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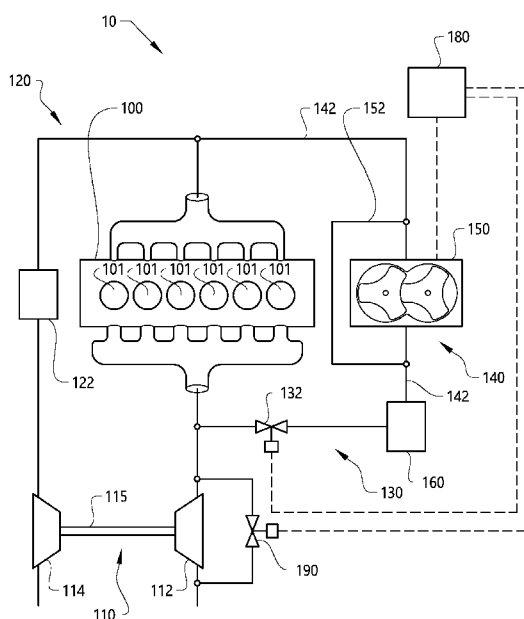


FIG. 2

(57) Abstract: The invention relates to a method of operating an internal combustion engine (100) being connected to a turbocharger (110), an intake system (120) configured for feeding intake air to the engine (100), an exhaust system (130) configured for conveying exhaust gas away from the engine (100), and an exhaust gas recirculation (EGR) system (140). The EGR system (140) comprises a gas feeding device (150) being configured, during normal EGR operation, to feed exhaust gas branched off from the exhaust system (130) through an EGR conduit (142) and into the intake system (120). The method comprises the steps of i) determining (S200) a requested start of the internal combustion engine (100), and ii) operating (S210) the gas feeding device (150) to provide a reversed gas flow to a turbine (112) of a turbocharger (110), such that said turbine (112) of the turbocharger (110) is accelerated, prior to starting the internal combustion engine (100).

A vehicle system, and a method for operating an internal combustion engine

TECHNICAL FIELD

The present invention relates to a vehicle system, a vehicle comprising such a vehicle system, as well as to a method for operating an internal combustion engine.

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The invention may be applied with respect to a variety of combustion engines. The invention is, however, particularly advantageous when applied to engines configured for heavy-duty application such as in trucks, busses, construction equipment, marine applications and stationary applications etc.

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Although the invention will, in the below, be described with respect to application in a truck, the invention is not in any way limited to this particular application.

BACKGROUND

- 15 Heavy duty internal combustion engines are well known in the art. Internal combustion engines may be provided with turbine systems configured for recovering energy in the exhaust gas flow in order to improve fuel economy, reduce emissions, and/or to provide higher power and higher torque. Such turbine systems may include a turbocharger having a turbine arranged in the exhaust gas flow downstream the engine. The turbocharger is
- 20 configured to convert energy from the exhaust gas into pressure increase of the intake air by means of a compressor forming part of the turbocharger.

- During start-up it is desired to rapidly reach a high engine speed of the internal combustion engine. Slow combustion engine engagement time may be caused by the
- 25 compressor of the turbocharger restricting the air flow, whereby the reduced volume of intake air will further decrease acceleration of the internal combustion engine. This is especially undesired in hybrid vehicles, operating by frequently starting and stopping of the internal combustion engine in order to change between purely electric drive, purely internal combustion engine drive, or optionally a combination of electric drive and internal
- 30 combustion engine drive. When it is desired to switch from purely electric drive the requirements on the internal combustion engine to reach a higher speed and higher torque are normally very high, and typically the response time requirements from start-up to full load are stringent.

In view of this, there is a need for an improved method for operating an internal combustion engine which allows for a more rapid start-up of the internal combustion engine.

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SUMMARY

An object of the present invention is therefore to provide a method for operating an internal combustion engine which allows for reduced start-up response, and especially by reducing the risk for the compressor to restrict the airflow of the intake air.

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The present invention suggests the use of a gas feeding device forming part of an exhaust gas recirculation (EGR) system, and controlling the gas flow after determining a requested start of the internal combustion engine. The gas flow is controlled such that the gas feeding device provides a reversed flow to a turbine of a turbocharger, whereby the turbine (and consequently also the compressor of the turbocharger) is accelerated prior to starting the internal combustion engine. Accordingly, the required time for reaching a high engine speed is reduced.

According to a first aspect of the invention, the object is achieved by a method according to claim 1. According to a second aspect of the invention, the object is achieved by a computer program according to claim 9. According to a third aspect, the object is achieved by a computer readable medium according to claim 10. According to a fourth aspect, the object is achieved by a control unit according to claim 11. According to a fifth aspect, the object is achieved by a vehicle system according to claim 12. According to a sixth aspect, the object is achieved by a vehicle according to claim 20.

According to an embodiment, a step of operating the gas feeding device is performed such that air is drawn through a compressor of the turbocharger, the intake system, the EGR conduit, and pushed through the turbine of the turbocharger. The reversed gas flow thus replaces the exhaust gases that normally spin up the turbine.

According to an embodiment, the step of operating the gas feeding device is performed such that air is pushed through an EGR cooler before reaching the turbine of the turbocharger. Especially for a hybrid vehicle, by allowing the air to pass the EGR cooler

before reaching the turbine the air will be heated to engine temperature, which in turn provides an increased volume flow for the turbine.

