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(54) **Title:** ENGINE EXHAUST GAS CONTROL SYSTEM

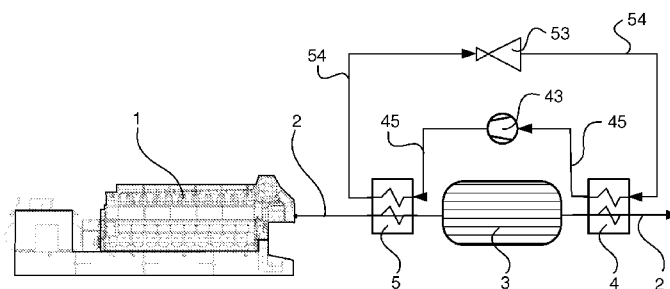


FIG. 1

(57) **Abstract:** An engine (1) exhaust gas control system for internal combustion engine (1), the system comprising: - an exhaust gas line (2) is provided for leading the engine (1) exhaust gases out, - the exhaust gas line (2) comprises an exhaust gas aftertreatment device (3) for reducing unwanted emissions of the engine (1), - an exhaust gas heat recovery heat exchanger (4) is in the exhaust gas line (2) downstream of the exhaust gas aftertreatment device (3), - an exhaust gas heating device (5) is in the exhaust gas line (2) upstream of the exhaust gas aftertreatment device (3), - a heating medium line (45) from the exhaust gas heat recovery heat exchanger (4) to the exhaust gas heating device (5) comprises (5) a compressor (43) for providing heating medium to the exhaust gas heating device (5), - a heating medium line (54) from the exhaust gas heating device (5) to the exhaust gas heat recovery heat exchanger (4) comprises an expansion unit (53) to expand and lower the pressure of the heating medium.



Engine exhaust gas control system

TECHNICAL FIELD

[001] The present invention concerns in general the technical field of internal combustion engine exhaust systems. Especially the invention concerns an engine exhaust gas control system for internal combustion reciprocating engine, the system comprising:

- an exhaust gas line is provided for leading the engine exhaust gases out,
- the exhaust gas line comprises an exhaust gas aftertreatment device for reducing unwanted emissions of the engine.

10 BACKGROUND OF THE INVENTION

[002] In modern internal combustion piston engines the burning process is well under control, but the high burning temperature causes part of the nitrogen of the intake air to convert in to NO_x and there may also be in exhaust gas other unwanted substances such as unburned fractions of the fuel (or unburned hydrocarbons UHC) such as methane (CH_4). For the purpose of reducing unwanted substances and converting those in to less harmful substances there are different exhaust gas aftertreatment devices, which utilize different catalytic processes for said purpose.

[003] Selective catalytic reduction (SCR) is a means of converting nitrogen oxides, also referred to as NO_x with the aid of a catalyst into diatomic nitrogen, N_2 , and water, H_2O . A gaseous reductant, typically anhydrous ammonia, aqueous ammonia or urea, is added to a stream of flue or exhaust gas and is adsorbed onto a catalyst. Carbon dioxide, CO_2 is a reaction product when urea is used as the reductant. Commercial selective catalytic reduction systems are typically found on large utility boilers, industrial boilers, and municipal solid waste boilers and have been shown to reduce NO_x by 70-95%. More recent applications include diesel engines, such as those found on large ships, diesel locomotives, gas turbines, and even automobiles. A SCR system needs stable exhaust gas entry temperature to work properly. Also the temperature needs to be between certain limits.

[004] Different new technologies within the engine technology have resulted in a significant rise in engine overall performance and efficiency. At the same time the emissions are decreased and thus the engine causes less pollution. If gas turbines and reciprocating gas engines are compared, the reciprocating engines may still have relatively higher content of unburned hydrocarbons

(UHC) in the exhaust. There are some reasons for this, it is mainly due to the non-continuous combustion in reciprocating engines, but other reasons are crevices in the combustion chamber, cold walls, and a possible carry over from intake valve to exhaust valve during scavenging.

