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(72) Inventors:
• FESSLER, Harald
9320, ARBON (CH)
• DELLORA, Giancarlo
10129, TORINO (IT)

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(74) Representative: Gervasi, Gemma, Dr. et al
NOTARBARTOLO & GERVASI Srl,
Corso di Porta Vittoria, 9
20122 Milano (IT)

(71) Applicant: Iveco S.p.A.
10156 Torino (IT)

(54) **Method for recirculating the exhaust gases in an internal combustion engine apparatus and the relative internal combustion engine apparatus**

(57) Method for recirculating the exhaust gases (EGR system) in an internal combustion engine whereby the gases to be recirculated are cooled to a temperature at which the condensable elements are con-

densed. The method comprises separating the particulate prior to cooling and separating the condensate, which is expelled before the gas is reintroduced into the air intake line.

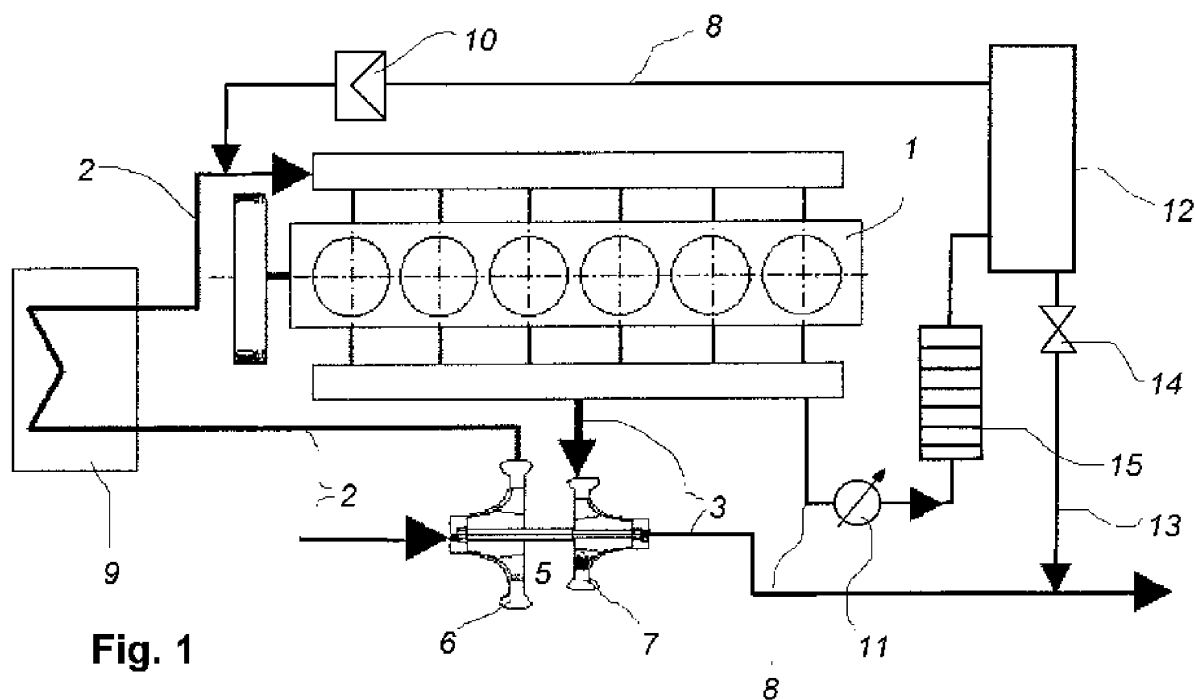


Fig. 1

Description

FIELD OF THE INVENTION

[0001] The present invention relates to a method for recirculating the exhaust gases in an engine apparatus, in particular in a turbocharged diesel engine apparatus for use in an industrial vehicle.

STATE OF THE ART

[0002] Exhaust gas recirculation, or EGR, is common practice in the field of internal combustion engines, especially in diesel engines. In this system a portion of the exhaust gases from the engine are recirculated upstream of the engine and reintroduced into the combustion chambers with the intake air. This permits to lower the combustion temperature and leads to a reduced formation of nitrogen oxides, one of the main pollutants in internal combustion engine emissions.

