.
22. Système de recirculation des gaz d'échappement pour un moteur à combustion interne, comprenant un premier dispositif de refroidissement selon l'une des revendications 1 à 21, configuré pour recevoir des gaz d'échappement depuis ledit moteur à combustion interne; et un deuxième dispositif de refroidissement connecté en série avec ledit premier dispositif de refroidissement et disposé pour recevoir des gaz d'échappement refroidis depuis une sortie dudit premier dispositif de refroidissement, une sortie dudit deuxième dispositif de refroidissement étant connecté avec une admission dudit moteur à combustion interne.

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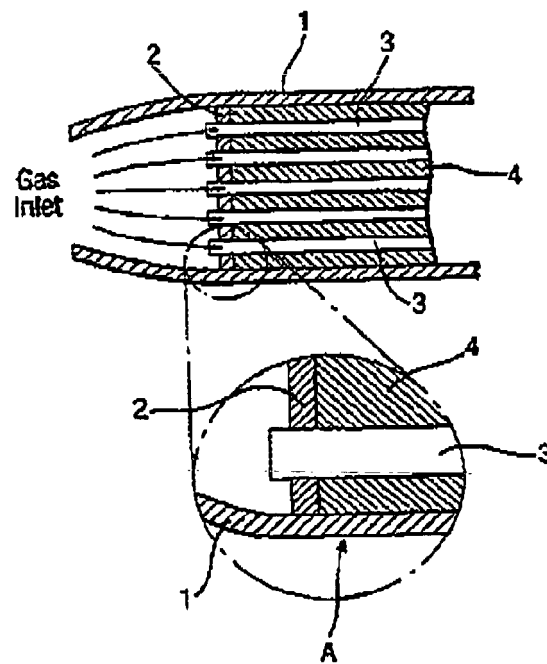


Fig. 1
(Prior Art)

