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(54) Title: ARRANGEMENT IN A LOW-TEMPERATURE COOLING SYSTEM FOR A SUPERCHARGED COMBUSTION ENGINE

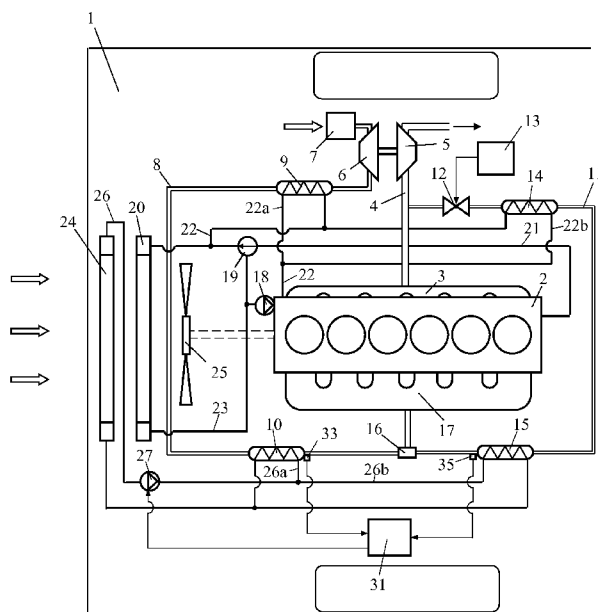


Fig 1

(57) Abstract: The present invention relates to an arrangement for a supercharged combustion engine (2). The arrangement comprises a low-temperature cooling system with a coolant, a coolant pump (27) adapted to circulating the coolant in the cooling system, and a cooler (10, 15) in which a gaseous medium which contains water vapour is intended to be cooled by the coolant in the cooling system. The arrangement comprises also at least one sensor (33, 35) adapted to detecting a parameter which indicates whether the gaseous medium is cooled so much that there is ice formation or risk of ice formation in the cooler (10, 15), and a control unit (31) adapted to receiving information from said sensors (33, 35) and to deciding whether there is ice formation or risk of ice formation in the cooler (10, 15) and, if so, to controlling the coolant pump in such a way that the latter is temporarily switched off or circulates a reduced flow of coolant through the cooler (10, 15) relative to a normal flow.



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Arrangement in a low-temperature cooling system for a
supercharged combustion engine

BACKGROUND TO THE INVENTION, AND STATE OF THE ART

The present invention relates to an arrangement for a supercharged combustion engine
5 according to the preamble of claim 1.

The amount of air which can be supplied to a supercharged combustion engine depends on
the pressure of the air but also on the temperature of the air. Supplying the largest possible
amount of air to the combustion engine entails effective cooling of the air before it is led to
the combustion engine. The air is usually cooled in a charge air cooler arranged at a front
10 portion of a vehicle. At that location the charge air cooler has a cooling air flow at the
temperature of the surroundings flowing through it, which makes it possible for the
compressed air to be cooled to a temperature close to the temperature of the surroundings. In
cold weather conditions, the compressed air may be cooled to a temperature below the
dewpoint temperature of the air, resulting in precipitation of water vapour in liquid form in
15 the charge air cooler. When the temperature of the surrounding air is lower than 0°C, there is
also risk of the precipitated water freezing to ice within the charge air cooler. Such ice
formation will cause a greater or lesser amount of obstruction of the air flow ducts within the
charge air cooler, resulting in a reduced flow of air to the combustion engine and consequent
operational malfunctions or stoppages.

20 The technique known as EGR (exhaust gas recirculation) is a known way of recirculating part
of the exhaust gases from a combustion process in a combustion engine. The recirculating
exhaust gases are mixed with the inlet air to the combustion engine before the mixture is led
to the cylinders of the combustion engine. Adding exhaust gases to the air causes a lower
combustion temperature, resulting inter alia in a reduced content of nitrogen oxides NO_x in
25 the exhaust gases. This technique is used both for Otto engines and for diesel engines.
Supplying a large amount of exhaust gases to the combustion engine entails effective cooling
of the exhaust gases before they are led to the combustion engine. The exhaust gases may be
subjected to a first step of cooling in an EGR cooler which is cooled by coolant from the
combustion engine's cooling system, and a second step of cooling in an air-cooled EGR
30 cooler. The exhaust gases can thus also be cooled to a temperature close to the temperature
of the surroundings. Exhaust gases contain water vapour which condenses within the EGR

cooler when the exhaust gases undergo the second step of cooling to a temperature which is lower than the dewpoint of the water vapour. When the temperature of the temperature of the surroundings is below 0°C, there is also risk of the condensate formed freezing to ice within the second EGR cooler. Such ice formation will cause a greater or lesser amount of obstruction of the exhaust gas flow ducts within the EGR cooler. When the recirculation of exhaust gases ceases or is considerably reduced, the result is an increased content of nitrogen oxides in the exhaust gases.

