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DE 102010001752 A1 **JP 2009202794 A**
JP 2009174362 A **JP 2008267180 A**
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(54) Title of the Invention: **Cooling system for a hybrid powertrain provided with an EGR system**
Abstract Title: **Cooling system for a hybrid powertrain having exhaust gas recirculation**

(57) A cooling system comprises a high temperature cooling circuit 20, a low temperature cooling circuit 30 and a motor generator unit (MGU) cooler 36 for a motor generator unit 10 which is connected along the low temperature cooling circuit 30 of an exhaust gas recirculation system (EGR) 300. The MGU 10 is connected downstream of a low temperature radiator 33 and upstream of a low temperature cooler 31 in the low temperature cooling circuit 30. A hybrid powertrain has an internal combustion engine, e.g. diesel engine 110, which has the exhaust gas recirculation system 300, at least one motor generator unit 10 and the cooling system.

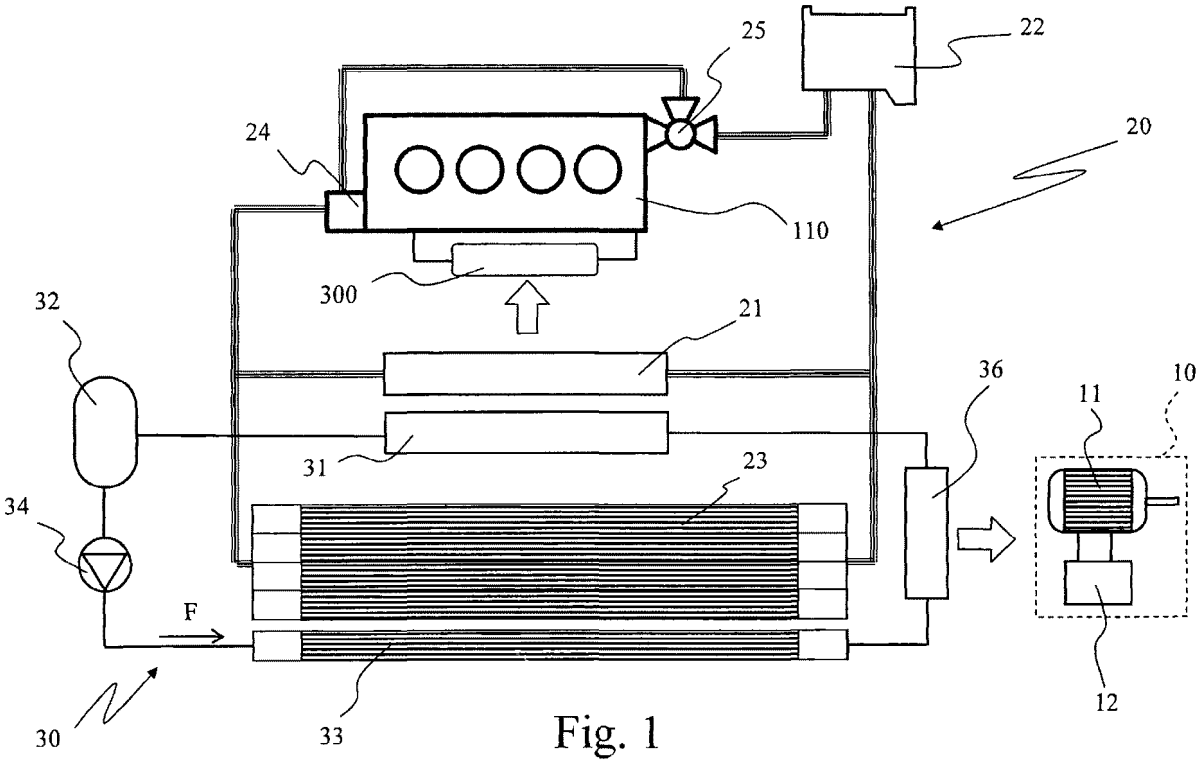

Fig. 1

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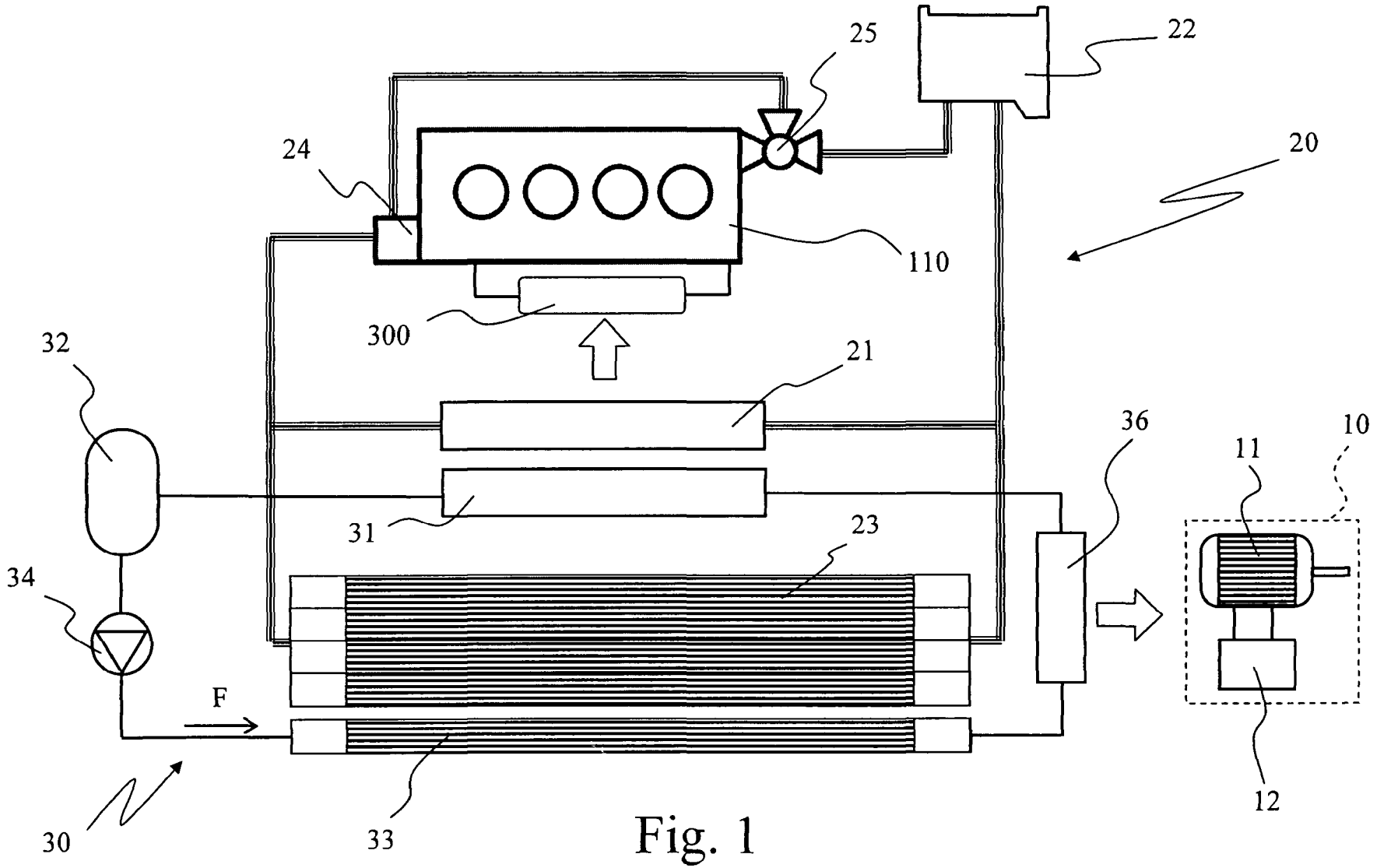

Fig. 1

Cooling system for a hybrid powertrain provided with an EGR system

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Technical field

The present invention relates to a cooling system for a hybrid powertrain with an internal combustion engine provided with an EGR system and at least one motor generator unit.

Background

There are known in the art internal combustion engines, both of the gasoline and diesel type, provided with an Exhaust Gas Recirculation (EGR) system. EGR works by recirculating a portion of an engine's exhaust gas back to the engine cylinders.