[0003] One problem in connection with this method is that the exhaust gases contain a number of components (water vapor, acids, particulate) that can cause corrosion and wear and result in the build-up of deposits in the parts of the engine with which they come into contact. For this reason, conditions under which the recirculated gas could condense are usually avoided, and recirculation takes place at the high temperature at which the gas is withdrawn. This solution is unsatisfactory due to the fact that said components are reintroduced into the engine, with the risk of anyway causing the problems described above; moreover, large amounts of gas are usually recirculated, so that the high temperature of such recirculated gases, especially when such gases are drawn upstream of the turbines on the exhaust gas line, as in turbocharged engines, may raise the temperature of the air being supplied to the engine, which is disadvantageous with respect to the formation of nitrogen oxides.

SUMMARY OF THE INVENTION

[0004] The problems described above have now been solved by a method for recirculating the exhaust gases to an internal combustion engine, preferably a diesel engine, comprising the following steps:

withdrawal of a portion of the exhaust gases coming from the engine;
cooling of said portion below the dew point;
reintroduction of said portion into the engine.

[0005] According to a preferred embodiment, the method includes the separation of the condensate from said portion of the exhaust gases.

[0006] The method may also include a step of particulate abatement, more preferably prior to the cooling step. The engine is preferably a turbocharged engine.

[0007] The invention also relates to an engine apparatus comprising an engine as described above, an air intake line to said engine, an exhaust gas line from said engine, an exhaust gas recirculation line suitable for conveying gas from said exhaust line to said intake line, a cooler, preferably comprising means for discharging the condensate, placed on said recirculation line.

[0008] It is a particular object of the invention what set forth in the appended claims.

LIST OF DRAWINGS

[0009] The invention will now be illustrated through a detailed description of preferred but not exclusive embodiments, furnished merely by way of example, with the aid of figure 1 that is attached and which illustrates the layout of a power plant according to this invention.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

[0010] The description refers to figure 1, which illustrates the layout of an engine apparatus, which may be the engine apparatus of an industrial vehicle according to the invention; the engine apparatus comprises an internal combustion engine 1, generally a diesel engine, an air intake line 2 to the engine, that takes in air from the outside, and the exhaust gas line 3 that may comprise a manifold 4. There is preferably a compression unit 5 comprising the turbocharger compressor 6 on the intake line, driven by the turbine 7 on the exhaust gas line. There may be several compression units in series, as known in the prior art (multi-stage turbocharged engine). In case of a turbocharged engine, there are usually one or more coolers like cooler 9 on the intake line.

[0011] The recirculation line 8 draws a portion of the exhaust gases coming from the engine (this portion may be for example up to 50% of the total exhaust gases) and reintroduces said portion into the intake line.

[0012] The exhaust gases may be conveyed spontaneously if the pressure of the exhaust gases leaving the engine 1 is higher than the intake pressure. If this condition is not maintained continuously there is generally a check valve 10 (for example a reed valve), which may also be foreseen in any case. If, as it often happens, the engine intake pressure is higher than the exhaust pressure, or if deemed necessary, in order to increase or control the rate of recirculation, specific circulation means 11, such as a compressor, may be included. Said means may be driven by an electric motor or in any other appropriate manner.

[0013] On the line 8 there is an appropriate type of cooler 12, for example having all the parts that must come into contact with gases and condensate being corrosion-proof; for example, such parts may be coated with an appropriate type of material, such as Teflon.

[0014] The engine apparatus preferably includes devices for separating the condensate. Said devices may

be an integral part of the cooler 12 and of the inertial type. The cooler and separator may be of conventional type. For example, a cooler may be used in which the recirculated gases flow through the shell side and a cooling fluid through the tube side. Condensate separation may be achieved by the loss of speed due to an increased cross-section of the passage, the liquid collecting at the shellbottom. There may be baffles to divert the flow of gas in order to facilitate separation, and the system may comprise a specific separation section before the gas leaves the shell, with baffle or centrifugal separators. The recirculated gas may also flow through the tube side into a specific separation chamber. This and other solutions, with the separator as an integral part of the cooler or as a separate unit, can readily be implemented according to the specific operating conditions and results to be achieved.

[0015] According to this invention, the gas flowing along the recirculation line is cooled to a temperature at which separation of condensate can be achieved. For example, under conditions normally present in turbocharged engines, such as the one illustrated here (with an engine exhaust pressure of about 2.8 absolute bar), said temperature, upstream of the turbine 7, may be less than 95°C and preferably not more than 70°C. Cooling may be effected by transferring the heat to an appropriate fluid; for example, engine cooling water coming from the radiator may be supplied to the cooler 12. According to a possible embodiment of the invention, the water from the radiator is supplied first to the cooler 12 and then to the engine 1, in order to ensure adequate cooling of the recirculated gases. The apparatus according to the invention comprises an engine cooling circuit comprising a radiator to cool a fluid (preferably water) contained in said radiator and circulating through the cooler 12. The condensate may be discharged from the cooler in an appropriate manner. For example, there may be a discharge line 13 through which the condensate is discharged into the exhaust line 3 downstream of the turbine(s) 7 exploiting the natural difference in pressure between the cooler and the line 3 downstream of the turbine. The condensate flow rate can be controlled by means of an appropriate valve or by using a conventional condensate discharger 14 installed in an appropriate position on the bottom of the cooler or on the exhaust line. The condensate may be discharged at regular intervals or according to the amount of condensate that has been collected. The discharge system may also consist of a simple and appropriately sized orifice.

