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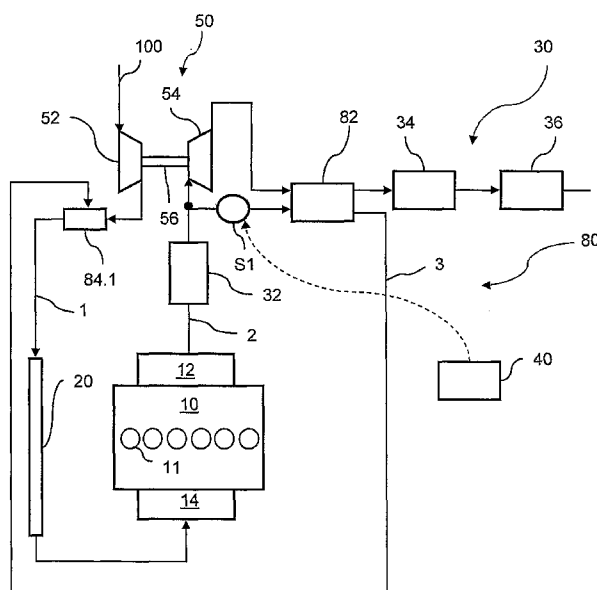


Figure 1

(57) Abstract: The invention relates to a method and an arrangement for recirculation of exhaust gases of a combustion engine (10) with a turbocharger (50). A first cooler (82) is adapted to make a heat exchange between the exhaust gases of a return line (3) led through a first path of the first cooler (82), and the exhaust gases of the exhaust line (2) downstream of the turbine (54) of the turbocharger unit (50) with respect to the intended direction of the exhaust gas flow in the exhaust line (2) led through a second path of the first cooler (82), wherein the first path and the second path of the first cooler (82) are cleaned by nitric dioxides (NO₂) produced in an oxidation catalyst (32) upstream of the turbine (54) of the turbocharger unit (50) with respect to the intended direction of the exhaust gas flow in the exhaust line (2).

DESCRIPTION

Method and Arrangement for Recirculation of Exhaust Gases of a Combustion Engine

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TECHNICAL FIELD

The invention relates to a method for recirculation of exhaust gases of a combustion engine with a turbocharger and an arrangement for recirculation of exhaust gases of a combustion engine with a turbocharger according to the preambles of the independent claims.

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BACKGROUND OF THE INVENTION

The recent years have shown a trend towards stricter legislation concerning emission levels from vehicles. For gasoline powered vehicles, the three-way catalyst has made it possible to run an engine practically without unwanted emissions.

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For diesel powered vehicles or compression ignition (CI) engines, the emission problems are, however, far from solved. CI engines have inherent high emission levels for nitric oxides NO_x, such as NO and NO₂, and particulate matter, such as soot, whereas the emission levels of carbon monoxide (CO) and hydrocarbons (HC) are low. Moreover, it is fairly easy to reduce the already low emission of HC and CO from a CI engine.

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One other inherent feature of CI engines is the low fuel consumption. There is, however, a well-known trade-off between fuel consumption and emissions: an engine tuned for maximum fuel economy will emit large amounts of NO_x and small amounts of particulates, whereas an engine tuned for low emissions of NO_x will get high fuel consumption and high emissions of particulates.

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Another well known phenomenon is the connection between engine speed and particulate emissions. Lowering of the engine speed usually leads to a reduction of the particulate emissions, simply due to the fact that there will be more time to combust the particulates in the combustion chamber.

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Today, it is more or less an industry standard to provide the engine exhaust system with some kind of Exhaust gas After Treatment System (EATS), e.g. a particulate trap, a three-way catalyst (for gasoline engines), a SCR (SCR = Selective Catalytic Reduction) catalyst or a NOx trap catalyst.

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A common method to improve the performance and fuel consumption of a CI engine is to provide the engine with a turbocharger. The function of the turbocharger is to recover some of the energy present in the exhaust gases in a turbine connected to a compressor used to compress air to be let into the engine cylinders. This leads to more air being
10 inducted into the cylinders during the intake stroke, which in turn leads to the engine being able to provide more power per swept engine volume.

Moreover, particulate emissions depend heavily on injection pressure, i.e. the pressure with which the diesel fuel is injected into the combustion chambers. The higher the
15 injection pressure, the lower the particulate emissions.

Another known technique to reduce the content of NOx in the exhaust gases is known as EGR (exhaust gas recirculation). In an EGR system part of the exhaust gases from the combustion process in a combustion engine are lead back via a return line to an inlet for
20 supplying air to the combustion engine. A mixture of air and exhaust gases is thus applied via the inlet line to the engine's cylinders in which the combustion takes place. Adding exhaust gases to the air causes a lower combustion temperature which results in a reduced content of NOx in the exhaust gases. This technique can be used for both Otto engines and diesel engines.

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EP 0 596 855 A1 describes a method and an arrangement for recirculation of exhaust gases of a combustion engine with a turbocharger in a vehicle. The described arrangement comprises a turbine placed in a exhaust line and adapted to be driven by exhaust gases from the combustion engine, a compressor adapted to be driven by the
30 turbine in order to supply compressed air to an inlet line, which is adapted to lead compressed air to an intake of the combustion engine, a return line adapted to recirculate exhaust gases from the exhaust line connected with an exhaust outlet of the combustion engine to the inlet line, wherein the return line is connected with the exhaust line upstream of the turbine of the turbocharger unit with respect to the intended direction of
35 the exhaust gas flow in the exhaust line, a first cooler arranged in the return line in order to cool the exhaust gases, and a first valve means arranged in the return line upstream of the first cooler with respect to the intended direction of exhaust gas flow in the return line,

wherein the first valve means is guided in a given position in accordance with an actual operation condition of the combustion engine, and wherein the first valve means allows the exhaust gas flow between the exhaust line and the inlet line passing the first cooler in an open position and prevents such an exhaust gas flow in a closed position. An exhaust gas aftertreatment system for reducing emissions of the internal combustion engine is arranged in the exhaust line upstream of the first cooler with respect to the intended direction of the exhaust gas flow, so that the recirculated exhaust gases are passing the exhaust gas aftertreatment system before entering the first cooler. The exhaust gas aftertreatment system comprises a device for reducing a content of particulates in the exhaust gas or an oxidation catalyst for cleaning the exhaust gases.

US 2005/0199229 A1 describes an arrangement for recirculation of exhaust gases of a combustion engine with a turbocharger in a vehicle. The described arrangement comprises an EGR system with a return line, a valve device and a number of different exhaust gas coolers used to lower the temperature of the exhaust gases prior to lead them back from an exhaust line towards cylinders of the combustion engine in order to reduce NO_x emissions. The valve device is arranged in the return line upstream of the coolers with respect to the intended direction of exhaust gas flow in the return line. The recirculated exhaust gases are cooled by a first and second cooler and compressed air is cooled by a third cooler. The mixing of the recirculated exhaust gases and the compressed air can be performed upstream or downstream of the third cooler. The first cooler uses engine cooling water as cooling medium. The second cooler than can use air, a low temperature coolant or a refrigerant as cooling medium in order to further cool the exhaust gases.

US 2007/0199317 A1 describes an arrangement for recirculation of exhaust gases of a combustion engine with a turbocharger in a vehicle. The described arrangement comprises an exhaust line operable to lead exhaust gases out from the combustion engine, an inlet line operable to lead compressed air to the combustion engine, a return line comprising a connection to the exhaust line and a connection to the inlet line, so that the return line is operable to recirculate exhaust gases from the exhaust line to the inlet line, a first cooler operable to cool the exhaust gases in the return line by use of a liquid medium, and second cooler cooled by ambient air and arranged in the inlet line downstream from the connection of the return line to the inlet line, so that the second cooler is cooling a mixture of exhaust gases and the compressed air before the mixture is led to the combustion engine.

SUMMARY OF THE INVENTION

5 It is an object of the invention to provide an improved method for recirculation of exhaust gases of a combustion engine with a turbocharger which allows achieving that an internal surface of an exhaust gas cooler is kept substantially free from residuals of the exhaust gases of the combustion engine in an emission neutral manner. Another object is to provide an improved arrangement for recirculation of exhaust gases of a combustion engine with a turbocharger.

10 The objects are achieved by the features of the independent claims. The other claims and the description disclose advantageous embodiments of the invention.