5 [005] By improvement of combustion chamber design this emission has been reduced. But as the combustion process is non-continuous in the engine there will be a limit how low it is possible to go with the emissions. Aftertreatment of the flue gasses is necessary for this. Oxidation catalysts have been successfully used for CO reduction purposes. Within the field of exhaust gas after-
10 treatment systems a number of tests have also been carried out for using oxidation catalysts for reduction of the unburned hydrocarbons, especially methane, as this has a relatively large greenhouse gas potential. Earlier tests have shown that oxidation catalysts can reduce unburned hydrocarbons. However, as gas engines have become more efficient and the combustion leaner,
15 the exhaust temperatures are too low to ensure good and continuous reduction.

[006] From the state of the art it is known WO 2006/031910 A2 –publication which discloses an emissions control system that utilizes otherwise wasted heat to efficiently reduce emissions in a main exhaust flow. Heat stored in ex-
20 haust from an auxiliary generator (i.e., auxiliary exhaust) may be used to convert urea to ammonia used by a Selective Catalytic Reducer (SCR) system, and/or the auxiliary exhaust may be used to heat the main exhaust flow before entry into an SCR. Additionally, a heat exchanger may be used to transfer heat from a hot clean flow out of the SCR, to the main exhaust flow entering the
25 SCR. The publication explains that previously, mobile emissions control systems have not used SCR systems to reduce NO_x because of the cost and space required for heater fuel. The efficient use of otherwise wasted heat reduces fuel cost and fuel storage requirements, and thereby makes an SCR systems feasible for use in mobile emissions control systems.

30 SUMMARY OF THE INVENTION

[007] An objective of the invention is to present a system for reducing the unwanted or harmful emissions, such as NO_x, CO, UHC emissions of an engine by providing a relatively simple system that maintains the necessary conditions for different exhaust gas aftertreatment processes.

[008] The objects of the invention are reached by system as defined by the respective independent claims. In more detail it is an engine exhaust gas control system for internal combustion engine, the system comprising:

- an exhaust gas line is provided for leading the engine exhaust gases out,
- 5 - the exhaust gas line comprises an exhaust gas aftertreatment device for reducing unwanted emissions of the engine,
- an exhaust gas heat recovery heat exchanger is in the exhaust gas line downstream of the exhaust gas aftertreatment device,
- an exhaust gas heating device is in the exhaust gas line upstream of the ex-
- 10 haust gas aftertreatment device,
- a heating medium line from the exhaust gas heat recovery heat exchanger to the exhaust gas heating device comprises a compressor for providing heating medium to the exhaust gas heating device,
- a heating medium line from the exhaust gas heating device to the exhaust
- 15 gas heat recovery heat exchanger comprises an expansion unit to expand and lower the pressure of the heating medium.

[009] The system as presented above enables the use of heat at the exhaust gas to be effectively used so that the process conditions for different exhaust gas aftertreatment devices can be maintained at a proper level. This also en-

20 ables the location to the exhaust gas aftertreatment system to be located at a position more remote to the engine where the exhaust gas temperature is otherwise already decreased. Without the present system the heat delivered by the exhaust gas would not necessary be high enough to ensure the proper high temperature for aftertreatment and furthermore the energy of heat would

25 be wasted if not recovered for some other purpose.

BRIEF DESCRIPTION OF THE DRAWINGS

[010] In figure 1 it is presented a schematic view of the present system.

DETAILED DESCRIPTION

[011] In Fig. 1 it is presented an engine 1 exhaust gas control system for inter-

30 nal combustion engine 1, the system comprising:

- an exhaust gas line 2 is provided for leading the engine 1 exhaust gases out,
- the exhaust gas line 2 comprises an exhaust gas aftertreatment device 3 for reducing unwanted emissions of the engine 1,
- an exhaust gas heat recovery heat exchanger 4 is in the exhaust gas line 2

downstream of the exhaust gas aftertreatment device 3,

- an exhaust gas heating device 5 is in the exhaust gas line 2 upstream of the exhaust gas aftertreatment device 3,

- a heating medium line 45 from the exhaust gas heat recovery heat exchanger 4 to the exhaust gas heating device 5 comprises a compressor 43 for providing heating medium to the exhaust gas heating device 5,

- a heating medium line 54 from the exhaust gas heating device 5 to the exhaust gas heat recovery heat exchanger 4 comprises an expansion unit 53 to expand and lower the pressure of the heating medium.