In diesel engines nowadays, the EGR technique has been developed in order to contain NO_x emissions: experimental activities have shown that mixing the air at the intake with a cooler exhaust gas helps reducing NO_x emissions.

To enhance the performance of the EGR system, one of the solutions that could be adopted uses an EGR cooler to cool down exhaust gases that exchanges heat with a coolant at a lower temperature that the engine one. Such solution, which is named "Low Temperature EGR", adopts a separated water circuit operating at a lower temperature (55°-65°C) than that of the traditional cooling system of the internal combustion engines (about 90 °C).

In a hybrid architecture also the Motor Generator Unit (MGU), i.e. the unit including an electric motor/generator and its electronics, requires a specific cooling circuit, due to a different operating temperature than that of the internal combustion engine. Consequently, this involves an increase in terms of system complexity, space required to house all the components of a separate cooling system and weight.

An object of an embodiment of the present invention is to provide a cooling system for a hybrid powertrain provided with an EGR system which allows to limit the number of

components and the space required for properly cooling the motor generator unit.

Another object of an embodiment of the present invention is to provide a cooling system for a hybrid powertrain provided with an EGR system which allows to reduce the weight of the cooling system dedicated to the motor generator unit.

These objects are achieved by a cooling system for a hybrid powertrain having the features recited in claim 1. Further peculiar aspects of the cooling system are set out in the dependent claims.

Summary

One embodiment of the present invention provides a cooling system for the internal combustion engine of a hybrid powertrain including an exhaust gas recirculation (EGR) system, the cooling system including a high temperature cooling circuit for the exhaust gas recirculation system having a high temperature cooler, a low temperature cooling circuit for the exhaust gas recirculation system having a low temperature cooler, and a cooler for the motor generator unit of the hybrid powertrain connected along the low temperature cooling circuit for the exhaust gas recirculation system.

In this way, the cooling circuit for the motor generator unit is integrated in the low temperature cooling circuit for the EGR system by simply connecting the cooler for the electric motor/generator unit in the same low temperature circuit.

Indeed, the cooling system adopted to cool down the electric motor and its electronics must ensure temperatures under the 70°C, according to the requirements specification of these components. The idea is therefore to integrate the cooler for the MGU in the same cooling circuit of the EGR system which operates at a lower temperature, i.e. 55°-65°C. This allows to reduce the system complexity, the number of components, the weight and the cost of a hybrid architecture in order to reach fuel consumption and price targets.

According to an embodiment of the present invention, the cooler for the MGU is connected downstream a low temperature radiator and upstream the low temperature cooler in the low temperature circuit of the exhaust gas recirculation system.

According to another embodiment of the present invention, it is provided a hybrid

powertrain with an internal combustion engine provided with an EGR system and at least one motor generator unit, wherein the hybrid powertrain has a cooling system in which a cooler for the motor generator unit of the hybrid powertrain is connected along the low temperature cooling circuit for the exhaust gas recirculation system.

The hybrid powertrain could have an internal combustion engine of the diesel type, i.e. a kind of engine which is usually provided with an EGR system to reduce NO_x emissions. However, this does not exclude to apply the same solution also to hybrid powertrains having a gasoline engine provided with an EGR system.

Brief Description of the Drawings

Further advantages and features of an embodiment of the present invention will be more apparent from the description below, provided with reference to the accompanying drawings, purely by way of a non-limiting example, wherein:

- Figure 1 is a simplified scheme of a cooling system of a hybrid powertrain according to an embodiment of the present invention.

Detailed Description

Figure 1 shows a simplified scheme of a cooling system for at least one exemplary embodiment of a hybrid powertrain having at least one motor generator unit 10 and an internal combustion engine 110 with an exhaust gas recirculation (EGR) system 300.

The cooling system has a high temperature cooling circuit 20 (shown in thicker lines) for engine 110 and EGR 300 including a high temperature EGR cooler 21 connected to the traditional cooling circuit for the engine 110, e.g. a cooling circuit having a surge tank 22, a high temperature radiator 23, a switchable pump 24 and a thermostat 25.