[0016] The particulate is preferably removed from the recirculated gas upstream of the cooler, for example by means of a trap 15 on the line 8. In view of the high temperature of the gases, the trap 15 is preferably of a type that is capable of withstanding high temperatures, such as a metal trap, for example. The method according to this invention allows to reduce the content of some components (that are usually a product of combustion) which are found in recirculating gases and are poten-

tially harmful for the engine and other parts (for example sulphuric and nitric acid). The low recirculation temperature is advantageous because it enables the temperature inside the combustion chambers to be lowered, which leads to a reduced formation of pollutants (such as nitrogen oxides), and enhances combustion chamber filling efficiency and thus engine performance.

10 Claims

1. Method for recirculating the exhaust gases to an internal combustion engine, **characterized by** the fact that it comprises the following steps:

withdrawal of a portion of the exhaust gases coming from the engine;
cooling of said portion to below the dew point;
reintroduction of said portion into the engine.

2. Method according to claim 1, **characterized by** the fact that said engine is a turbocharged diesel engine comprising an air intake line provided with a compressor and an exhaust gas line provided with a turbine, wherein the gases are withdrawn at a point on the exhaust line between the engine and the turbine and reintroduced at a point on the intake line between the compressor and the engine.

3. Method according to any of the previous claims, **characterized by** the fact that it comprises the separation of the condensate from said portion of exhaust gases.

4. Method according to any of the previous claims **characterized, by** the fact that it comprises the removal of the particulate from said portion of exhaust gases.

5. Method according to any of the previous claims, **characterized by** the fact that cooling is effected by transferral of heat to the engine cooling water.

6. Engine apparatus comprising a diesel engine (1), an air intake line (2) to said engine, an exhaust gas line (3) from said engine, an exhaust gas recirculation line (8) suitable for conveying gas from said exhaust line to said intake line, **characterized by** the fact that it comprises a cooler (12) on said recirculation line.

7. Engine apparatus according to claim 6 comprising an air intake line (2) provided with a compressor (6) and an exhaust gas line (3) provided with a turbine (7), **characterized by** the fact that said recirculation line (8) connects said exhaust line between said engine and said turbine with said intake line between said compressor and said engine.

8. Engine apparatus according to claim 6 or 7, **characterized by** the fact that said recirculation line comprises a particulate trap (15).