According to an embodiment the gas feeding device is a pump running in a first direction
5 during normal EGR operation, and the step of operating the pump to provide a reversed gas flow is performed by reversing the operation direction of the pump. By using a reversible pump a very simple construction is provided, requiring only different control signals to change between normal EGR mode and reversed gas flow. In specific embodiments, the gas feeding device is a displacement pump, such as a Roots blower.

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According to an embodiment the gas feeding device is a pump running in a first direction during normal EGR operation, and the step of operating the pump further comprises controlling at least one valve such that the direction of the gas flow through the EGR conduit, when the pump is running in the first direction, is reversed. Such solution is
15 particularly advantageous in that it can be retro-fitted on existing EGR systems without replacing the EGR pump, which in normal cases only is operating in a single pump direction. Further to this, controlling valves to open and close is a simple control, making it possible to use readily available components and software.

20 According to an embodiment a step of determining a requested start of the internal combustion engine is performed automatically upon start of an associated vehicle. The method may thereby be performed immediately once a driver intends to start the engine, thus reducing start-up time and allowing for improved acceleration of engine speed.

25 According to an embodiment the step of determining a requested start of the internal combustion engine further comprises a step of determining electric drive of an associated hybrid vehicle, and a step of determining a required torque addition from the internal combustion engine. The method is thereby performed automatically during drive of the hybrid vehicle, always ensuring improved engine performance.

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According to an embodiment the method further comprises a step of controlling the operation of the gas feeding device to normal EGR operation when the internal combustion engine is started. The method thereby automatically resets the gas feeding device after start-up of the engine such that normal EGR can be provided during engine
35 operation.

According to a second aspect, a computer program is provided, comprising program code means for performing the steps of the method according to the first aspect.

- 5 According to a third aspect, a computer readable medium is provided, carrying a computer program comprising program code means for performing the steps of the method according to the first aspect.

- According to a fourth aspect, a control unit is provided, being configured to perform the
10 steps of the method according to the first aspect.

- According to a fifth aspect, a vehicle system is provided. The vehicle system comprises an internal combustion engine and a thereto connected turbocharger, an intake system configured for feeding intake air to the engine, an exhaust system configured for
15 conveying exhaust gas away from the engine, and an exhaust gas recirculation system. The EGR system comprises a gas feeding device being configured to, during normal EGR operation, feed exhaust gas branched off from the exhaust system through an EGR conduit and into the intake system. The gas feeding device is connected to a control unit being configured to operate the gas feeding device to provide a reversed gas flow to a
20 turbine of a turbocharger, such that said turbine of the turbocharger is accelerated prior to starting of the internal combustion engine.

- In an embodiment, the gas feeding device is a displacement pump, such as a Roots blower.
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- In an embodiment, the gas feeding device is a reversible pump running in a first direction during normal EGR operation, and in a second opposite direction for reversing the flow prior to starting of the internal combustion engine.
- 30 In an embodiment, the gas feeding device is a pump running in a first direction during normal EGR operation, and in the same first direction for reversing the flow prior to starting of the internal combustion engine, and the vehicle system further comprises at least one valve for changing the gas flow direction through the EGR conduit.

According to an embodiment there is provided a first valve arranged on a first side of the pump facing the intake system, a second valve arranged on a second side of the pump facing the exhaust system, a third valve arranged in a first bypass line bypassing the second valve and the pump, and a fourth valve arranged in a second bypass line
5 bypassing the first valve and the pump. In such embodiment the first, second, third, and fourth valves are controlled to change the direction of the gas flow through the EGR conduit.

In an embodiment, operation of each one of the at least one valve is controlled by the
10 control unit.

According to an embodiment, the control unit is configured to operate the gas feeding device to provide a reversed flow automatically upon start of an associated vehicle.

15 According to an embodiment, the control unit is configured to operate the gas feeding device to provide a reversed flow by determining electric drive of an associated hybrid vehicle, and by determining a required torque addition from the internal combustion engine.

20 According to a sixth aspect, a vehicle is provided. The vehicle comprises a vehicle system according to the fifth aspect.

Advantages and further embodiments of the second, third, fourth, fifth and sixth aspects of the invention are largely analogous with advantages and embodiments of the first aspect
25 of the present invention. Further advantages and advantageous features of the invention are disclosed in the following description and in the dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

30 With reference to the appended drawings, below follows a more detailed description of embodiments of the invention cited as examples.

In the drawings:

Figure 1 is a schematic drawing showing a truck with a vehicle system according to an aspect of the invention;

Figure 2 is a schematic view of a vehicle system according to an embodiment;

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Figure 3 is a schematic view of a vehicle system according to another embodiment; and

Fig. 4 is a schematic view of a method for operating an internal combustion engine according to an embodiment.

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DETAILED DESCRIPTION OF EXAMPLE EMBODIMENTS OF THE INVENTION

It is to be understood, that the present invention is not limited to the embodiments described above and illustrated in the drawings; rather, the skilled person will recognize, 15 that many changes and modifications may be made within the scope of the appended claims.

Figure 1 is a schematic drawing showing a truck 1 with a vehicle system 10. The vehicle system 10 comprises an internal combustion engine 100 as will be explained in the 20 following.

Figure 2 is a schematic drawing showing a vehicle system 10 being suitable to fit with the truck 1. The term "vehicle system" should however not be considered to be limiting, as the system 10 is equally well suitable to be used with other machines and equipment relying 25 on the operation of internal combustion engines. Hence, the systems 10 described with reference to figures 2 and 3 can be used for vehicle applications, and for non-vehicle applications like power generators etc.