SUMMARY OF THE INVENTION

The object of the present invention is to provide an arrangement whereby a gaseous medium which contains water vapour can be subjected to very good cooling in a cooler while at the same time the risk of the cooler being obstructed is eliminated.

This object is achieved with the arrangement of the kind mentioned in the introduction which is characterised by the features indicated in the characterising part of claim 1. For it to be possible for the gaseous medium to be effectively cooled, it needs to be cooled by a coolant which is at a low temperature. A cooling system which contains such a coolant may be referred to as a low-temperature cooling system. When coolant in a low-temperature cooling system is used, the gaseous medium is usually cooled to a temperature at which water in liquid form is precipitated within the cooler. If the coolant is also colder than 0°C, there is obvious risk of the water freezing to ice within the cooler. The lower the temperature of the coolant in the low-temperature cooling system, the greater this risk. The invention therefore uses at least one sensor which detects a parameter which indicates whether the gaseous medium is cooled so much that there is ice formation or risk of ice formation in the cooler. When there is such risk, the control unit switches off the coolant pump in the low-temperature cooling system or reduces the speed of the coolant pump to a suitable value. The control unit may be a computer unit with suitable software for the purpose. The cooling effect provided in a coolant-cooled cooler is related to the coolant's temperature and the coolant flow through the cooler. By thus completely stopping or reducing the coolant flow through the radiator, it is therefore possible for the cooling effect undergone by the gaseous medium in the cooler to be reduced quickly and effectively when there is risk of ice formation. When the risk of ice formation is over, the control unit reactivates the coolant pump so that it circulates a normal coolant flow through the cooler. By such intermittent

activation of the coolant pump it is possible for the gaseous medium to be cooled to a low temperature and kept within a temperature range in which there is no risk of its being cooled to such a low temperature that ice will form within the cooler when a low ambient temperature prevails. With such control of the coolant pump, no extra energy supply is
5 required for warming the coolant or melting any ice, and energy utilisation is rather reduced in situations in which the coolant pump is not running.

According to a preferred embodiment of the invention, said sensor is a temperature sensor adapted to detecting a temperature which indicates whether the gaseous medium is cooled so much that there is ice formation or risk of ice formation in the cooler. With advantage, the
10 temperature sensor may detect the temperature of the gaseous medium after it has been cooled in the cooler. Alternatively, said sensor may be a pressure sensor which detects a parameter related to the pressure of the gaseous medium after the cooler or the pressure drop of the medium in the cooler. The control unit is with advantage adapted to controlling the coolant pump in such a way that the latter is switched off temporarily or circulates a reduced
15 flow of coolant through the cooler when the control unit receives a parameter value which is below a lower threshold value. That threshold value may take the form of a lowest temperature value or pressure value which should not be undershot. The lower threshold value is preferably set with a suitable margin to a critical value at which ice formation will take place in the cooler. If a temperature sensor is used which detects the temperature of the
20 medium after it has been cooled in the cooler, the critical temperature value is usually 0°C. Using a lower threshold value which is a suitable number of degrees above 0°C will ensure that ice formation cannot occur in the cooler.

According to another preferred embodiment of the invention, the control unit is adapted to controlling the coolant pump so that it again circulates a normal flow of coolant through the
25 cooler when it receives a parameter value which exceeds an upper threshold value. When the coolant pump is switched off or circulates a reduced flow through the cooler, the gaseous medium undergoes reduced cooling in the cooler. The gaseous medium leaving the cooler will therefore be at a progressively rising temperature. When the temperature of the medium has risen to the upper threshold value, the control unit will find that the risk of ice formation
30 is at least temporarily over, after which it will restart the coolant pump. The coolant pump is with advantage powered electrically. Such a coolant pump can easily be switched on and off.

There is also the possibility of regulating the speed of an electric coolant pump to provide a desired coolant flow through the cooler.

According to another preferred embodiment of the invention, said low-temperature cooling system comprises a radiator element in which the circulating coolant is cooled by air at the temperature of the surroundings. The coolant may thus be cooled to a temperature close to the temperature of the surroundings. In favourable circumstances, the coolant can therefore also effect cooling of the gaseous medium to a temperature close to the temperature of the surroundings.