15 According to a first aspect of the invention a method is proposed for recirculation of exhaust gases of a combustion engine with a turbocharger, wherein the combustion engine comprises a turbine placed in a exhaust line and adapted to be driven by exhaust gases from the combustion engine, a compressor adapted to be driven by the turbine in order to supply compressed air to an inlet line, which is adapted to lead compressed air to an intake of the combustion engine, a return line adapted to recirculate exhaust gases
20 from the exhaust line connected with an exhaust outlet of the combustion engine to the inlet line, wherein the return line is connected with the exhaust line upstream of the turbine of the turbocharger unit with respect to the intended direction of the exhaust gas flow in the exhaust line, a first cooler arranged in the return line in order to cool the exhaust gases, and a valve means arranged in the return line upstream of the first cooler with
25 respect to the intended direction of exhaust gas flow in the return line, wherein the valve means is guided in a given position in accordance with an actual operation condition of the combustion engine, and wherein the valve means allows the exhaust gas flow between the exhaust line and the inlet line passing the first cooler in an open position and prevents such an exhaust gas flow in a closed position. The first cooler is adapted to
30 make a heat exchange between the exhaust gases of the return line led through a first path of the first cooler, and the exhaust gases of the exhaust line downstream of the turbine of the turbocharger unit with respect to the intended direction of the exhaust gas flow in the exhaust line led through a second path of the first cooler, wherein the first path and the second path of the first cooler are cleaned by nitric dioxides (NO₂) produced in an
35 oxidation catalyst upstream of the turbine of the turbocharger unit with respect to the intended direction of the exhaust gas flow in the exhaust line.

Embodiments of the invention optimize the engine performance in respect to emissions, fuel consumption and high pressure rating by cleaning the first cooler on both sides of a heat exchanging wall between the first path and the second path inside the first cooler providing an optimized heat transfer and thus an improved combustion process. This is especially important if the heat transfer from the recirculated exhaust gas to the exhaust gas flow is used, because in this case the temperature difference and thus the driving force is lower compared to a standard case of cooling the recirculated exhaust gas either with air or engine coolant. The improved performance of the engine performing the recirculation of exhaust gases according to embodiments of the invention is closing a gap towards the performance of no recirculation of exhaust gases of a combustion engine at all due to lowering the temperature of the inlet air temperature of the combustion engine. The accumulated residuals in the first cooler can thereby be cleared away and led back in the exhaust line where they can be treated e.g. by an exhaust aftertreatment system or a separator. Additionally embodiments of the invention allow the continuous cleaning of the first cooler close to 100% of the heat exchanging area. In known cleaning processes the cleaning of the first cooler was limited to a maximum of 50% due to the fact that previous methods address only one side of the heat exchanging wall for cleaning.

Favourably, an exhaust aftertreatment system for reducing emissions of the internal combustion engine is used, wherein the exhaust aftertreatment system is arranged in the exhaust line downstream of the second path of the first cooler with respect to the intended direction of the exhaust gas flow in the exhaust line.

Preferably, in case of increased contamination of the first cooler, i.e. the contamination rate is larger than the NO_2 oxidation rate of the carbon containing species NO_x emissions of the engine are temporarily increased. This is especially suitable in case of using an exhaust gas aftertreatment system with an SCR catalyst (SCR: Selective Catalytic Reduction), because the SCR catalyst guarantees an emission neutral cleaning procedure of the first cooler.

Favourably, the cleaning process of the first cooler is started at temperatures as low as 200°C to 250°C by oxidizing NO to NO_2 in the oxidation catalyst independently of the performance of the exhaust gas aftertreatment system. Since the residual oxidation by NO_2 is facilitated at such low temperatures the cleaning procedure is more or less continuously during an entire map of engine operation points, because the upper limit is determined by the NO_2 thermodynamic stability, which is a clear advantage versus previous cleaning procedures of the first cooler.

In an embodiment of the method more than one cooler for cooling the compressed air and/or the recirculated exhaust gases are used. Additionally different coolant media can be used in different coolers. Furthermore at least one of the coolers is bypassed in accordance with an actual operation condition of the combustion engine. The bypassing of at least one of the coolers is done during conditions of cold start to fast warm up the engine inclusive engine oil and/or during cold weather that would otherwise lead to freezing of condensates in the corresponding cooler.

In a further embodiment of the method mixing the exhaust gases of the return line with compressed air of the inlet line is done upstream of at least one second cooler with respect to the intended direction of compressed air flow in the inlet line, wherein the at least one second cooler is used for cooling the mixture of the compressed air and the recirculated exhaust gases. Because of cooling the recirculated exhaust gases in a two stage manner by using the second cooler the size and/or the cooling performance of the first cooler can be reduced.

Alternatively mixing the exhaust gases of the return line with compressed air of the inlet line is done downstream of at least one second cooler with respect to the intended direction of compressed air flow in the inlet line, wherein the at least second cooler is used for cooling the compressed air of the inlet line.

In yet a further embodiment of the method mixing the exhaust gases of the return line with compressed air of the inlet line is done upstream or downstream of at least one second cooler with respect to the intended direction of compressed air flow in the inlet line, wherein the second cooler is used for cooling the mixture of the compressed air and the recirculated exhaust gases, or for cooling the compressed air of the inlet line, wherein the mixing position is chosen in accordance with an actual operation condition of the combustion engine.

According to another aspect of the invention an arrangement for recirculation of exhaust gases of a combustion engine with a turbocharger for performing the above described method, comprises a turbine placed in a exhaust line and adapted to be driven by exhaust gases from the combustion engine, a compressor adapted to be driven by the turbine in order to supply compressed air to an inlet line, which is adapted to lead compressed air to an intake of the combustion engine, a return line adapted to recirculate exhaust gases from the exhaust line connected with an exhaust outlet of the combustion engine to the

inlet line, wherein the return line is connected with the exhaust line upstream of the turbine of the turbocharger unit with respect to the intended direction of the exhaust gas flow in the exhaust line, a first cooler arranged in the return line in order to cool the exhaust gases, a first valve means arranged in the return line upstream of the first cooler with
5 respect to the intended direction of exhaust gas flow in the return line, and a control unit, wherein the control unit is guiding the first valve means is in a given position in accordance with an actual operation condition of the combustion engine, and wherein the first valve means allows the exhaust gas flow between the exhaust line and the inlet line passing the first cooler in an open position and prevents such an exhaust gas flow in a
10 closed position. The first cooler is adapted to make a heat exchange between the exhaust gases of the return line led through a first path of the first cooler, and the exhaust gases of the exhaust line downstream of the turbine of the turbocharger unit with respect to the intended direction of the exhaust gas flow in the exhaust line led through a second path of the first cooler, wherein the first path and the second path of the first cooler are cleaned
15 by nitric dioxides produced in an oxidation catalyst arranged upstream of the turbine of the turbocharger unit with respect to the intended direction of the exhaust gas flow in the exhaust line.

Favourably, an exhaust aftertreatment system for reducing emissions of the internal
20 combustion engine is arranged in the exhaust line downstream of the second path of the first cooler with respect to the intended direction of the exhaust gas flow in the exhaust line. The exhaust aftertreatment system can comprise a device for reducing a content of particulates in the exhaust gas and/or a device for reducing a content of NO_x in the exhaust gas. Therefore accumulated residuals in the first cooler which form particulates
25 can be removed from the exhaust gases trapped by DPF, so that the cleaning process of the first cooler can be done in an emission neutral manner. The device for reducing a content of particulates in the exhaust gas is arranged upstream or downstream of the device for reducing a content of nitrogen oxides in the exhaust gas.

30 In an embodiment of the arrangement the exhaust outlet of the combustion engine is build as an exhaust gas manifold. Furthermore, the oxidation catalyst is located in the exhaust gas manifold of the combustion engine.

In case of increased contamination of the first cooler the control unit is temporarily
35 increasing the NO_x emissions of the engine. This is especially suitable in case of using an exhaust gas aftertreatment system with an SCR catalyst, because the SCR catalyst guarantees an emission neutral cleaning procedure of the first cooler.

Favourably, the cleaning process of the first cooler is starting at temperatures as low as 200°C to 250°C by oxidizing NO to NO₂ in the oxidation catalyst independently of the performance of the exhaust gas aftertreatment system.