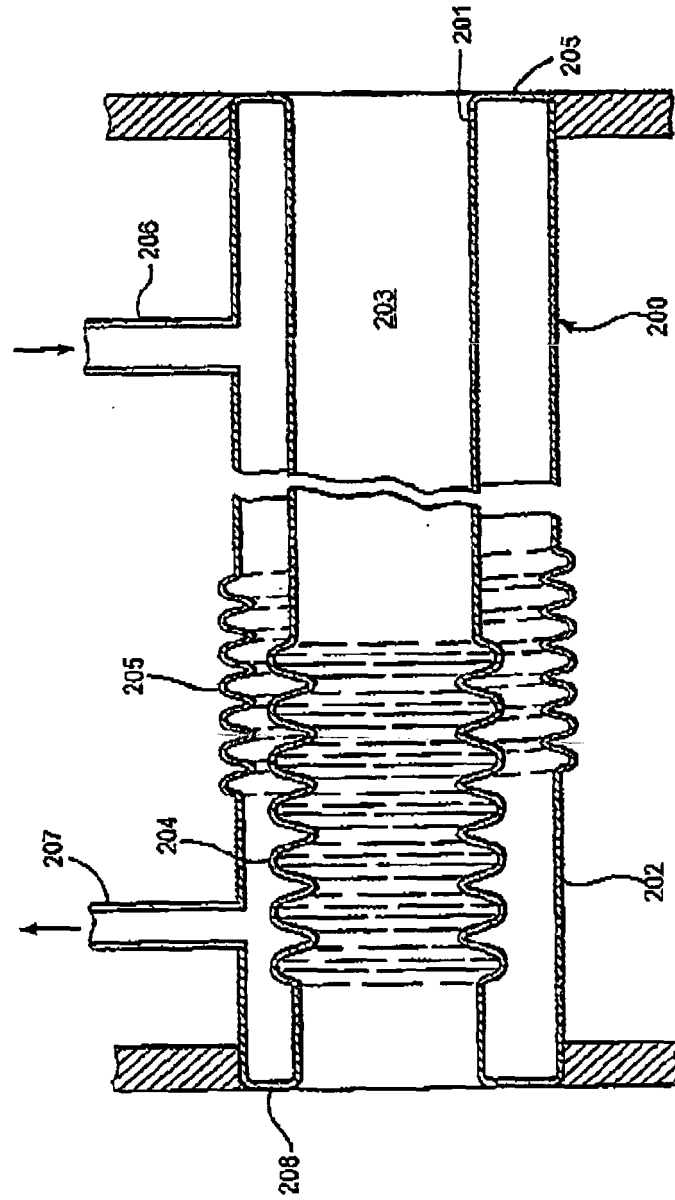


Fig. 2

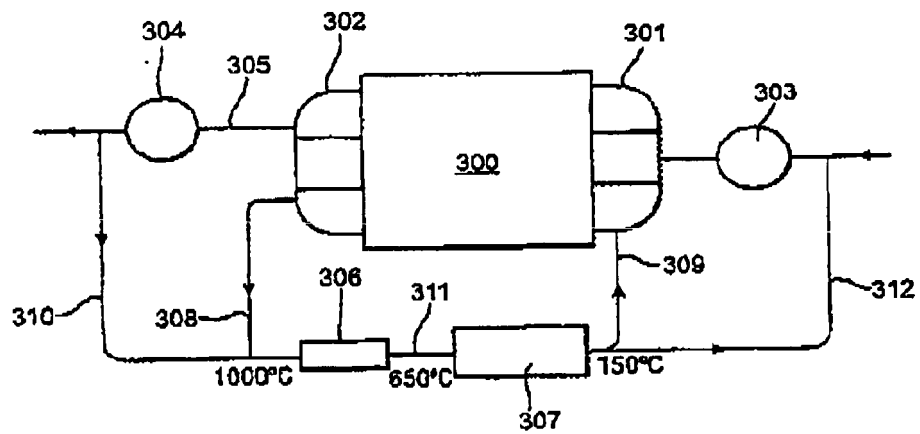


Fig. 3

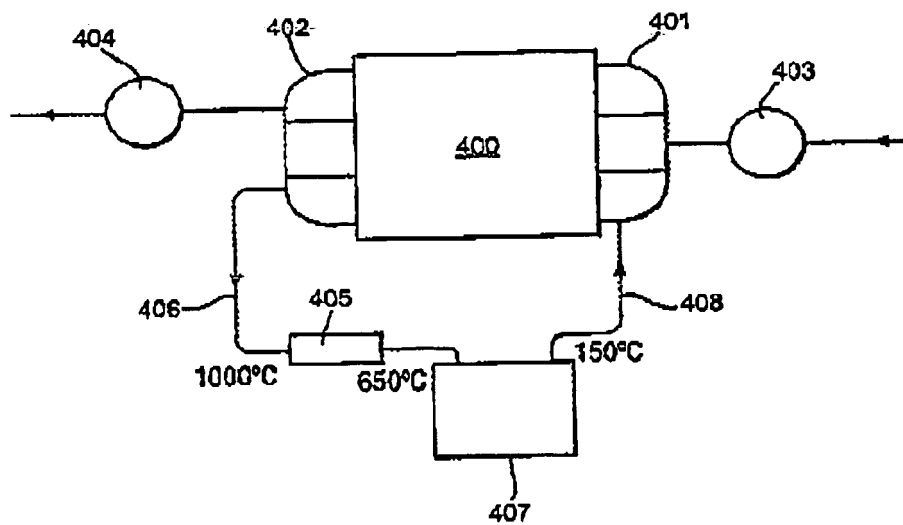


Fig. 4

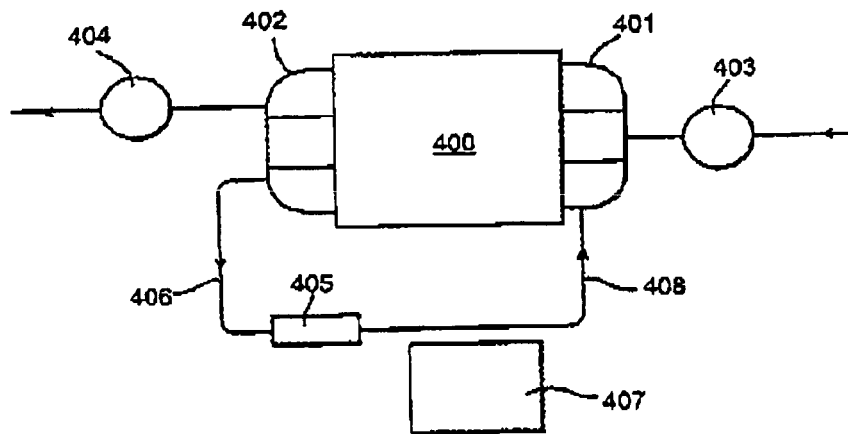


Fig. 5

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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