The system 10, may it be a vehicle system or a non-vehicle system, comprises an internal 30 combustion engine 100. The internal combustion engine 100 has one or more cylinders 101, and the cylinders 101 may be arranged in any configuration such in in-line, in a V, in flat/boxer configuration etc.

Although not shown, each cylinder 101 includes a cylinder head, a piston configured for 35 reciprocating towards and away from the cylinder head and a combustion chamber

located between the piston and the cylinder head. Each cylinder moreover includes one or more intake valves arranged in association with the combustion chamber and one or more exhaust valves arranged in association with the combustion chamber.

- 5 An intake system 120 for feeding intake air to the engine 100 is provided in connection with the intake valves, and an exhaust system 130 for conveying exhaust gas away from the engine 100 is provided in connection with the exhaust valves.

An exhaust gas recirculation (EGR) system 140 is provided between the exhaust system
10 130 and the intake system 120. The EGR system 140 includes a gas feeding device 150, and an EGR conduit 142 allowing for fluid communication between the exhaust system 130 and the intake system 120. The gas feeding device 150 is arranged as part of the EGR conduit 142 and is operative to feed and/or control flow of exhaust gas from the exhaust system 130 via the EGR conduit 142 to the intake system 120. For such control
15 functionality, the gas feeding device 150 is in communication with a control unit 180 being configured to transmit control signals to the gas feeding device 150, as well as providing power to the gas feeding device 150.

The system 10 further comprises a pressure charging system connected to the intake
20 system 120, for, in certain operating conditions of the internal combustion engine 100, pressurising the intake air to a pressure above the pressure in exhaust system 130. In figures 2 and 3 the pressure charging system is a turbocharger 110 comprising a turbine 112 and a compressor 114. The turbine 112 is operative to drive the compressor 114 via a turbine shaft 115.

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The EGR system 140 is preferably a high pressure EGR system where exhaust gas is branched off from the flow of exhaust gas upstream the turbine 112.

The compressor 114 is arranged to pressurise air in the intake system 120 dependent on
30 operating conditions of the internal combustion engine 100 and can, at some operating circumstances, even provide a positive pressure differential between the intake system 120 and the exhaust system 130 such that the pressure in the intake system 120 exceeds the pressure in the exhaust system 130.

A so called wastegate 190 may be provided to divert exhaust gas away from the turbine 112 in order to regulate turbine speed. The wastegate 190 is preferably controlled by the control unit 180. The wastegate 190 is formed by a valve being operative to bypass excess pressure, or excess flow of exhaust gas, around the turbine 112 in order to
5 regulate boost pressure delivered by the turbocharger 110.

Once introduced by the compressor 114, the pressurised intake air may be cooled in a cooler 122 such as a charge air cooler, or intercooler. The cooler 122 increases the efficiency of the pressure charging system by reducing, or removing a part of, induction air
10 heat and compression heat added to the compressed intake air by the turbocharger 110. By this, volume density of the intake air is increased.

During operation of the internal combustion engine 100, a portion of the exhaust gas is branched off from the flow of exhaust gas flowing in exhaust system 130, upstream the
15 turbine 112, to the EGR system 140. The remaining exhaust gas is conveyed to the turbine 112 of the turbocharger 110.

The exhaust gas branched off from the flow of exhaust gas is, via EGR conduit 142, led to the gas feeding device 150 and, in certain operating conditions, the gas feeding device
20 150 is preferably capable of pressurising the exhaust gas to a pressure level at least corresponding to the absolute pressure level in the intake system 120; this in order to allow for flow of exhaust gas from the exhaust system 130 to the intake system 120 irrespective of the pressure differential between the exhaust system 130 and the intake system 120.

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Flow of exhaust gas in the EGR conduit 142 is preferably controlled by one or more EGR valves 132, as is well known in the art. Such EGR valve 132 is preferably also controlled by the control unit 180.

30 In operating conditions wherein the pressure in the exhaust system 130 is sufficiently high, pressurisation by means of the gas feeding device 150 may be unnecessary - and the gas feeding device 150 may be bypassed via a bypass conduit 152. A bypass valve (not shown) may be provided for controlling the flow in the bypass conduit 152.

The gas feeding device 150 can thereby be operated in a feed mode to feed exhaust gas into the intake system 120. In accordance with the embodiments described herein, the system 10 is also capable of reversing the gas flow through the EGR conduit 142. This is performed for providing pressure towards the turbine 112 in order to spin up the
5 compressor 114 before start of the internal combustion engine 100. Reverse mode may be applied irrespective of the differential pressure between the exhaust system 130 and the intake system 120.

The gas feeding device 150 may be any type of pump capable of feeding or pumping gas;
10 within this specification the word "gas" is used to represent both exhaust gas and air. If the gas feeding device 150 constitutes a displacement pump, it will add or receive work only when there is a pressure difference across the pump. This is due to the fact that the displacement pump has no internal compression.

15 The preferred type of displacement pump is a Roots pump (blower), which has a continuous flow compared to intermittent flow. This means that the flow is not interrupted and flows continuously into the intake system 120 of the internal combustion engine 100.

As can be seen in Fig. 2, the gas feeding device 150 must be capable of reversing the
20 pump direction in order to feed air to the turbine 112 prior to engine start-up. Hence, the control unit 180 is therefore configured to receive a signal that start of the internal combustion engine 100 is requested, and upon receiving such signal start the gas feeding device 150 in the reverse direction. When the bidirectional, or reversible gas feeding device 150 is running air is drawn from the ambient through the compressor and the
25 intake system 120, through the gas feeding device 150, and further through the turbine 112 which thereby is accelerated. Once the internal combustion engine 100 is started, the already accelerated compressor 114 is capable of rapidly pressurize intake air such that high engine speed can be reached in a reduced time.