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In a further embodiment of the arrangement more than one cooler are used for cooling the compressed air and/or the recirculated exhaust gases. Furthermore different coolers are using different coolant media like exhaust gases, ambient air, engine coolant etc.

Preferably at least one of the coolers is bypassed using a third valve means controlled by the control unit in accordance with an actual operation condition of the combustion engine. The bypassing of at least one of the coolers is done during conditions of cold start to fast warm up the engine inclusive engine oil and/or during cold weather that would otherwise lead to freezing of condensates in the corresponding cooler.

15 In a further embodiment of the arrangement a first mixer is mixing the exhaust gases of the return line with compressed air of the inlet line upstream of at least one second cooler with respect to the intended direction of compressed air flow in the inlet line, wherein the second cooler is used for cooling the mixture of the compressed air and the recirculated exhaust gases.

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Alternatively a second mixer is mixing the exhaust gases of the return line with compressed air of the inlet line upstream of at least one second cooler with respect to the intended direction of compressed air flow in the inlet line, wherein the second cooler is used for cooling the compressed air of the inlet line.

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In yet a further embodiment of the arrangement the first mixer is mixing the exhaust gases of the return line with compressed air of the inlet line upstream of at least one second cooler with respect to the intended direction of compressed air flow in the inlet line, or the second mixer is mixing the exhaust gases of the return line with compressed air of the inlet line downstream of at least one second cooler with respect to the intended direction of compressed air flow in the inlet line, wherein the second cooler is used for cooling the mixture of the compressed air and the recirculated exhaust gases, or for cooling the compressed air of the inlet line, wherein the control unit is choosing the mixing position in accordance with an actual operation condition of the combustion engine using a second valve means.

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All together embodiments of the invention control the recirculation of exhaust gases and the exhaust gas aftertreatment system during operation and diagnose the efficiency level of the recirculation of exhaust gases of a combustion engine and the exhaust gas aftertreatment system in regard to NO_x and particulate reduction in a given engine map point as well as the recirculation of exhaust gases of a combustion engine in terms of heat transfer. Furthermore embodiments of the invention are able to clean the first cooler more or less continuously.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention together with the above-mentioned and other objects and advantages may best be understood from the following detailed description of the embodiments, but not restricted to the embodiments, wherein is shown schematically:

- Fig. 1 a first embodiment of an arrangement for recirculation of exhaust gases of a combustion engine with a turbocharger in a vehicle according to the invention;
- Fig. 2 a second embodiment of an arrangement for recirculation of exhaust gases of a combustion engine with a turbocharger in a vehicle according to the invention
- Fig. 3 a third embodiment of an arrangement for recirculation of exhaust gases of a combustion engine with a turbocharger in a vehicle according to the invention,
- Fig. 4 a fourth embodiment of an arrangement for recirculation of exhaust gases of a combustion engine with a turbocharger in a vehicle according to the invention;
- Fig. 5 thermodynamic equilibrium curve for NO₂/NO, NO₂ engine out emissions and NO₂ emissions downstream an oxidation catalyst, and
- Fig. 6 a curve of required NO_x/soot ratio as function of exhaust gas temperature for NO₂ based soot burning.

In the drawings, equal or similar elements are referred to by equal reference numerals. The drawings are merely schematic representations, not intended to portray specific parameters of the invention. Moreover, the drawings are intended to depict only typical embodiments of the invention and therefore should not be considered as limiting the scope of the invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

Figures 1 to 4 are schematically illustrating arrangements according to different
5 embodiments of the present invention, which can be utilised particularly for a combustion
engine of the diesel type.

According to preferred embodiments, the diesel engine 10 is by way of example intended
for use in a load carrying vehicle, and comprises e.g. six cylinders 11 (only one is denoted
10 with a reference numeral). The invention is however not limited to any specific number of
cylinders or any specific cylinder configuration. The diesel engine 10 can also be used for
stationary engines for electrical power generation etc.

In a way as such previously known, the engine 10 is equipped with an inlet manifold 14, to
15 which air is fed from the atmosphere via an intake conduit 100 and an inlet line 1. The
input air is then divided between the various cylinders 11. Furthermore, fuel is supplied to
the cylinders 11 by a corresponding number of fuel injection devices (not shown) that are
each connected to a central control unit 40 via an electrical connection (not shown). The
control unit 40, which is preferably computer based, is in a known manner operative to
20 control each fuel injection device so as to supply, in each instant, an appropriate fuel/air
mixture to the engine 10.

During operation of the engine 10, the control unit 40 is operative to control the respective
injection device in such a way that the fuel/air mixture supplied to the engine 10 will be
25 adapted, in each instant, to the current operating conditions. The fuel supply is hereby
obtained in a generally known manner, i.e. in dependence of a multitude of parameters
representative of the operating conditions of the engine 10 and the vehicle in question.
For example, the control can be performed depending on the present throttle position and
the rotational speed and load of the engine 10.

Each cylinder 11 is provided with an exhaust outlet. Together, the exhaust outlets
converge into an exhaust manifold 12, continuing into an exhaust line 2. This exhaust line
2 runs via a turbocharger unit 50, which as such is substantially conventional. Thus, the
turbocharger unit 50 comprises a compressor 52 and an energy absorbing unit 54 for
35 absorbing energy from the exhaust gases in the form of a turbine, which is arranged in the
exhaust line 2 and is being rotated by the exhaust gases flowing through the exhaust line

2 and which drives the compressor 52. As an alternative to the embodiment shown in the figures, which is designed in such a way that the exhaust outlets join into a single exhaust line 2 (known as a "single inlet"), the exhaust outlets may be grouped into two groups, making the exhaust duct consist of two lines leading to the turbine 54 (known as a "twin inlet").

The turbine 54 is arranged on a shaft 56, on which the compressor 52 is likewise arranged. The energy absorbed from the exhaust flow by the turbine 54 is in this way transferred to the compressor 52, which functions to compress the in-flowing air in the air conduit 100 to the inlet conduit 14 of the engine 10. In this manner, an increased fuel amount may be fed to the engine 10, whereby its power output can be increased.

An exhaust aftertreatment system 30 favourably comprises at least one of a unit 34 for reducing particulate matter in the exhaust gas or a unit 36 for converting NO_x, particularly a SCR catalyst. The NO_x converting unit 36 can be arranged upstream or downstream of the unit 34. Preferably the unit 34 is a particulate filter which holds back soot particles.

The engine 10 is further equipped with an arrangement 80 for recirculation of a certain amount of exhaust gases to the intake side of the engine 10. According to what was discussed in the introduction, an EGR system 80 ("Exhaust Gas Recirculation") is as such previously known. According to the embodiment, a return line 3 is therefore connected to the exhaust line 2, at a point upstream of the turbine 54 with respect to the intended direction of the exhaust gas flow in the exhaust line 2. The NO_x generation in the respective cylinder 11 is temperature-dependent and for this reason it is desirable to lower, as far as possible, the temperature of the gases (i.e. including air and recirculated EGR gases) coming in to the engine 10. For this reason, the return line 3 is provided with a first cooler 82 functioning to cool the EGR gases recirculated to the inlet manifold 14.

According to the invention the first cooler 82 is adapted to make a heat exchange between the EGR gases of the return line 3 led through a first path of the first cooler 82, and the exhaust gases of the exhaust line 2 downstream of the turbine 54 of the turbocharger unit 50 and upstream of the exhaust gas aftertreatment system 30 with respect to the intended direction of the exhaust gas flow in the exhaust line 2 led through a second path of the first cooler 82. The first path and the second path of the first cooler 82 are cleaned continuously by nitric dioxides NO₂ produced in an oxidation catalyst 32 arranged upstream of the turbine 54 of the turbocharger unit 50 and a connection point of the exhaust line 2 and the return line 3 with respect to the intended direction of the exhaust

gas flow in the exhaust line 2. By means of this first cooler 82, the EGR gases can be cooled, which further contributes to reducing the generated amount of NOx compounds.