According to another preferred embodiment of the invention, the arrangement comprises a further cooler in which the gaseous medium is intended to be subjected to a first step of cooling by the coolant in a high-temperature cooling system before the gaseous medium is led to the aforesaid cooler in which it undergoes a second step of cooling by the coolant in the low-temperature cooling system. The gaseous medium may be compressed air which is led into an inlet line to the combustion engine. When air is compressed, it undergoes an amount of heating which is related to the degree of compression of the air. In supercharged combustion engines, air is being used at an ever higher pressure. The air therefore requires effective cooling. Accordingly, it is advantageous to cool the compressed air in more than one so-called charge air cooler and in two or more stages so that it can reach a desired low temperature before it is led to the combustion engine. Said gaseous medium may also be recirculating exhaust gases which are led in a return line to the combustion engine. The exhaust gases may be at a temperature of 500-600°C when they are led into the return line. It is therefore also advantageous to cool the exhaust gases in more than one so-called EGR cooler and in two or more stages so that they can reach a desired low temperature before they are led to the combustion engine. The cooling system which cools a combustion engine is at a temperature of 80-100°C during normal operation. This cooling system may therefore be referred to as a high-temperature cooling system. It is therefore very advantageous to use this existing cooling system for subjecting the gaseous medium to a first step of cooling.

BRIEF DESCRIPTION OF THE DRAWINGS

An embodiment of the invention is described below by way of example with reference to the attached drawings, in which:

Fig. 1 depicts an arrangement for a supercharged combustion engine according to a first embodiment of the invention and

Fig. 2 depicts a diagram of how the temperature of the compressed air and the temperature of the recirculating exhaust gases may vary with time t during operation of the combustion engine.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT OF THE INVENTION

Fig. 1 depicts an arrangement for a supercharged combustion engine which is intended to power a schematically depicted vehicle 1. The combustion engine is here exemplified as a diesel engine 2. The diesel engine 2 may be intended to power a heavy vehicle 1. The exhaust gases from the cylinders of the diesel engine 2 are led via an exhaust manifold 3 to an exhaust line 4. The diesel engine 2 is provided with a turbo unit which comprises a turbine 5 and a compressor 6. The exhaust gases in the exhaust line 4, which are at above atmospheric pressure, are led initially to the turbine 5. The turbine 5 is thus provided with driving power which is transferred, via a connection, to the compressor 6. The compressor 6 uses this power to compress air which is drawn into an air inlet line 8 via an air filter 7. The air in the inlet line is cooled initially in a first coolant-cooled charge air cooler 9. The air is cooled in the first charge air cooler 9 by coolant from the combustion engine's cooling system. The compressed air is thereafter cooled in a second coolant-cooled charge air cooler 10. The air is cooled in the second charge air cooler 10 by coolant from a low-temperature cooling system, i.e. a cooling system which has a coolant at a relatively low temperature.

The arrangement comprises a return line 11 for effecting recirculation of part of the exhaust gases in the exhaust line 4. The return line 11 has an extent between the exhaust line 4 and the inlet line 8. The return line 11 comprises an EGR valve 12 by which the exhaust flow in the return line 11 can be shut off. The EGR valve 12 may also be used for regulating the amount of exhaust gases which is led from the exhaust line 4 to the inlet line 8 via the return line 11. A control unit 13 is adapted to controlling the EGR valve 12 on the basis of information about the current operating state of the diesel engine 2. The return line 11 comprises a first coolant-cooled EGR cooler 14 for subjecting the exhaust gases to a first step of cooling. The exhaust gases are cooled in the first EGR cooler 14 by coolant from the combustion engine's cooling system. The exhaust gases are subjected to a second step of

cooling in a coolant-cooled EGR cooler 15. The exhaust gases are cooled in the second EGR cooler 15 by coolant from the low-temperature cooling system.

In certain operating situations in supercharged diesel engines 2, the pressure of the exhaust gases in the exhaust line 4 will be lower than the pressure of the compressed air in the inlet line 8. In such operating situations it is not possible to mix the exhaust gases in the return line 11 directly with the compressed air in the inlet line 8 without special auxiliary means. To this end it is possible to use, for example, a venturi 16 or a turbo unit with variable geometry. If instead the combustion engine 2 is a supercharged Otto engine, the exhaust gases in the return line 11 can be led directly into the inlet line 8, since the exhaust gases in the exhaust line 4 of an Otto engine in substantially all operating situations will be at a higher pressure than the compressed air in the inlet line 8. When the exhaust gases have mixed with the compressed air in the inlet line 8, the mixture is led to the respective cylinders of the diesel engine 2 via a manifold 17.