30 As soon as the internal combustion engine 100 is started, the gas feeding device 150 can be reset to normal EGR mode, i.e. the pump direction is again changed such that exhaust gas can be branched off from the exhaust system 130 through the EGR conduit 142 and into the intake system 120.

In figure 3 another embodiment of a system 100 is shown, showing great similarities with the embodiment of figure 2. Common features are therefore denoted by the same reference numerals, and they will not be described again. However, in the embodiment of figure 3 the EGR system 140 operates in a quite different manner as compared to the
5 EGR system 140 of figure 2.

Instead of having a reversible pump, the gas feeding device 150 of figure 3 is only capable of operating in a single direction corresponding to the pumping direction of normal EGR mode. In other words, the gas feeding device 150 can only draw exhaust gas
10 towards the intake system 120. In order to provide for the reversed gas flow, i.e. drawing air from the ambient through the turbine 112, valves 170a-d are provided.

The valves 170a-d, being connected to the control unit 180, are configured be actuated to re-direct the flow from the gas feeding device 150 from its normal feed direction to a
15 reversed flow direction.

As for the embodiment of figure 2, the gas feeding device 150 is a pump running in a first direction during normal EGR operation. The gas feeding device 150 of figure 3 is however running in the same first direction also for reversing the flow prior to starting of the internal
20 combustion engine 100. Control of the valves 170a-d is instead required to change the gas flow direction through the EGR conduit 142.

A first valve 170a arranged on a first side of the pump 150 facing the intake system 120, and a second valve 170b is arranged on a second side of the pump 150 facing the
25 exhaust system 130. The first and second valves 170a-b are therefore arranged on opposite sides of the pump 150. A first bypass line 172a is connected to the EGR conduit 142 and arranged to bypass the second valve 170b, and a third valve 170c is arranged in the first bypass line 172a. A second bypass line 172b is connected to the EGR conduit 142 and arranged to bypass the first valve 170a, and a fourth valve 170d is arranged in
30 that second bypass line 172b.

During normal EGR mode the first and second valves 170a-b are open, while the third and fourth valves 170c-d are closed. Exhaust gas will thereby be drawn from the exhaust system 130 through the pump 150 and into the intake system 120 via the EGR conduit
35 142. Before engine start-up, the valves 170a-d are controlled in opposite manner, i.e. the

first and second valves 170a-b are closed, while the third and fourth valves 170c-d are open. The pump 150 will in this mode draw air from the intake system 120, into the EGR conduit 142, and further through the turbine 112 of the turbocharger 110.

- 5 It should be noted that the third valve 170c could be replaced by a non-return valve, which thereby would reduce the required control of the system. Further, it should be noted that bypass lines 172a-b could also be used to bypass the pump 150, as explained earlier with respect to the bypass conduit 152.
- 10 Other valve configurations are also possible within the context of this application, as long as they allow for a change in flow direction through the EGR conduit 142 while the gas feeding device 150 is running in only one direction.

- Figures 2 and 3 further show that the control unit 180 is operative to control various
- 15 devices in the system 10. The control unit 180 may e.g. be configured for obtaining various input signals from a plurality of sensors (not shown). Control of the various devices may depend on operating conditions and control may be performed in response to software stored in a memory held in the control unit 180. As an example, the control unit 180 may be operative to automatically control the gas feeding device 150 in response
 - 20 to operating conditions, user input and/or drive mode.

As is shown in the figures the control unit 180 may also be operative to control the wastegate 190, the EGR valve 132, one or more bypass valves, etc.

- 25 Figure 4 schematically shows a flowchart illustrating operation of a system 10 as described above.

- The method 200 of operating the internal combustion engine 100 requires some structural configurations; the internal combustion engine 100 is connected to a turbocharger 110, an
- 30 intake system 120 configured for feeding intake air to the engine 100, an exhaust system 130 configured for conveying exhaust gas away from the engine 100, and an EGR system 140. The EGR system 140 is further provided with a gas feeding device 150 being configured to, during normal EGR operation, feed exhaust gas branched off from the exhaust system 130 through an EGR conduit 142 and into the intake system 120.

Again returning to the method 200, it comprises a first step of determining S200 a requested start of the internal combustion engine 100. Following such determination, the method 200 proceeds with a step of operating S210 the gas feeding device 150 to provide a reversed gas flow to the turbine 112 of the turbocharger 110, such that the turbine 112
5 of the turbocharger 110 is accelerated, prior to starting the internal combustion engine 100.

The step of determining S200 a requested start of the internal combustion engine 100 is preferably performed automatically upon start of an associated machine or vehicle 1. The
10 step of determining S200 a requested start of the internal combustion engine 100 may in some embodiments further comprise a step of determining S202 electric drive of an associated hybrid vehicle, and a subsequent step of determining S204 a required torque addition from the internal combustion engine 100.

15 Returning to the description above, the step of operating S210 the gas feeding device 150 can be performed in different manners. For each embodiment this step S210 is performed such that air is drawn through the compressor 114 of the turbocharger 110, the intake system 120, the EGR conduit 142, and pushed through the turbine 112 of the turbocharger 110. Also, the step of operating S210 the gas feeding device 150 is
20 preferably performed such that air is pushed through an EGR cooler 160 before reaching the turbine 112 of the turbocharger 110.