According to a first embodiment of the present invention shown in figure 1, the return line 3 is connected with the inlet line 1 which is connected with the inlet manifold 14 via a first mixer unit 84.1, at a point upstream of a second cooler 20 and the inlet manifold 14 of the engine 10 with respect to the intended direction of compressed air flow in the inlet line 1. The first mixer unit 84.1 is realized as a venturi, for example. The second cooler 20, also known as an "intercooler", which is used for cooling the mixture of the compressed air supplied by the compressor 52 and the recirculated exhaust gases according to the first embodiment of the invention. This also contributes to a reduction of the amount of NOx compounds generated in the engine 10. The second cooler 20 is preferably arranged for cooling by ambient air. The mixer unit 84 mixes the recirculating exhaust gases with the compressed air in the inlet line 1. Along the return line 3, a controllable first valve means S1 is arranged, connected to the control unit 40 via a further connection, which is represented by a dashed line. The control unit 40 is operative, in dependence of the present operating conditions, to adjust the first valve means S1 to a closed, open or partially open position. Depending on the position of the first valve means S1, a corresponding amount of exhaust gases will thus be recirculate to the inlet manifold 14 via the return line 3. Through the recirculation of these EGR gases to the intake manifold 12, a temperature reduction during the combustion is achieved in the respective cylinder 11, whereby the NOx generation in the cylinder 11 is reduced.

During operation of the engine 10 equipped with an EGR system 80 the first cooler 82 needs to be frequently cleaned due to contamination of the cooler 82 with soot, sludge, etc. decreasing the heat transfer efficiency of the cooler 82 and thus impacting detrimental on the engine performance. In conventional 1-stage EGR cooling systems, the first cooler 82 is indirectly cooled, i.e. the EGR gas is cooled with engine coolant. In state-of-the-art 2-stage EGR cooling systems, the first cooler 82 (high temperature) is indirectly cooled, while the second cooler 20 is directly cooled, i.e. the EGR gas is cooled with air. In conventional 1-stage and state-of-the-art 2-stage EGR cooling systems, only the heat transferring surface exposed to the EGR gas is cleaned. However, according to the invention the first cooler 82 is located in the exhaust gas stream and uses the exhaust gas as a coolant medium, than both surfaces of the first cooler 82 should be cleaned in order to provide optimum heat transfer characteristics of the system. This cleaning procedure can be performed emission neutral with high efficiency in regard to fuel consumption and required duration by applying the aspects of the present invention.

During operation of the engine 10, inlet air is compressed and led through the inlet pipe 1 through the second cooler 20 also named as charge air cooler further to the inlet manifold 14. At the first mixer unit 84.1, the inlet air is mixed with the EGR gas that has been taken from the exhaust gas stream leaving the engine 10 via the exhaust line 2 passing the oxidation catalyst 32. The EGR gas flow is controlled by the first valve S1 and is led via the return line 3, passing the first cooler 82. Over the oxidation catalyst 32, NO comprised in the EGR gas is oxidized to NO₂, see figure 5. Both EGR gas flow and exhaust gas flow are rich in NO₂ after passing the oxidation catalyst 32, see figure 2. The NO₂ formed is a potent oxidation agent for the reduction of contaminants within the EGR system 80 and especially on both heat transferring surfaces of the first cooler 82. For example, soot oxidation by NO₂ is facilitated at temperatures as low as 200-250°C, see figure 6, it is more or less continuously during the entire map of engine operation points, because the upper limit is determined by the NO₂ thermodynamic stability, see figure 5. Such thermodynamic characteristics are also advantageous for using the NO₂ portion in the exhaust gas for optimum performance of the diesel particulate filter 34 regeneration process and NO_x reduction over the SCR catalyst 36, because NO₂ formed in the oxidation catalyst 32 upstream the turbine 54 experiences a temperature drop as soon as it has passed the turbine 54 passing further downstream the exhaust gas line 3 towards the exhaust gas aftertreatment system 30 comprising an diesel particulate filter 34 and/or SCR catalyst 36. Figure 5 is showing thermodynamic equilibrium curve for NO₂/NO (a), NO₂ engine out emissions (b), NO₂ emissions downstream an oxidation catalyst (c), and figure 3 is showing an example of required NO_x/soot ratio as a function of exhaust temperature for NO₂ based soot burning.

Figure 2 schematically illustrates an arrangement according to a second embodiment of the present invention. Except a second mixer unit 84.2 instead of the first mixer unit 84.1 the second embodiment of the present invention is the same as the first embodiment. The second mixer unit 84.2 is also realized as a venturi, for example. Therefore a repeating description of known components is here omitted.

As an alternative to the embodiment shown in the figure 1, which is designed in such a way that the first mixer unit 84.1 is mixing the EGR gas flow of the return line 3 with the compressed air of the inlet line 1 upstream of the second cooler 20 with respect to the intended direction of compressed air flow in the inlet line 1, the embodiment shown in figure 2 is mixing the EGR gas flow of the return line 3 with the compressed air of the inlet line 1 downstream of the second cooler 20 with respect to the intended direction of

compressed air flow in the inlet line 1 using the second mixer 84.2. So the second embodiment of the present invention is using just the first cooler 82 to cool the EGR gas flow of the return line 3. The overall performance of the second embodiment is except the position of the second mixing unit equivalent to the first embodiment.

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Figure 3 schematically illustrates an arrangement according to a third embodiment of the present invention. Except the use of two mixer units 84.1 and 84.2 the third embodiment of the present invention is the same as the first or second embodiment. Therefore a repeating description of known components is here omitted.

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In difference to the first embodiment shown in figure 1 and to the second embodiment shown in figure 2 the third embodiment comprises the first mixer unit 84.1 and the second mixer unit 84.2. The third embodiment shown in figure 3 is using the first mixer 84.1 for mixing the exhaust gases of the return line 3 with compressed air of the inlet line 1 upstream of the second cooler 20 with respect to the intended direction of compressed air flow in the inlet line 1, or the second mixer 84.2 for mixing the exhaust gases of the return line 3 with compressed air of the inlet line 1 downstream of the second cooler 20 with respect to the intended direction of compressed air flow in the inlet line 1, wherein the control unit 40 is choosing the mixing position in accordance with an actual operation condition of the combustion engine 10 using a controllable second valve means S2, for example. The second valve means S2 is connected to the control unit 40 via a further connection, which is represented by a dashed line. In a first position of the second valve means S2 the first mixer unit 84.1 is used for mixing the exhaust gases of the return line 3 with compressed air of the inlet line 1 and the second cooler 20 is used for cooling the mixture of the compressed air and the recirculated exhaust gases. In a second position of the second valve means S2 the second mixer unit 84.2 is used for mixing the exhaust gases of the return line 3 with compressed air of the inlet line 1 and the second cooler 20 is used just for cooling the compressed air of the inlet line 1. During conditions of cold start and/or during cold weather the control unit 40 may use the second position of the second valve means S2 to fast warm up of the engine 20 and the engine oil. Also during low load the control unit 40 may use the second position of the second valve means S2 to heat up the after treatment system to improve NOx reduction. The overall performance of the second embodiment is except the possibility to change the mixing position equivalent to the first or second embodiment.

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Figure 4 schematically illustrates an arrangement according to a fourth embodiment of the present invention. Except the second cooler 20 the fourth embodiment of the present

invention is the same as the third embodiment. Therefore a repeating description of known components is here omitted.

In difference to the third embodiment shown in figure 3 the fourth embodiment shown in figure 4 is using two coolers 22 and 24 as the second cooler 20 of the third embodiment. The use of two coolers 22 and 24 as the second cooler 20 is also suitable for the first embodiment shown in figure 1 and/or the second embodiment shown in figure 2.

Furthermore the coolant medium of the different coolers 82, 22 and 24 can be chosen different. For example, the first cooler uses exhaust gas as coolant, the additional cooler 22 uses engine coolant and the additional cooler 24 uses ambient air as coolant.

Additionally the fourth embodiment shown in figure 4 is including a bypass line 4 and bypass valve means S3 of the additional cooler 24 enabling the control unit 40 to shut down the additional cooler 24 during conditions of cold start, i.e. fast warm up of engine (incl. engine oil) and during cold weather that would otherwise lead to freezing of condensates in the additional cooler 24. The bypass valve means S3 is connected to the control unit 40 via a further connection, which is represented by a dashed line. The overall performance of the fourth embodiment is except the usage of two coolers 22, 24 in the inlet line 1 equivalent to the third embodiment.

Not shown, but similar applicable are embodiments of the invention if an oxidation catalyst 32 is located in the exhaust gas manifold.