The combustion engine 2 is cooled in a conventional manner by a cooling system which contains a circulating coolant. The coolant is circulated in the cooling system by a coolant pump 18. A main flow of the coolant is circulated through the combustion engine 2. After the coolant has cooled the combustion engine 2, it is led in a line 21 to a thermostat 19 in the cooling system. When the coolant has reached a normal operating temperature, the thermostat 19 is adapted to leading it to a radiator 20 fitted at a forward portion of the vehicle, in order to be cooled. A smaller portion of the coolant in the cooling system is nevertheless not led back to the combustion engine 2 but is circulated through a line 22 which divides into two parallel lines 22a, 22b. The line 22a leads coolant to the first charge air cooler 9, in which it subjects the compressed air to a first step of cooling. The line 22b leads coolant to the first EGR cooler 14, in which it subjects the recirculating exhaust gases to a first step of cooling. The coolant which has cooled the air in the first charge air cooler 9 and the coolant which has cooled the exhaust gases in the first EGR cooler 14 are reunited in the line 22, which leads the coolant back to the line 21. The warm coolant is led in the line 21 to the radiator 20.

The low-temperature cooling system comprises a radiator element 24 fitted in front of the radiator 20 in a peripheral region of the vehicle 1. In this case the peripheral region is situated at a front portion of the vehicle 1. A radiator fan 25 is adapted to generating an air

stream of surrounding air through the radiator element 24 and the radiator 20. As the radiator element 24 is situated in front of the radiator 20, the coolant in the radiator element 24 is cooled by air at the temperature of the surroundings. The coolant in the radiator element 24 can thus be cooled to a temperature close to the temperature of the surroundings. The cold
5 coolant from the radiator element 24 is circulated in the separate cooling system in a line 26 by an electrically powered coolant pump 27. The line 26 divides into two parallel lines 26a, 26b. The line 26a leads coolant to the second charge air cooler 10, in which it subjects the compressed air to a second step of cooling. The line 26b leads coolant to the second EGR cooler 15, in which it subjects the recirculating exhaust gases to a second step of cooling.
10 After the coolant has passed through the second charge air cooler 10 and the second EGR cooler 15, the lines 26a, 26b reunite. The coolant is thereafter led in the line 26 to the radiator element 24 in order to be cooled. A first temperature sensor 33 is provided in the air line 8 to detect the temperature of the air after it has been cooled in the second charge air cooler 10. A second temperature sensor 35 is provided in the return line 11 to detect the
15 temperature of the exhaust gases after they have been cooled in the second EGR cooler 15. The control unit 31 is adapted to receiving information from the temperature sensors 33, 35 concerning the temperature of the air and of the exhaust gases.

During operation of the diesel engine 2, exhaust gases flow through the exhaust line 4 and drive the turbine 5. The turbine 5 is thus provided with driving power which drives the
20 compressor 6. The compressor 6 draws surrounding air in via the air filter 7 and compresses the air in the inlet line 8. The air thus acquires an increased pressure and an increased temperature. The compressed air is cooled in the first charge air cooler 9 by the radiator liquid in the combustion engine's cooling system. The radiator liquid may here be at a temperature of about 80-85°C. Thus the compressed air can undergo in the first charge air
25 cooler 9 a first step of cooling to a temperature close to the temperature of the coolant. The compressed air is thereafter led through the second charge air cooler 10, in which it is cooled by the coolant in the separate cooling system. The coolant may here be at a temperature close to the temperature of the surroundings. Thus the compressed air can in favourable circumstances be cooled to a temperature close to the temperature of the surroundings.

30 In most operating states of the diesel engine 2, the control unit 13 will keep the EGR valve 12 open so that part of the exhaust gases in the exhaust line 4 is led into the return line 11. The exhaust gases in the exhaust line 4 may be at a temperature of about 500-600°C when they

reach the first EGR cooler 14. The recirculating exhaust gases undergo in the first EGR cooler 14 a first step of cooling by the coolant in the combustion engine's cooling system. The coolant in the combustion engine's cooling system will thus be at a relatively high temperature but definitely lower than the temperature of the exhaust gases. It is thus possible to effect good cooling of the exhaust gases in the first EGR cooler 14. The recirculating exhaust gases are thereafter led to the second EGR cooler 15, in which they are cooled by the coolant in the low-temperature cooling system. The coolant will here be at a definitely lower temperature and the exhaust gases can in favourable circumstances be cooled to a temperature close to the temperature of the surroundings. Exhaust gases in the return line 11 can thus undergo cooling to substantially the same low temperature as the compressed air before they mix and are led to the combustion engine 2. A substantially optimum amount of air and recirculating exhaust gases can thus be led into the combustion engine. Combustion in the combustion engine 2 with substantially optimum performance is thus made possible. The low temperature of the compressed air and the recirculating exhaust gases also results in a lower combustion temperature and hence a lower content of nitrogen oxides in the exhaust gases.