According to one embodiment the gas feeding device 150 is a pump running in a first direction during normal EGR operation, and the step of operating S210 the pump 150 to
25 provide a reversed gas flow is performed by reversing the operation direction of the pump 150. For such embodiment, it is suggested to use a reversible pump as explained earlier.

According to another embodiment the gas feeding device 150 is a pump running in a first direction during normal EGR operation, and the step of operating S210 the pump 150
30 comprises controlling at least one valve 170a-d such that the direction of the gas flow through the EGR conduit 142, when the pump 150 is running in the first direction, is reversed. As is evident this particular embodiment does not require a pump only being operative in a single direction, but a reversible pump could be used also in this example.

As is further shown in figure 4 the method 200 also comprises a step of controlling S220 the operation of the gas feeding device 150 to normal EGR operation when the internal combustion engine 100 is started. This means that reversed gas flow is provided prior to engine start-up, while normal EGR mode is provided during engine running.

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Reversed gas flow (i.e. air flowing through the EGR conduit 142 to spin up the turbine 112) is normally provided for a few seconds, such as 2-3 seconds prior to engine start-up. This time may not be entirely sufficient to spin up the turbine 112 to optimum speed, but it may be sufficient to reduce the response time of the internal combustion engine 100. If
10 the internal combustion engine 100 is starting from standstill to idling it may even be sufficient to reverse the gas flow for less time, since choking of the engine components is less likely. On the other hand, if a hybrid vehicle 1 is running on purely electric drive of e.g. 50 km/h, start of the internal combustion engine 100 to provide engine drive may require a higher speed, e.g. around 1000 rpm. Such high speed should preferably be
15 available in very short time, whereby spin up of the turbine 112 is of greater importance. By reversing the gas flow so that the turbine 112 is accelerated will reduce the risk for choking, and further improve the response time of the internal combustion engine 100.

It is to be understood that the present invention is not limited to the embodiments
20 described above and illustrated in the drawings; rather, the skilled person will recognize that many changes and modifications may be made within the scope of the appended claims.

CLAIMS

1. A method of operating an internal combustion engine (100) being connected to a turbocharger (110), an intake system (120) configured for feeding intake air to the engine
5 (100), an exhaust system (130) configured for conveying exhaust gas away from the engine (100), and an exhaust gas recirculation (EGR) system (140), wherein the EGR system (140) comprises a gas feeding device (150) being configured to, during normal EGR operation, feed exhaust gas branched off from the exhaust system (130) through an EGR conduit (142) and into the intake system (120), **characterized in** that the method
10 includes the steps of:
- determining (S200) a requested start of the internal combustion engine (100),
and,
 - operating (S210) the gas feeding device (150) to provide a reversed gas flow to a turbine (112) of a turbocharger (110), such that said turbine (112) of the turbocharger
15 (110) is accelerated, prior to starting the internal combustion engine (100).
2. A method according to claim 1, wherein the step of operating (S210) the gas feeding device (150) is performed such that air is drawn through a compressor (114) of the turbocharger (110), the intake system (120), the EGR conduit (142), and pushed through
20 the turbine (112) of the turbocharger (110).
3. A method according to claim 1 or 2, wherein the step of operating (S210) the gas feeding device (150) is performed such that air is pushed through an EGR cooler (160) before reaching the turbine (112) of the turbocharger (110).
25
4. A method according to any of the preceding claims, wherein the gas feeding device (150) is a pump running in a first direction during normal EGR operation, and wherein the step of operating (S210) the pump (150) to provide a reversed gas flow is performed by reversing the operation direction of the pump (150).
30
5. A method according to any of claims 1-3, wherein the gas feeding device (150) is a pump running in a first direction during normal EGR operation, and wherein the step of operating (S210) the pump (150) further comprises controlling at least one valve (170a-d) such that the direction of the gas flow through the EGR conduit (142), when the pump
35 (150) is running in the first direction, is reversed.

6. A method according to any of the preceding claims, wherein the step of determining (S200) a requested start of the internal combustion engine (100) is performed automatically upon start of an associated vehicle (1).

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7. A method according to any of the preceding claims, wherein the step of determining (S200) a requested start of the internal combustion engine (100) further comprises a step of determining (S202) electric drive of an associated hybrid vehicle, and a step of determining (S204) a required torque addition from the internal combustion engine (100).

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8. A method according to any of the preceding claims, further comprising a step of controlling (S220) the operation of the gas feeding device (150) to normal EGR operation when the internal combustion engine (100) is started.

15 9. A computer program comprising program code means for performing the steps according to any one or more of the claims 1 - 8 when said program is run on a computer or on an ECU.

10. A computer readable medium carrying a computer program comprising program code
20 means for performing the steps according to any one or more of the claims 1 - 8 when said program product is run on a computer.

11. A control unit (180) configured to perform the steps of the method according to any one or more of the claims 1 – 8.

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12. A vehicle system (10), comprising an internal combustion engine (100) and a thereto connected turbocharger (110), an intake system (120) configured for feeding intake air to the engine (100), an exhaust system (130) configured for conveying exhaust gas away from the engine (100), and an exhaust gas recirculation (EGR) system (140), wherein the
30 EGR system (140) comprises a gas feeding device (150) being configured to, during normal EGR operation, feed exhaust gas branched off from the exhaust system (130) through an EGR conduit (142) and into the intake system (120), **characterized in** that the gas feeding device (150) is connected to a control unit (180) being configured to operate the gas feeding device (150) to provide a reversed gas flow to a turbine (112) of a

turbocharger (110), such that said turbine (112) of the turbocharger (110) is accelerated prior to starting of the internal combustion engine (100).