Not shown, but similar applicable are embodiments of the invention if the order within the exhaust gas system 30 has changed, i.e. the SCR catalyst 36 upstream the diesel particulate filter 34.

Not shown, but in case of increased contamination, i.e. the contamination rate is larger than the NO₂ oxidation rate of C-containing species, the control unit 40 is temporarily increasing the NO_x emissions of the engine 10. This is especially suitable in case of an SCR comprising exhaust gas aftertreatment system 30 because the SCR catalyst 36 guarantees an emission neutral EGR cleaning procedure.

CLAIMS

1. A method for recirculation of exhaust gases of a combustion engine (10) with a turbocharger (50), wherein the combustion engine (10) comprises a turbine (54) placed in a exhaust line (2) and adapted to be driven by exhaust gases from the combustion engine (10), a compressor (52) adapted to be driven by the turbine (54) in order to supply compressed air to an inlet line (1), which is adapted to lead compressed air to an intake (14) of the combustion engine (10), a return line (3) adapted to recirculate exhaust gases from the exhaust line (2) connected with an exhaust outlet (12) of the combustion engine (10) to the inlet line (1), wherein the return line (3) is connected with the exhaust line (2) upstream of the turbine (54) of the turbocharger unit (50) with respect to the intended direction of the exhaust gas flow in the exhaust line (2), a first cooler (82) arranged in the return line (3) in order to cool the exhaust gases, and a valve means (S1) arranged in the return line (3) upstream of the first cooler (82) with respect to the intended direction of exhaust gas flow in the return line (3), wherein the valve means (S1) is guided in a given position in accordance with an actual operation condition of the combustion engine (10), and wherein the valve means (S1) allows the exhaust gas flow between the exhaust line (2) and the inlet line (1) passing the first cooler (82) in an open position and prevents such an exhaust gas flow in a closed position, **characterized by** making a heat exchange between the exhaust gases of the return line (3) led through a first path of the first cooler (82) and the exhaust gases of the exhaust line (2) downstream of the turbine (54) of the turbocharger unit (50) with respect to the intended direction of the exhaust gas flow in the exhaust line (2) led through a second path of the first cooler (82), wherein the first path and the second path of the first cooler (82) are cleaned by nitric dioxides (NO₂) produced in an oxidation catalyst (32) upstream of the turbine (54) of the turbocharger unit (50) with respect to the intended direction of the exhaust gas flow in the exhaust line (2).
2. The method according to claim 1, characterized by reducing emissions of the internal combustion engine (10) in the exhaust line (2) by arranging an exhaust gas aftertreatment system (30) downstream of the second path of the first cooler (82) with respect to the intended direction of the exhaust gas flow in the exhaust line (2).

3. The method according to claim 1 or 2, characterized by temporarily increasing the NO_x emissions of the engine (10) in case of increased contamination of the first cooler (82).
- 5 4. The method according to any preceding claim, characterized by starting the cleaning process of the first cooler (82) at temperatures as low as 200°C to 250°C by oxidizing NO to NO₂ in the oxidation catalyst (32) independently of the performance of the exhaust gas aftertreatment system (30).
- 10 5. The method according to any preceding claim, characterized by using more than one cooler (82, 20, 22, 24) for cooling the compressed air and/or the recirculated exhaust gases.
- 15 6. The method according to claim 5, characterized by using different coolant media in different coolers (82, 20, 22, 24).
- 20 7. The method according to claim 5 or 6, characterized by bypassing at least one of the coolers (82, 20, 22, 24) in accordance with an actual operation condition of the combustion engine (10).
- 25 8. The method according to any preceding claim, characterized by mixing the exhaust gases of the return line (3) with compressed air of the inlet line (1) upstream of at least one second cooler (20, 22, 24) with respect to the intended direction of compressed air flow in the inlet line (1), wherein the at least one second cooler (20, 22, 24) is used for cooling the mixture of the compressed air and the recirculated exhaust gases.
- 30 9. The method according to any preceding claim, characterized by mixing the exhaust gases of the return line (3) with compressed air of the inlet line (1) downstream of at least one second cooler (20, 22, 24) with respect to the intended direction of compressed air flow in the inlet line (1), wherein the at least second cooler (20, 22, 24) is used for cooling the compressed air of the inlet line (1).
- 35 10. The method according to any preceding claim, characterized by mixing the exhaust gases of the return line (3) with compressed air of the inlet line (1) upstream or downstream of at least one second cooler (20, 22, 24) with respect to the intended direction of compressed air flow in the inlet line (1), wherein the

second cooler (20, 22, 24) is used for cooling the mixture of the compressed air and the recirculated exhaust gases, or for cooling the compressed air of the inlet line (1), wherein the mixing position is chosen in accordance with an actual operation condition of the combustion engine (10).

5
11. An arrangement for recirculation of exhaust gases of a combustion engine (10) with a turbocharger (50) for performing the method according to anyone of the preceding claims, wherein the arrangement comprises a turbine (54) placed in a exhaust line (2) and adapted to be driven by exhaust gases from the combustion
10 engine (10), a compressor (52) adapted to be driven by the turbine (54) in order to supply compressed air to an inlet line (1), which is adapted to lead compressed air to an intake (14) of the combustion engine (10), a return line (3) adapted to recirculate exhaust gases from the exhaust line (2) connected with an exhaust outlet (12) of the combustion engine (10) to the inlet line (1), wherein the return
15 line (3) is connected with the exhaust line (2) upstream of the turbine (54) of the turbocharger unit (50) with respect to the intended direction of the exhaust gas flow in the exhaust line (2), a first cooler (82) arranged in the return line (3) in order to cool the exhaust gases, a first valve means (S1) arranged in the return line (3) upstream of the first cooler (82) with respect to the intended direction of exhaust
20 gas flow in the return line (3), and a control unit (40), wherein the control unit (40) is guiding the first valve means (S1) is in a given position in accordance with an actual operation condition of the combustion engine (10), and wherein the first valve means (S1) allows the exhaust gas flow between the exhaust line (2) and the inlet line (1) passing the first cooler (82) in an open position and prevents such
25 an exhaust gas flow in a closed position, **characterized in that** the first cooler (82) is adapted to make a heat exchange between the exhaust gases of the return line (3) led through a first path of the first cooler (82), and the exhaust gases of the exhaust line (2) downstream of the turbine (54) of the turbocharger unit (50) with respect to the intended direction of the exhaust gas flow in the exhaust line (2) led
30 through a second path of the first cooler (82), wherein the first path and the second path of the first cooler (82) are cleaned by nitric dioxides (NO₂) produced in an oxidation catalyst (32) arranged upstream of the turbine (54) of the turbocharger unit (50) with respect to the intended direction of the exhaust gas flow in the exhaust line (2).

35
12. The arrangement according to claim 11, characterized in that an exhaust gas aftertreatment system (30) for reducing emissions of the internal combustion

engine (10) is arranged in the exhaust line (2) downstream of the second path of the first cooler (82) with respect to the intended direction of the exhaust gas flow in the exhaust line (2).

- 5 13. The arrangement according to claims 11 or 12, characterized in that the exhaust outlet (12) of the combustion engine (10) is build as an exhaust gas manifold.
14. The arrangement according to anyone of the claims 11 to 13, characterized in that the oxidation catalyst (32) is located in the exhaust gas manifold (12) of the
10 combustion engine (10).
15. The arrangement according to anyone of the claims 11 to 14, characterized in that the control unit (40) is temporarily increasing the NO_x emissions of the engine (10) in case of increased contamination of the first cooler (82).
15
16. The arrangement according to anyone of the claims 11 to 15, characterized in that the cleaning process of the first cooler (82) is starting at temperatures as low as 200°C to 250°C by oxidizing NO to NO₂ in the oxidation catalyst (32) independently of the performance of the exhaust gas aftertreatment system (30).
20
17. The arrangement according to anyone of the claims 11 to 16, characterized in that more than one cooler (82, 20, 22, 24) are used for cooling the compressed air and/or the recirculated exhaust gases.
- 25 18. The arrangement according to claim 17, characterized in that different coolers (82, 20, 22, 24) are using different coolant media.
19. The arrangement according to claims 17 or 18, characterized in that at least on of the coolers (22, 24) is bypassed using a third valve means (S3) controlled by the
30 control unit (40) in accordance with an actual operation condition of the combustion engine (10).
20. The arrangement according to anyone of the claims 11 to 19, characterized in that a first mixer (84.1) is mixing the exhaust gases of the return line (3) with
35 compressed air of the inlet line (1) upstream of at least one second cooler (20, 22, 24) with respect to the intended direction of compressed air flow in the inlet line

(1), wherein the second cooler (20, 22, 24) is used for cooling the mixture of the compressed air and the recirculated exhaust gases.