In order to enhance the performance of the EGR system 300, the cooling system further includes a low temperature circuit 30 with a low temperature EGR cooler 31. The low temperature circuit 30, which operates at a lower temperature (55°-65°C) than that of the high temperature cooling circuit 20 (about 90 °C), may include for example an expansion vessel 32, a low temperature radiator 33 and an electric pump 34.

A MGU cooler 36 for the motor generator unit 10 is connected along the low

temperature circuit 30 between the low temperature radiator 33 and the low temperature EGR cooler 31. With respect to the flow direction denoted by the letter "F" imparted by the electric pump 34, the cooling fluid outputs the low temperature radiator 33, for example at a temperature of 45 °C, and flows firstly in the cooler 36 in order to remove heat from the MGU 10 and maintain the motor generator 11 and its electronics 12 below a preset temperature, for example 70 °C, which is specified by the manufacturer of these components.

Due to the heat removal from the MGU 10, the cooling fluid outputs the MGU cooler 36 at a slightly higher temperature with respect to 45 °C, for example at a temperature in the range of 46-50 °C, but which is sufficient to remove heat from the EGR system 300 through the low temperature EGR cooler 31. From the latter, the temperature of the cooling fluid increases, for example at 51-55 °C , and then can be lowered again through the low temperature radiator 33.

While at least one exemplary embodiment has been presented in the foregoing summary and detailed description, it should be appreciated that a vast number of variations exist. It should also be appreciated that the exemplary embodiment or exemplary embodiments are only examples, and are not intended to limit the scope, applicability, or configuration in any way. Rather, the foregoing summary and detailed description will provide those skilled in the art with a convenient road map for implementing at least one exemplary embodiment, it being understood that various changes may be made in the function and arrangement of elements described in an exemplary embodiment without departing from the scope as set forth in the appended claims and their legal equivalents.

List of references in the drawings

10	motor generator unit (MGU)
11	motor generator
12	MGU electronics
20	high temperature cooling circuit
21	high temperature EGR cooler
22	surge tank
23	high temperature radiator
24	switchable pump
25	thermostat
30	low temperature circuit
31	low temperature EGR cooler
32	expansion vessel
33	low temperature radiator
34	electric pump
36	MGU cooler
110	internal combustion engine
300	exhaust gas recirculation (EGR) system
F	flow direction

CLAIMS

1. A cooling system for a hybrid powertrain with an internal combustion engine (110) provided with an exhaust gas recirculation system (300) for the internal combustion engine (110) and at least one motor generator unit (10), the cooling system including:
   - a high temperature cooling circuit (20) for the exhaust gas recirculation system (300) including a high temperature cooler (21);
   - a low temperature cooling circuit (30) for the exhaust gas recirculation system (300) including a low temperature cooler (31), and
   - a MGU cooler (36) for said motor generator unit (10) connected along said low temperature cooling circuit (30) for the exhaust gas recirculation system (300).

2. The cooling system according to claim 1, wherein the MGU cooler (36) for said motor generator unit (10) is connected downstream of a low temperature radiator (33) and upstream of said low temperature cooler (31) in the low temperature cooling circuit (30) of the exhaust gas recirculation system (300).

3. A hybrid powertrain with an internal combustion engine (110) provided with an exhaust gas recirculation system (300) and at least one motor generator unit (10), wherein the hybrid powertrain has a cooling system according to claim 1 and 2.

4. The hybrid powertrain according to claim 3, wherein the internal combustion engine (110) is a diesel engine.

Application No: GB1118094.0 **Examiner:** Mike McKinney

Claims searched: 1 to 4 **Date of search:** 7 February 2012

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
A	-	DE102010001752 A1 (FORD GLOBAL TECH LLC)
A	-	JP2009202794 A (TOYOTA MOTOR CORP)
A	-	JP2009174362 A (TOYOTA MOTOR CORP)
A	-	JP2008267180 A (TOYOTA MOTOR CORP)
A	-	JP2006207495 A (TOYOTA MOTOR CORP)

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

B60W; F02D

The following online and other databases have been used in the preparation of this search report

EPODOC, WPI

International Classification:

Subclass	Subgroup	Valid From
B60W	0020/00	01/01/2006
F02D	0041/00	01/01/2006