This effective cooling of the compressed air and the recirculating exhaust gases also has disadvantages. The compressed air is cooled in the second charge air cooler 10 to a temperature at which water in liquid form precipitates within the charge air cooler 10.

Similarly, the exhaust gases in the second EGR cooler 15 are cooled to a temperature at which condensate forms within the second EGR cooler 15. When the temperature of the surrounding air is lower than 0°C, there is also risk of the precipitated water freezing to ice within the second charge air cooler 10 and of the precipitated condensate freezing to ice within the second EGR cooler 15. Ice formation within the second charge air cooler 10 and the second EGR cooler 15 might seriously disturb the operation of the combustion engine 2. To prevent the second charge air cooler 10 and the second EGR cooler 15 from freezing up, the control unit 31 substantially continuously receives information from the temperature sensor 33 concerning the temperature T_A of the air after it has been cooled in the second charge air cooler 10 and from the temperature sensor 35 concerning the temperature T_E of the recirculating exhaust gases after they have been cooled in the second charge air cooler 15.

Fig. 2 depicts a diagram illustrating how the temperature T_A of the compressed air and the temperature T_E of the recirculating exhaust gases may vary with time t during operation of

the combustion engine 2. A critical temperature value $T_0=0^{\circ}\text{C}$ is marked in the diagram at which ice formation is very likely to occur in the charge air cooler 10 and the EGR cooler 15. The diagram marks a lower threshold value T_1 which is set with a suitable margin to the critical value T_0 . In this case the lower threshold value $T_1=5^{\circ}\text{C}$. The diagram also marks an upper threshold value T_2 which in this case is set at 10°C . At time t_0 the compressed air has a temperature T_A of about 8°C when it leaves the second charge air cooler 10 and the exhaust gases a temperature T_E of about 11°C when they leave the second EGR cooler 15. At time t_0 , the control unit 31 runs the coolant pump 27 in such a way as to provide a normal coolant flow through the second charge air cooler 10 and the second EGR cooler 15. In this example the surrounding air is at a relatively low temperature. The coolant in the low-temperature cooling system is thus cooled in the cooler 24 to an almost equally low temperature. This cold coolant effects very effective cooling of the compressed air in the second charge air cooler 10 and the exhaust gases in the second EGR cooler 15. The temperature T_A of the compressed air and the temperature T_E of the exhaust gases consequently drop over time t .

At time t_1 the temperature T_A of the compressed air has dropped to the lower threshold value T_1 . When the control unit 31 receives this information from the temperature sensor 33, it switches the coolant pump 27 off so that the circulation of coolant in the low-temperature cooling system ceases. The cooling of the compressed air in the second charge air cooler 10 and the exhaust gases in the second EGR cooler 15 is thus considerably reduced. This leads to the temperature T_A of the compressed air ceasing to drop. The temperature T_A of the compressed air is thus prevented, with a margin, from approaching the critical temperature T_0 at which ice forms in the second charge air cooler 10. As the circulation of cold coolant through the second charge air cooler 10 and the second EGR cooler 15 has ceased, the temperature T_A of the compressed air begins to rise, as too does the temperature T_E of the exhaust gases. At time t_2 temperature T_A of the compressed air has risen to the upper threshold value T_2 . The temperature T_E of the exhaust gases in this case is somewhat above the threshold value T_2 . When the control unit 31 receives information from the temperature sensor 33 which indicates that the temperature T_A of the compressed air has risen to the upper threshold T_2 , it finds that the risk of ice formation is at least temporarily over. The control unit 31 thereupon switches the coolant pump 27 off so that the circulation of coolant resumes in the low-temperature cooling system. The resumed circulation of cold coolant leads again to very effective cooling of the compressed air in the second charge air cooler 10 and the

exhaust gases in the second EGR cooler 15. The temperature T_A of the compressed air therefore ceases to rise. The temperature T_A of the compressed air and the temperature T_E of the exhaust gases thereafter begin to fall again. In this example, the coolant pump 27 is switched off when the temperature T_A of the compressed air reaches the lower threshold value T_1 . If instead the temperature T_E of the exhaust gases cools down first to the lower threshold value T_1 , the control unit 31 here again switches the coolant pump 27 off. The coolant pump 27 is kept switched off until the control unit 31 receives information from the temperature sensor 35 which indicates that the temperature T_E of the exhaust gases has risen to the upper threshold value T_2 . When this happens, the control unit switches the coolant pump 27 back on.