21. The arrangement according to anyone of the claims 11 to 19, characterized in that
5 a second mixer (84.2) is mixing the exhaust gases of the return line (3) with compressed air of the inlet line (1) upstream of at least one second cooler (20, 22, 24) with respect to the intended direction of compressed air flow in the inlet line (1), wherein the second cooler (20, 22, 24) is used for cooling the compressed air of the inlet line (1).

10 22. The arrangement according to anyone of the claims 11 to 21, characterized in that a first mixer (84.1) is mixing the exhaust gases of the return line (3) with compressed air of the inlet line (1) upstream of at least one second cooler (20, 22, 24) with respect to the intended direction of compressed air flow in the inlet line
15 (1), or a second mixer (84.2) is mixing the exhaust gases of the return line (3) with compressed air of the inlet line (1) downstream of at least one second cooler (20, 22, 24) with respect to the intended direction of compressed air flow in the inlet line (1), wherein the second cooler (20, 22, 24) is used for cooling the mixture of the compressed air and the recirculated exhaust gases, or for cooling the compressed
20 air of the inlet line (1), wherein the control unit (40) is choosing the mixing position in accordance with an actual operation condition of the combustion engine (10) using a second valve means (S2).

23. The arrangement according to anyone of the claims 11 to 22, characterized in that
25 the exhaust aftertreatment system (30) comprises a device (32) for reducing a content of particulates in the exhaust gas.

24. The arrangement according to anyone of the claims 11 to 23, characterized in that
30 the exhaust aftertreatment system (30) comprises a device (34) for reducing a content of nitrogen oxides (NOx) in the exhaust gas.

25. The arrangement according to claims 23 or 24, characterized in that the device
(32) for reducing a content of particulates in the exhaust gas is arranged upstream
or downstream of the device (34) for reducing a content of nitrogen oxides (NOx)
35 in the exhaust gas.