13. A vehicle system according to claim 12, wherein the gas feeding device (150) is a
5 displacement pump, such as a Roots blower.

14. A vehicle system according to claim 12 or 13, wherein the gas feeding device (150) is
a reversible pump running in a first direction during normal EGR operation, and in a
second opposite direction for reversing the flow prior to starting of the internal combustion
10 engine (100).

15. A vehicle system according to claim 12 or 13, wherein the gas feeding device (150) is
a pump running in a first direction during normal EGR operation, and in the same first
direction for reversing the flow prior to starting of the internal combustion engine (100),
15 and wherein the vehicle system (10) further comprises at least one valve (170a-d) for
changing the gas flow direction through the EGR conduit (142).

16. A vehicle system according to claim 15, comprising a first valve (170a) arranged on a
first side of the pump (150) facing the intake system (120), a second valve (170b)
20 arranged on a second side of the pump (150) facing the exhaust system (130), a third
valve (170c) arranged in a first bypass line (172a) bypassing the second valve (170b) and
the pump (150), and a fourth valve (170d) arranged in a second bypass line (172b)
bypassing the first valve (170b) and the pump (150).

25 17. A vehicle system according to claim 15 or 16, wherein the operation of each one of
the at least one valve (170a-d) is controlled by the control unit (180).

18. A vehicle system according to any of claims 12 - 17, wherein the control unit (180) is
configured to operate the gas feeding device (150) to provide a reversed flow
30 automatically upon start of an associated vehicle (1).

19. A vehicle system according to any of claims 12 - 18, wherein the control unit (180) is
configured to operate the gas feeding device (150) to provide a reversed flow by
determining electric drive of an associated hybrid vehicle, and by determining a required
35 torque addition from the internal combustion engine (100).