- 10 In Fig. 1 the exhaust gas aftertreatment device 3 is a device utilizing a process or processes for reducing unwanted emissions such as NO_x , unburned fractions of the fuel (or unburned hydrocarbons UHC) such as methane (CH_4) or carbon oxide CO. The exhaust gas aftertreatment device 3 can be for example a selective catalytic reduction device or a methane oxidation catalyst
- 15 device. These are both examples of reduction processes which require rather high operating temperature and there is a possibility that the exhaust gas temperature is not high enough to ensure the catalytic process to be performed as designed. For example, the Selective Catalytic Reduction –process requires exhaust gas temperature of about 300 °C to perform effectively. In more detail,
- 20 the minimum operating temperature for SCR in general is 300 °C and for bio fuels 340 °C. Higher sulphur content of the fuel requires a higher operating temperature. For instance a sulphur content of 2% in the fuel requires an exhaust gas temperature of 350°C. As an other example, the methane oxidation catalyst requires the minimum temperature ranges:
- 25 a) catalytic 500-600°C and
b) non-catalytic 800-900°C to perform effectively.

- [012] In Fig. 1 there is an exhaust gas heat recovery heat exchanger 4 is in the exhaust gas line 2 downstream of the exhaust gas aftertreatment device 3. The function of the exhaust gas heat recovery heat exchanger 4 is to take heat
- 30 out of exhaust gas. Exhaust gas temperature is dependent on several factors of the engine and the used fuel. For example a turbocharger is utilizing energy of high pressure, velocity and temperature of exhaust gas. After the turbocharger the parameters above have decreased but still the exhaust gas is contains plenty of thermal energy. The exhaust gas heat recovery heat exchanger
- 35 4 is configured to recover heat from the exhaust gas (primary flow) and exchange it to a medium of a secondary flow. Then the heated medium is trans-

ported through a heating medium line 45 to a compressor 43 where the medium is further compressed and where the temperature of the medium raises still more. After the compressor the temperature of the medium is higher than the temperature of the exhaust gas before the exhaust gas heating device 5. In the
5 exhaust gas heating device 5 the heat is exchanged back to the exhaust gas and the medium is cooling correspondingly.

[013] The cooled medium is led through a heating medium line 54 to expansion unit 53 where the pressure of the medium is lowered such that the temperature of the medium decreases below the exhaust gas temperature after
10 the exhaust gas aftertreatment device 3. Thus the circuit explained above transfers heat from the downstream side of the exhaust gas aftertreatment device 2 to the upstream side of the exhaust gas aftertreatment device 2. This causes the exhaust gas temperature to increase before entering to the exhaust gas aftertreatment device 3 and cooling at the downstream end of the exhaust
15 gas line 2.

[014] The compressor 43 of the system needs to fulfill certain criteria to be suitable for the purpose. First of all it needs to be able to compress the medium at relatively high temperatures of up to about 700 °C. According to one
20 embodiment the compressor 43 is steam driven. According to an other embodiment the compressor 43 is an absorption heat pump. Still more, according to an embodiment the compressor 43 is mechanically or electrically driven. The selection of the compressor 43 type is not dependent of the selected exhaust gas aftertreatment device 2 and can be used with both the Selective Catalytic Reduction device and the Methane Oxidation Catalyst device.

[015] As evident to those skilled in the art, the invention and its embodiments are not limited to the above-described embodiment examples. Expressions representing the existence of characteristics, such as "the system comprising an exhaust gas line", are non-restrictive such that the description of characteristics does not exclude or prerequisite the existence of such other characteristics
30 tics which are not presented in the independent or dependent claims.

The reference signs in the figures:

- 1 engine
- 2 exhaust gas line
- 3 exhaust gas aftertreatment device
- 5 4 exhaust gas heat recovery heat exchanger
- 43 compressor
- 45 heating medium line
- 5 exhaust gas heating device
- 53 expansion unit
- 10 54 heating medium line