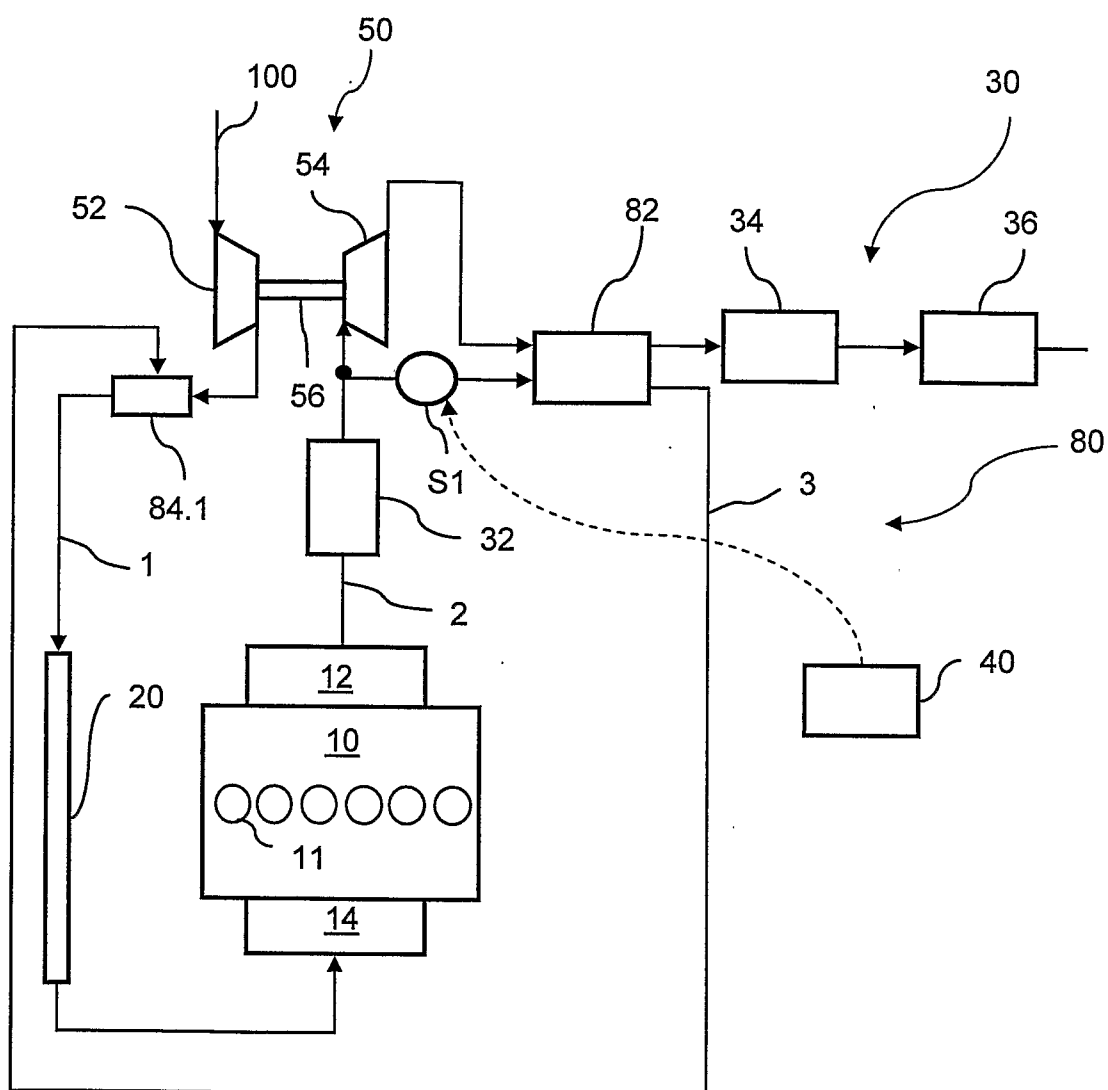


Fig. 1

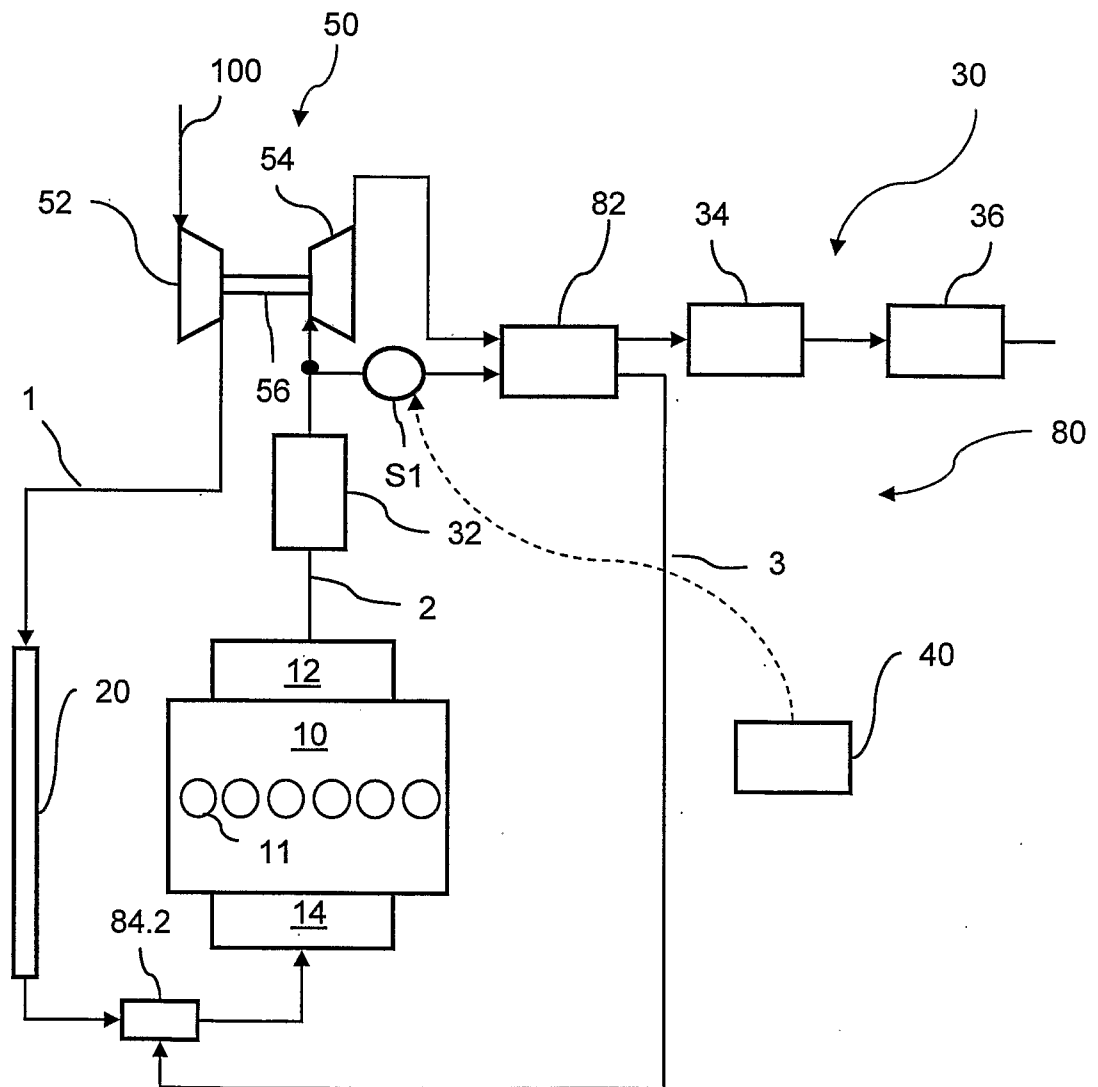


Fig. 2

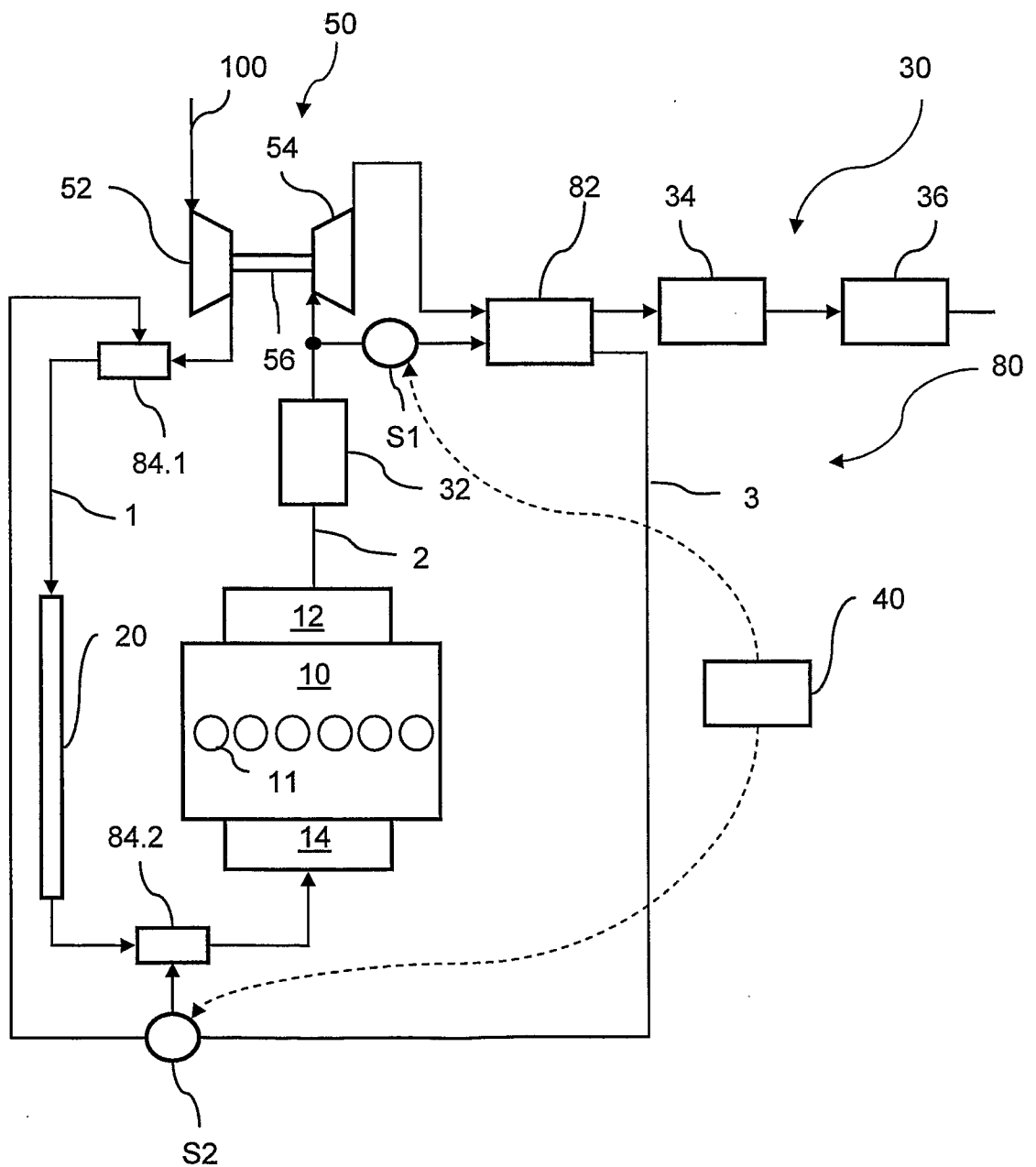


Fig. 3

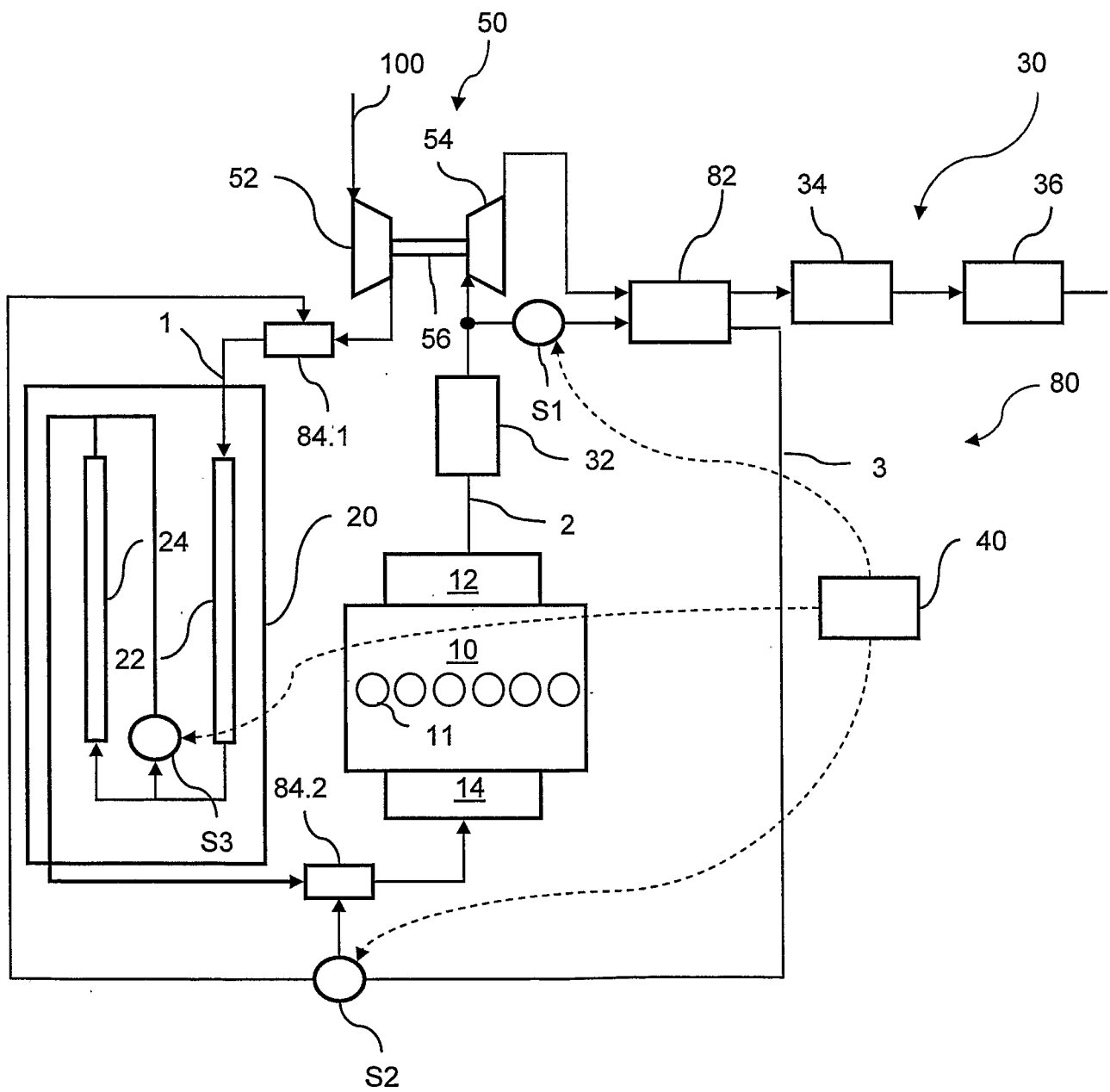


Fig. 4

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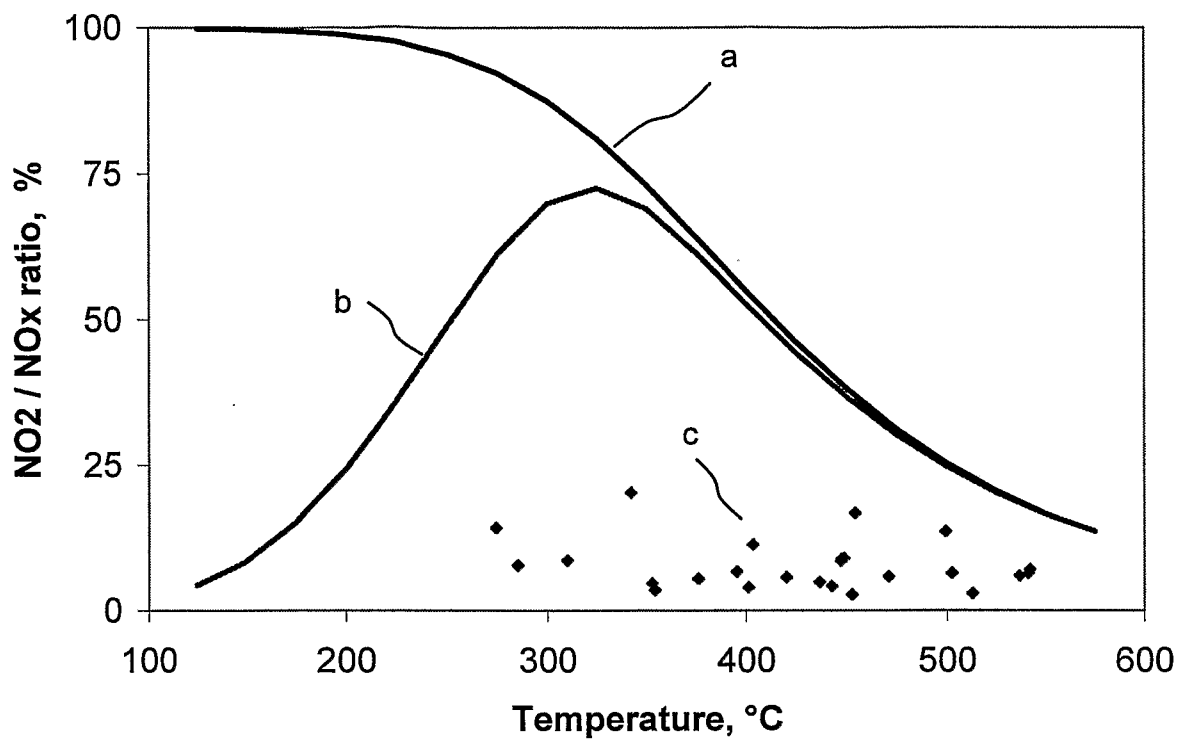


Fig. 5

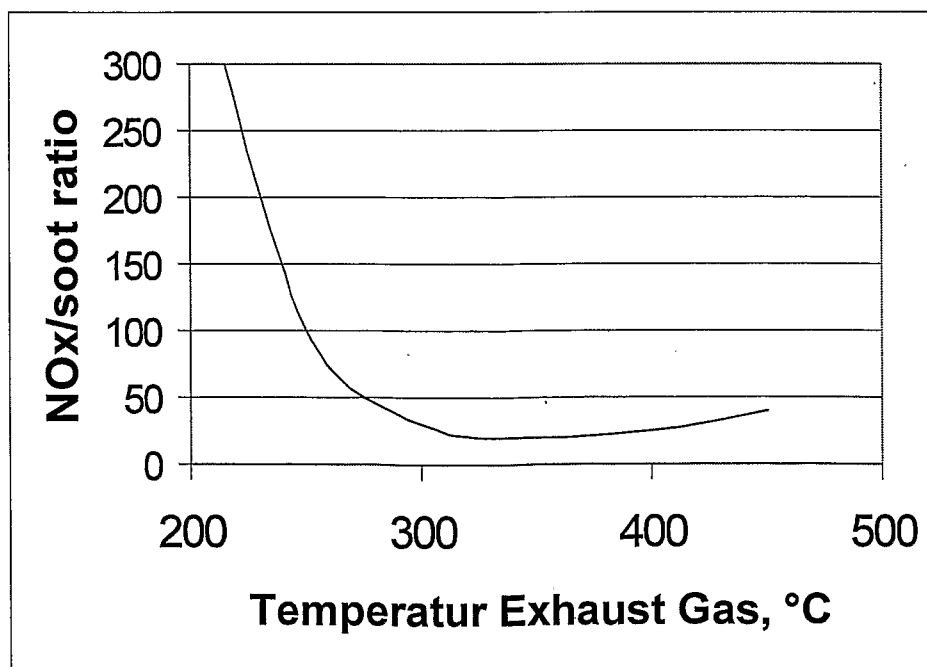


Fig. 6

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE2009/000205

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: F02M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 20070089716 A1 (SAELE), 26 April 2007 (26.04.2007), figure 2, abstract, paragraphs (0020)-(0023),(0030) --	1-25
Y	US 7189374 B1 (HAWKER), 13 March 2007 (13.03.2007), column 2, line 41 - line 64; column 3, line 10 - line 25; column 3, line 42 - line 51, figure 1, abstract --	1-25
Y	US 5203311 A (HITOMI ET AL), 20 April 1993 (20.04.1993), column 3, line 18 - line 21; column 3, line 29 - line 30; column 6, line 27 - line 50, figure 5 --	7,10,13,14, 19,22

☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

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Date of the actual completion of the international search