When a low ambient temperature prevails, the control unit 31 activates the coolant pump 27 intermittently so that a reduced or no coolant flow is temporarily received in the low-temperature cooling system. The cooling of the compressed air and the recirculating exhaust gases is thus reduced so that they are substantially not cooled to a lower temperature than the lower threshold value T_1 . However, a certain inertia in the system may cause the compressed air and the exhaust gases to be for a short period at a somewhat lower temperature than the lower threshold value T_1 . The lower threshold value T_1 is set, however, with a margin such as to provide assurance that the compressed air and the recirculating exhaust gases will not cool down to the critical temperature T_0 . Such control of the coolant pump 27 eliminates substantially completely the risk of ice forming in the second charge air cooler 10 and the second EGR cooler 15. The lower threshold value T_1 and the upper threshold T_2 may of course be given values other than those in the example indicated above.

The invention is in no way limited to the embodiment described above but may be varied freely within the scopes of the claims. The embodiment example uses a temperature sensor 33 for detecting the temperature T_A of the compressed air after it has been cooled in the second charge air cooler 10 and a temperature sensor 35 for detecting the temperature T_B of the exhaust gases after they have been cooled in the second EGR cooler 15. Alternatively, pressure sensors may be used instead for estimating when ice has begun to form within the second charge air cooler 10 or within the second EGR cooler 15. When the pressure of the air after the charge air cooler 10 or the pressure of the exhaust gases after the EGR cooler 15 falls below a predetermined pressure value, the control unit 31 may in this case find that ice is beginning to form within one of these coolers 10, 15. The control unit thereupon switches the

coolant pump 27 off. The cooling in the charge air cooler 10 and the EGR cooler 15 respectively is thus reduced so that the ice formed quickly melts away. The control unit reactivates the coolant pump 27 as soon as it receives a desired pressure value from said pressure sensor. In the above example, the control unit 31 switches the coolant pump 27 off
5 completely when there is risk of ice formation. It is also possible to reduce the speed of the coolant pump instead of switching it off completely when there is risk of ice formation. The coolant pump 27 will thus deliver to the respective coolers a reduced coolant flow which may be sufficient to prevent ice formation in them. The arrangement is intended for a supercharged combustion engine in which a turbo unit is used for compressing the air which
10 is led to the combustion engine. The arrangement may of course also be used for supercharged combustion engines in which the air is compressed by more than one turbo unit. In such cases the first charge air cooler may be used as an intermediate cooler for cooling the air between the compressions in the compressors of the turbo units.

Claims

1. An arrangement for a supercharged combustion engine (2), which arrangement comprises a low-temperature cooling system with a coolant, a coolant pump (27) adapted to circulating the coolant in the cooling system, and a cooler (10, 15) in which a gaseous
5 medium which contains water vapour is intended to be cooled by the coolant in the cooling system, characterised in that the arrangement comprises at least one sensor (33,35) adapted to detecting a parameter which indicates whether the gaseous medium is cooled so much that there is ice formation or risk of ice formation in the cooler (10, 15), and a control unit (31) adapted to receiving information from said sensors (33,35) and to deciding whether there is
10 ice formation or risk of ice formation in the cooler (10, 15) and, if so, to controlling the coolant pump in such a way that the latter is temporarily switched off or circulates a reduced flow of coolant through the cooler (10, 15) relative to a normal flow.
2. An arrangement according to claim 1, characterised said sensor is a temperature sensor (33, 35) adapted to detecting a temperature which indicates whether the gaseous medium is
15 cooled so much that there is ice formation or risk of ice formation in the cooler (10, 15)
3. An arrangement according to claim 2, characterised in that the control unit (31) is adapted to controlling the coolant pump (27) in such a way that the latter is temporarily switched off or circulates a reduced flow of coolant through the cooler (10, 15) when the control unit receives a parameter value which is below a lower threshold value (T_1).
- 20 4. An arrangement according to claim 3, characterised in that the lower threshold value (T_1) is set with a margin to a critical value (T_0) when ice formation occurs in the cooler (10, 15).
5. An arrangement according to claim 3 or 4, characterised in that the control unit (31) is adapted to controlling the coolant pump (27) in such a way that the latter again circulates a normal flow of coolant through the cooler (10, 15) when it receives a parameter value which
25 is above an upper threshold value (T_2).
6. An arrangement according to any one of the foregoing claims, characterised in that the coolant pump (27) is powered electrically.
7. An arrangement according to any one of the foregoing claims, characterised in that said low-temperature cooling system comprises a radiator element (24) in which the circulating

coolant is cooled by air at the temperature of the surroundings.