Claims

1. An engine (1) exhaust gas control system for internal combustion engine (1), the system comprising:
 - an exhaust gas line (2) is provided for leading the engine (1) exhaust gases out,
 - the exhaust gas line (2) comprises an exhaust gas aftertreatment device (3) for reducing unwanted emissions of the engine (1),
characterized in that
 - an exhaust gas heat recovery heat exchanger (4) is in the exhaust gas line (2) downstream of the exhaust gas aftertreatment device (3),
 - an exhaust gas heating device (5) is in the exhaust gas line (2) upstream of the exhaust gas aftertreatment device (3),
 - a heating medium line (45) from the exhaust gas heat recovery heat exchanger (4) to the exhaust gas heating device (5) comprises a compressor (43) for providing heating medium to the exhaust gas heating device (5),
 - a heating medium line (54) from the exhaust gas heating device (5) to the exhaust gas heat recovery heat exchanger (4) comprises an expansion unit (53) to expand and lower the pressure of the heating medium.
2. System according to patent claim 1, **characterized** in that the exhaust gas aftertreatment device (3) is a selective catalytic reduction device.
3. System according to patent claim 1, **characterized** in that the exhaust gas aftertreatment device (3) is a methane oxidation catalyst device.
4. System according to patent claim 1, **characterized** in that the compressor (43) is steam driven.
5. System according to patent claim 1, **characterized** in that the compressor (43) is an absorption heat pump.
6. System according to patent claim 1, **characterized** in that the compressor (43) is mechanically or electrically driven.

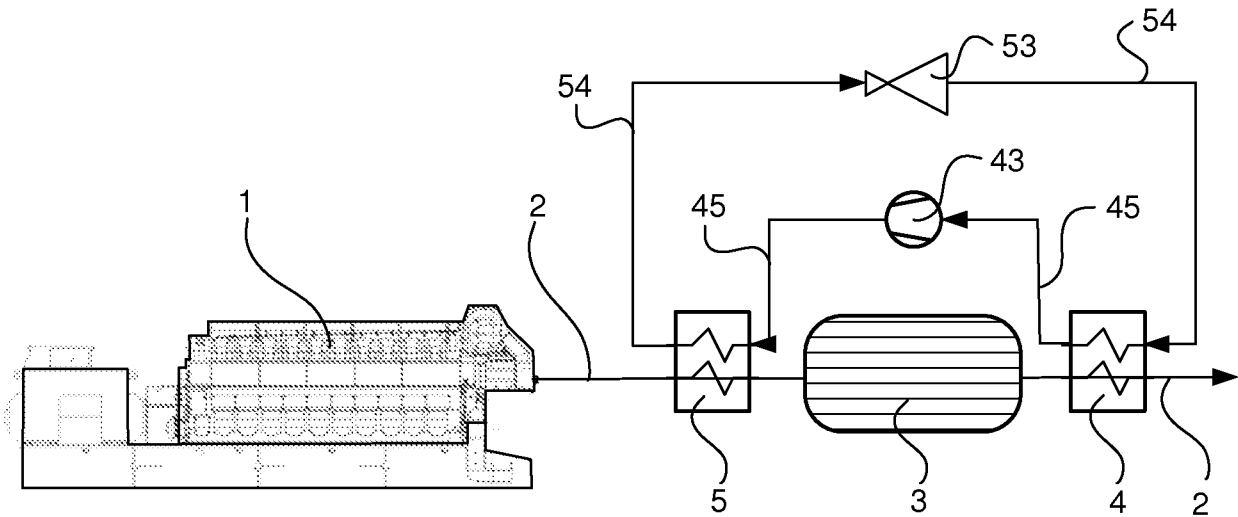


FIG. 1

INTERNATIONAL SEARCH REPORT

International application No
PCT/FI2014/050982

A. CLASSIFICATION OF SUBJECT MATTER
INV. F01N3/20 F01N5/02
ADD.

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)
F01N

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 10 2011 116227 A1 (SCANIA CV AB [SE]) 18 April 2013 (2013-04-18) abstract paragraphs [0034], [0020] - [0023] -----	1-6
A	US 2006/053775 A1 (POWELL JOHN G [US] ET AL) 16 March 2006 (2006-03-16) abstract; figure 1 -----	1-6
A	US 2008/223019 A1 (GONZE EUGENE V [US] ET AL) 18 September 2008 (2008-09-18) abstract; figure 1 -----	1-6
A	US 2006/213197 A1 (CARO SAL [US] ET AL) 28 September 2006 (2006-09-28) abstract; figures 2, 4 paragraph [0031] -----	1-6



Further documents are listed in the continuation of Box C.



See patent family annex.

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"P" document published prior to the international filing date but later than the priority date claimed

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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