14 December 2009

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE2009/000205

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 20060185364 A1 (CHALGREN ET AL), 24 August 2006 (24.08.2006), figures 1,10 --	8,9,20,21
A	EP 1843033 A2 (MAN NUTZFAHRZEUGE ÖSTERREICH AG), 10 October 2007 (10.10.2007), figure 1, abstract, paragraph (0017) --	1-25
A	US 7299793 B1 (TYO ET AL), 27 November 2007 (27.11.2007), column 2, line 3 - line 21; column 3, line 63 - line 67, abstract --	1-25
A	Ioannis P. Kandylas et al " Diesel Soot Oxidation with NO2: Engine Experiments and Simulations, Ind. Eng. Chem. Res. 2002, 41, 5372-5384, paragraphs "Introduction" and "Concluding Remarks" -- -----	1-25

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/SE2009/000205

US	20070089716	A1	26/04/2007	NONE		
US	7189374	B1	13/03/2007	DE	60014662 D,T	23/02/2006
				EP	1203148 A,B	06/10/2004
				SE	1203148 T3	
				WO	0077353 A	31/05/2001
US	5203311	A	20/04/1993	DE	69130976 D,T	08/07/1999
				DE	69133098 D,T	17/04/2003
				EP	0489263 A,B	10/03/1999
US	20060185364	A1	24/08/2006	NONE		
EP	1843033	A2	10/10/2007	AT	503458 A,B	15/09/2008
US	7299793	B1	27/11/2007	NONE		