20. A vehicle (1) comprising a vehicle system according to any of claims 12- 19.

1/4

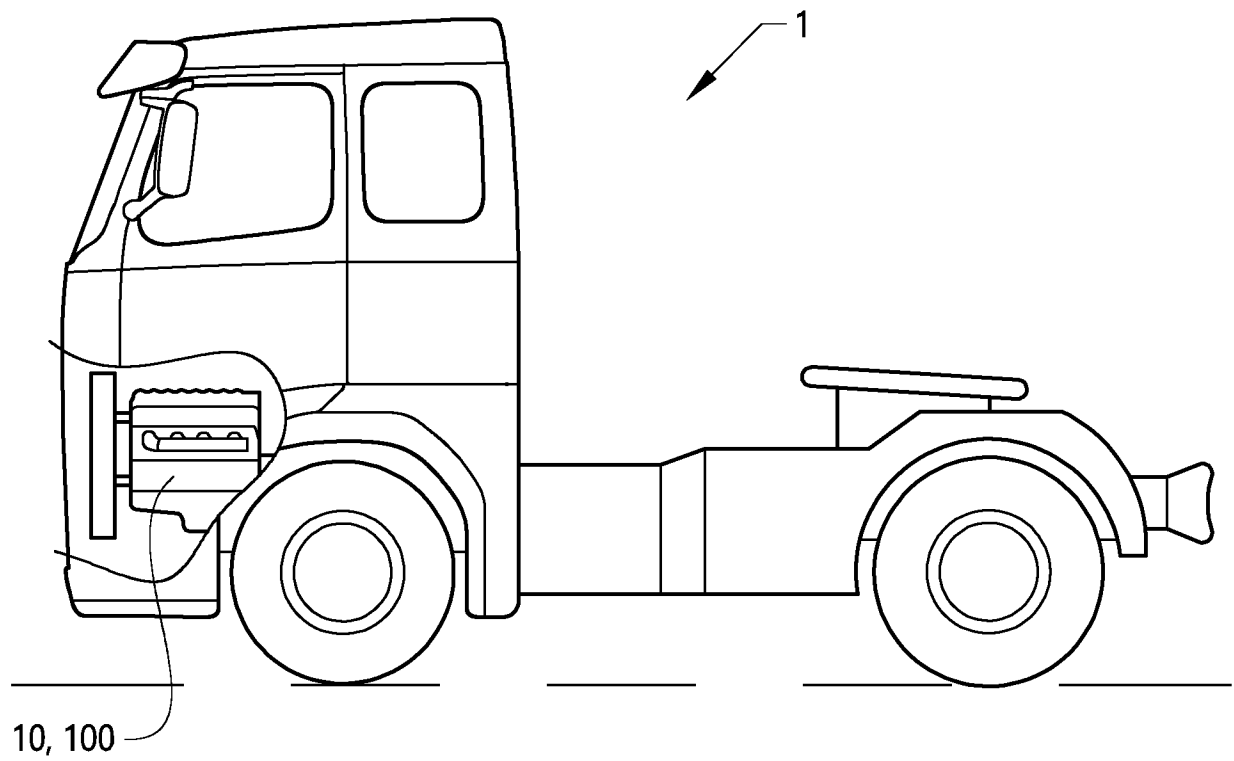


FIG. 1

2/4

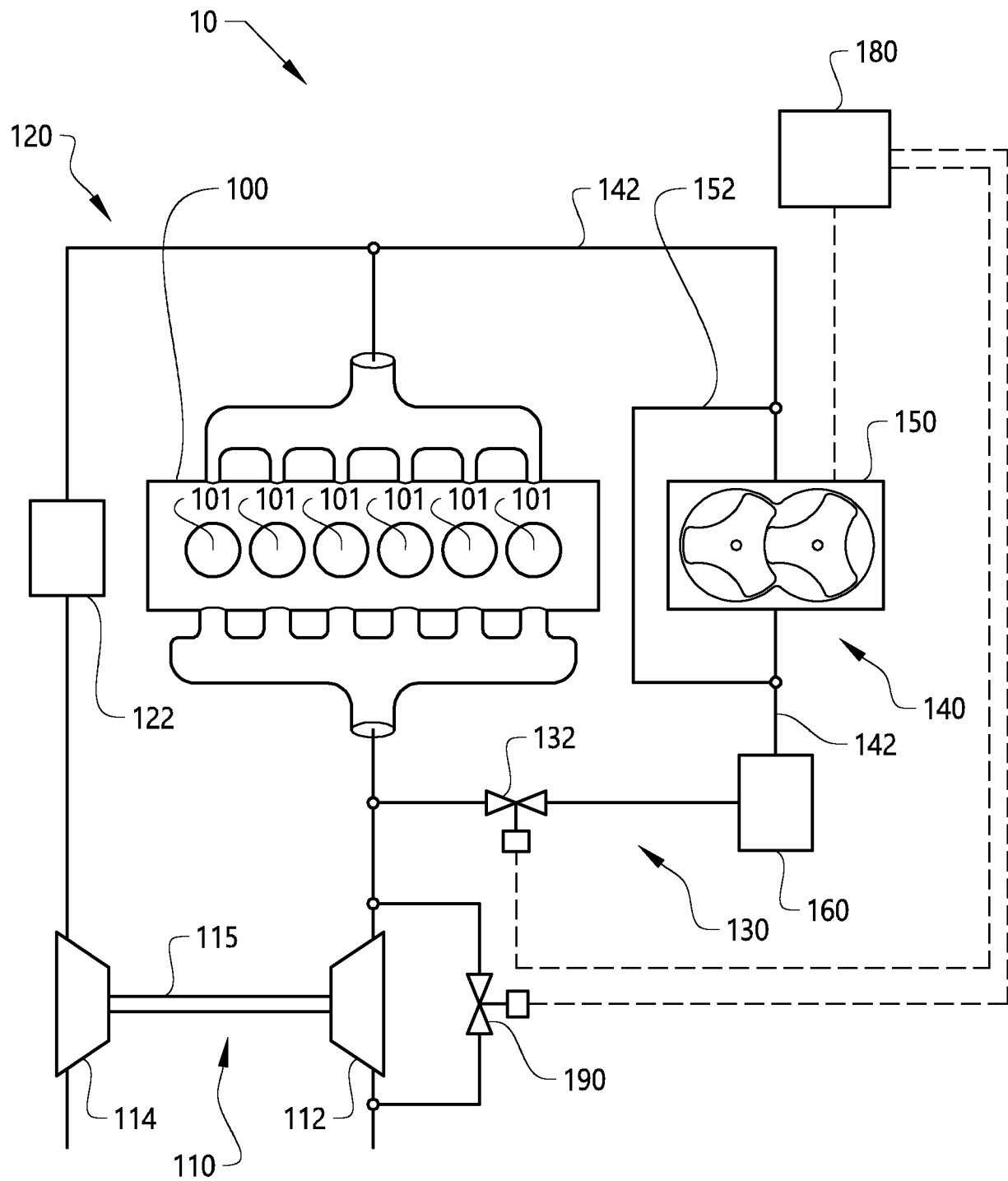


FIG. 2

3/4

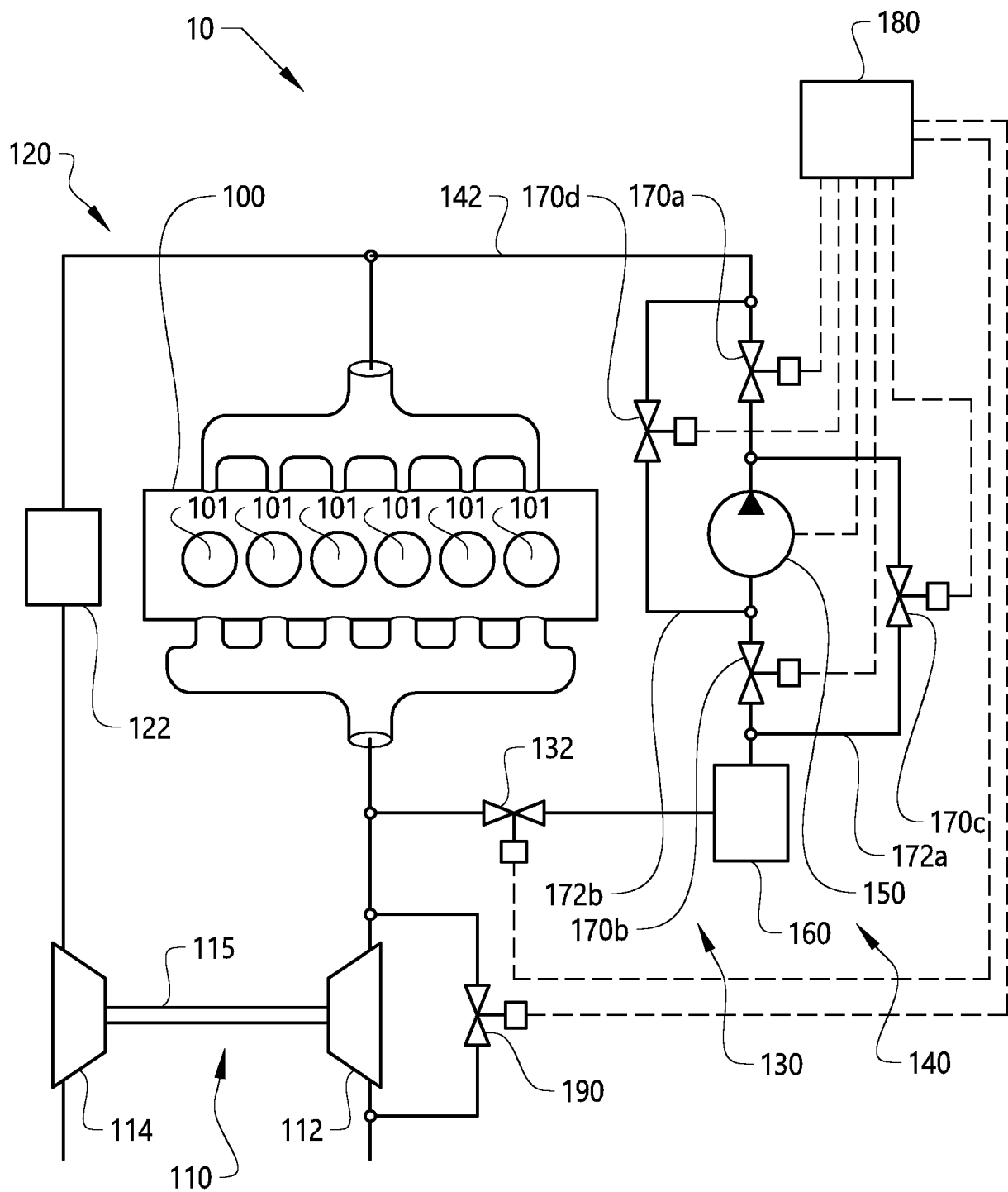


FIG. 3

4/4

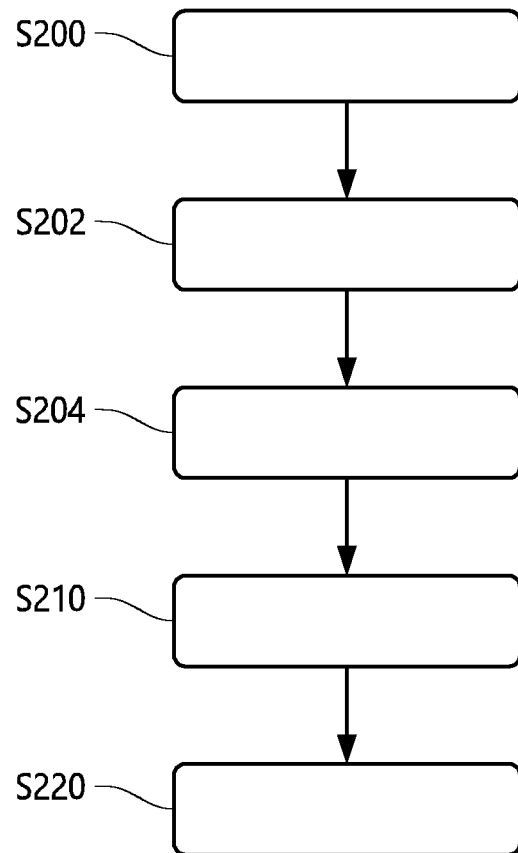


FIG. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2018/074434

A. CLASSIFICATION OF SUBJECT MATTER INV. F02M26/05 F02M26/10 F02M26/22 F02M26/34 F02M26/38 F02M26/39 F02B37/12 F02B37/04 F02D41/00 F02D41/06 F02D23/00														
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) F02M F02B F02D 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 <table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>X</td> <td>DE 10 2016 224192 A1 (BOSCH GMBH ROBERT [DE]) 7 June 2018 (2018-06-07) paragraph [0013] - paragraph [0034]; figure 1 -----</td> <td>1-3, 6-12, 18-20</td> </tr> <tr> <td>X</td> <td>US 6 435 166 B1 (SATO FUMIHIDE [JP] ET AL) 20 August 2002 (2002-08-20) column 6, line 6 - column 8, line 17; figure 1 -----</td> <td>1-20</td> </tr> <tr> <td>A</td> <td>WO 2016/083004 A1 (CONTINENTAL AUTOMOTIVE GMBH [DE]) 2 June 2016 (2016-06-02) the whole document -----</td> <td>5,15-17</td> </tr> </tbody> </table>			Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	X	DE 10 2016 224192 A1 (BOSCH GMBH ROBERT [DE]) 7 June 2018 (2018-06-07) paragraph [0013] - paragraph [0034]; figure 1 -----	1-3, 6-12, 18-20	X	US 6 435 166 B1 (SATO FUMIHIDE [JP] ET AL) 20 August 2002 (2002-08-20) column 6, line 6 - column 8, line 17; figure 1 -----	1-20	A	WO 2016/083004 A1 (CONTINENTAL AUTOMOTIVE GMBH [DE]) 2 June 2016 (2016-06-02) the whole document -----	5,15-17
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X	DE 10 2016 224192 A1 (BOSCH GMBH ROBERT [DE]) 7 June 2018 (2018-06-07) paragraph [0013] - paragraph [0034]; figure 1 -----	1-3, 6-12, 18-20												
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A	WO 2016/083004 A1 (CONTINENTAL AUTOMOTIVE GMBH [DE]) 2 June 2016 (2016-06-02) the whole document -----	5,15-17												
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INTERNATIONAL SEARCH REPORT

Information on patent family members

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