8. An arrangement according to any one of the foregoing claims, characterised in that it comprises a further cooler (9, 14) in which the gaseous medium is intended to be subjected to
5 a first step of cooling by the coolant in a high-temperature cooling system before the gaseous medium is led to the aforesaid cooler (10, 15) in which it is subjected to a second step of cooling by the coolant in the low-temperature cooling system.
9. An arrangement according to any one of the foregoing claims, characterised in that said gaseous medium is compressed air which is led in an inlet line (8) to the combustion engine
10 (2).
10. An arrangement according to any one of the foregoing claims, characterised in that said gaseous medium is recirculating exhaust gases which are led in a return line (11) to the combustion engine (2).

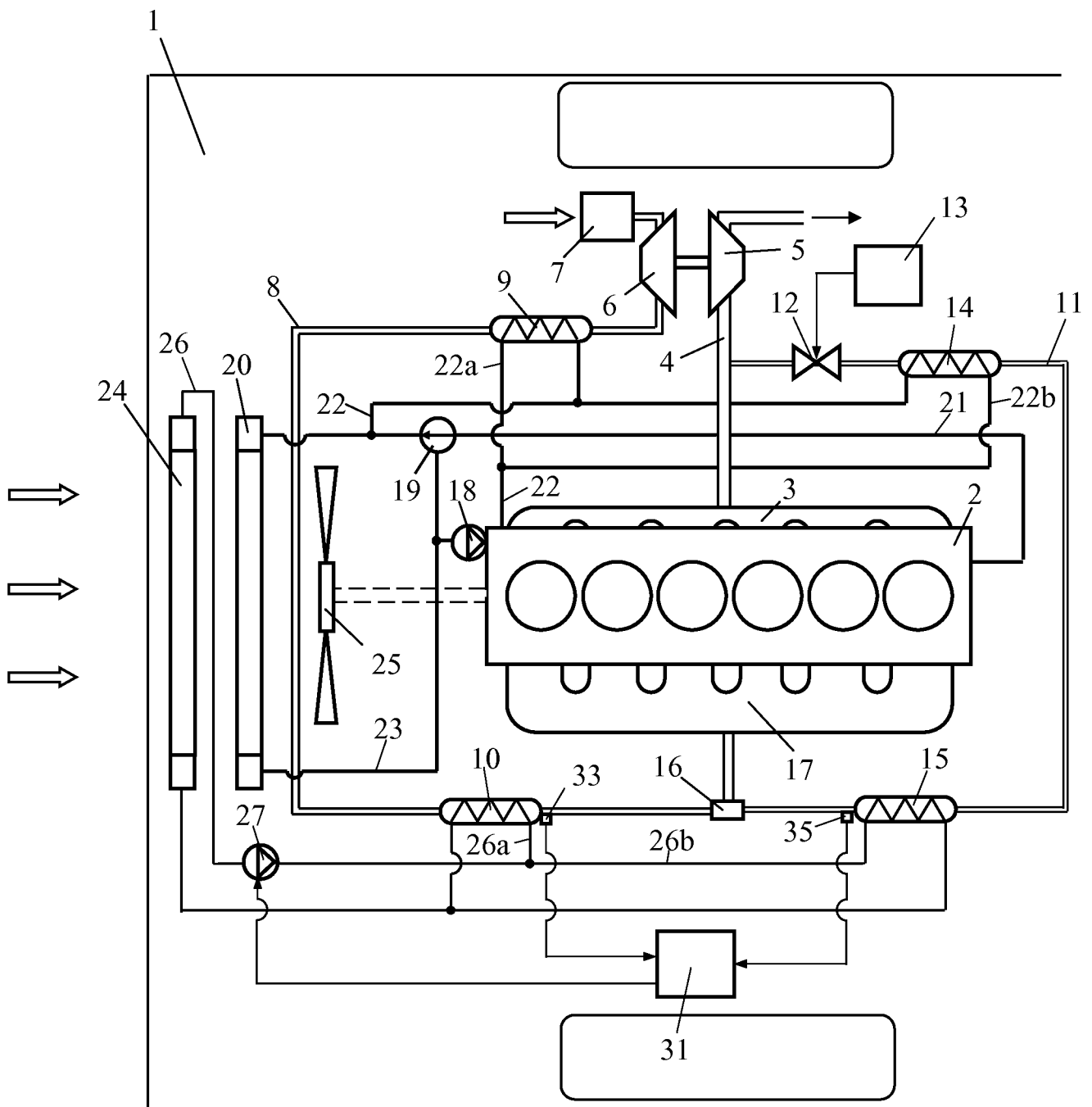


Fig 1

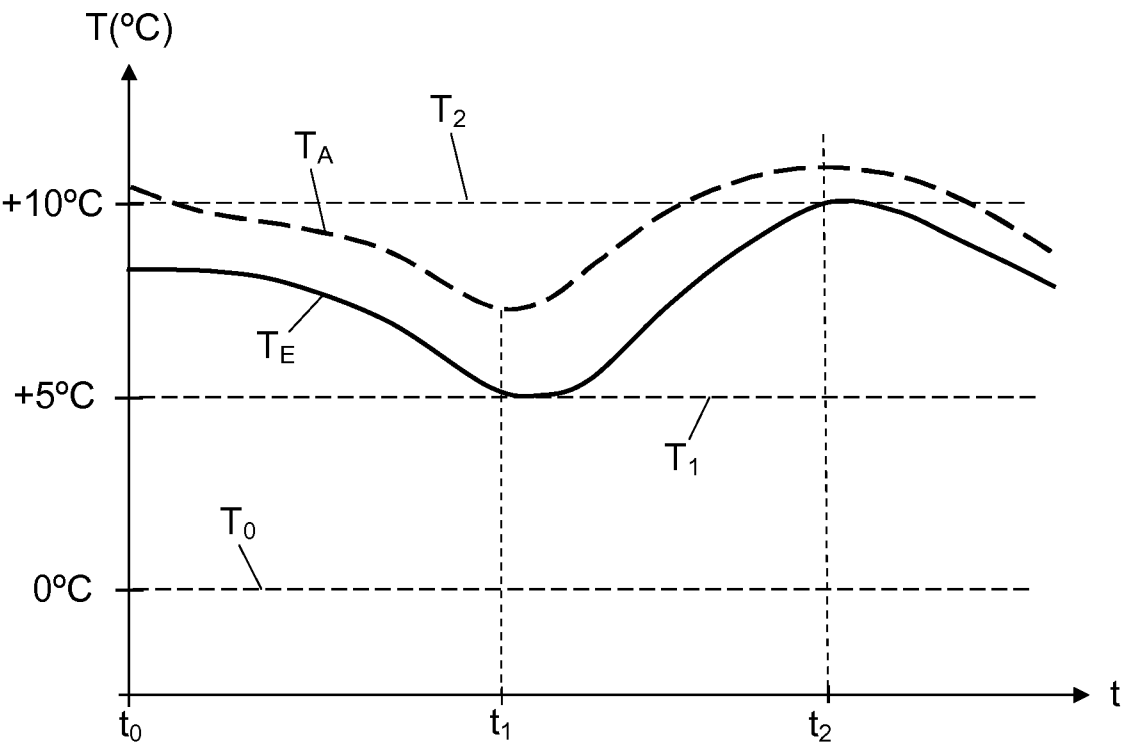


Fig 2

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE2009/051017

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, F02B, F01P

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.
P,X	EP 2096276 A1 (BEHR GMBH & CO. KG ET AL), 2 Sept 2009 (02.09.2009), figure 6B, paragraph (0053) --	1-10
Y	WO 2008080872 A1 (VALEO ENGINE COOLING AB), 10 July 2008 (10.07.2008), page 2, line 6 - line 20 --	1-10
Y	WO 0248516 A1 (SAMSUNG CLIMATE CONTROL CO., LTD), 20 June 2002 (20.06.2002), page 9, line 11 - line 19, figure 2 --	1-10

☒ 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
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE2009/051017

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	WO 2007108761 A1 (SCANIA CV AB), 27 Sept 2007 (27.09.2007), page 1, line 13 - line 21; page 1, line 31 - page 2, line 8; page 8, line 19 - page 9, line 21 --	1-10
Y	US 20030056772 A1 (BORRMANN ET AL), 27 March 2003 (27.03.2003), figure 1, claim 10, paragraphs (0005),(0006) --	1-10
A	JP 58150022 A, TOYOTA MOTOR CORP, 1983-09-06: (abstract) Retrieved from: PAJ database; Original document: fig. 1 --	2-6
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A	US 6230668 B1 (MARSH ET AL), 15 May 2001 (15.05.2001), column 5, line 23 - line 56, figure 1 -- -----	1-9

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Cited literature, if any, will be enclosed in paper form.

INTERNATIONAL SEARCH REPORT

Information on patent family members

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