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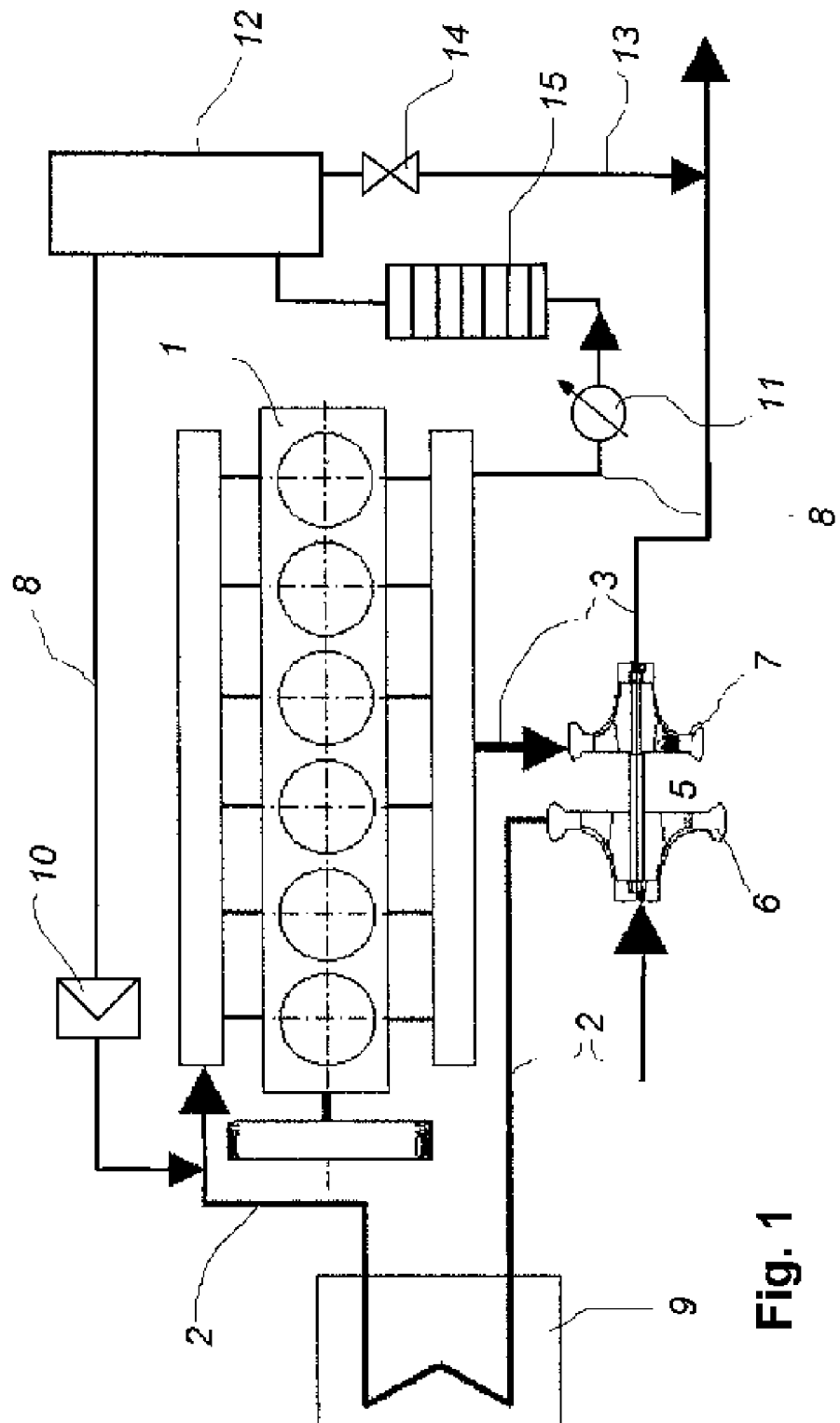


Fig. 1



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 04 10 6791

DOCUMENTS CONSIDERED TO BE RELEVANT				
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)	
X	US 4 055 158 A (MARSEE FREDERICK J) 25 October 1977 (1977-10-25)	1,3-5	F02M25/07	
A	* column 2, line 8 - column 5, line 53; figures 1-8 *	6,8		
X	US 6 301 887 B1 (CALABRESE JOHN LAWRENCE ET AL) 16 October 2001 (2001-10-16)	1,2,4-8		
	* column 2, line 17 - column 3, line 32; figure 1 *			
X	US 2001/045090 A1 (GRAY CHARLES L) 29 November 2001 (2001-11-29)	1,3,6		
A	* paragraph [0023]; figure 1 *	2,7		
X	EP 0 869 275 A (CATERPILLAR INC) 7 October 1998 (1998-10-07)	6-8		
A	* column 4, line 45 - column 5, line 45; figure 1 *	1,2,4		
				TECHNICAL FIELDS SEARCHED (Int.Cl.7)
				F02M
The present search report has been drawn up for all claims				
Place of search The Hague		Date of completion of the search 11 April 2005	Examiner Hakhverdi, M	
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document				

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

EP 04 10 6791

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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11-04-2005

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 4055158	A	25-10-1977	NONE	

US 6301887	B1	16-10-2001	AU 6316701 A	11-12-2001
			EP 1283953 A2	19-02-2003
			JP 2003535264 T	25-11-2003
			WO 0192711 A2	06-12-2001

US 2001045090	A1	29-11-2001	US 6301888 B1	16-10-2001
			AU 762474 B2	26-06-2003
			AU 6353100 A	13-02-2001
			CA 2376620 A1	01-02-2001
			EP 1198669 A1	24-04-2002
			JP 2003505642 T	12-02-2003
			WO 0107774 A1	01-02-2001

EP 0869275	A	07-10-1998	US 6003315 A	21-12-1999
			DE 69809108 D1	12-12-2002
			DE 69809108 T2	17-07-2003
			EP 0869275 A1	07-10-1998
			JP 10281017 A	20-10-1998
			US 6216458 B1	17-04-2001
			US 6038860 A	21-03-2000
