Title: COOLING SYSTEM FOR INTERNAL COMBUSTION ENGINE

Abstract: The invention relates to a cooling system (2) for an internal combustion engine (1), which cooling system (2) comprises a low-temperature cooling circuit (3) and a high-temperature cooling circuit (8) for coolant, and a circulating pump (4) for circulating coolant in the low-temperature cooling circuit (3). The cooling system (2) comprises a turbine-driven pump unit (12) for circulating coolant in the high-temperature cooling circuit (8), which turbine-driven pump unit (12) comprises a turbine (14) connected to the low-temperature cooling circuit (3) and a pump (13) connected to the high-temperature cooling circuit (8).
COOLING SYSTEM FOR INTERNAL COMBUSTION ENGINE

The invention relates to a cooling system for internal combustion engine, which cooling system comprises a low-temperature cooling circuit and a high-temperature cooling circuit for coolant and a circulating pump for circulating coolant in the low-temperature cooling circuit.

The cooling systems of large piston engines are typically provided with two cooling circuits, a low-temperature and a high-temperature cooling circuit, which operate at different temperature and pressure levels. The low temperature cooling circuit is arranged to cool lubricating oil and charge air of the engine. Correspondingly, the high-temperature cooling circuit is arranged to cool cylinder liners and/or cylinder heads of the engine. Both cooling circuits can be provided with their own coolant circulating pump. Typically the circulating pumps are motor driven and the pump drive has to be dimensioned to cope with the forces and vibrations coming from the engine. Therefore, the power of the pump drive is usually much greater than the nominal power of the pump. This increases the size of the pump drive, which in turn complicates the placement of the pumps in connection with the engine. The pump drives can be dimensioned smaller if the pumps are placed in the cooling unit, which is external to the base on which the engine block is mounted. This, however, increases the number of pipe connections between the engine base and the external cooling unit, which is not desirable.

The object of the present invention is to solve the problems described above.

The object of the invention is achieved as disclosed in claim 1. The cooling system according to the invention comprises a low-temperature cooling circuit and a high-temperature cooling circuit for coolant and a circulating pump for circulating coolant in the low-temperature cooling circuit. The system further comprises a turbine-driven pump unit for circulating coolant in the high-temperature cooling circuit. The turbine-driven pump unit comprises a turbine connected to the low-
temperature cooling circuit and a pump connected to the high-temperature cooling circuit.

Significant benefits can be achieved by means of the invention. The turbine driven pump may have a relatively small size and therefore can be easily mounted in connection with the engine. As a result, there is no need to place the circulating pump of the high-temperature cooling circuit in the external cooling unit. Thus, the number of pipe connections between the engine base and the external cooling unit can be minimized.

In the following the invention will be described by way of example with reference to the accompanying schematic drawing, which shows an internal combustion engine which is provided with a cooling system according to the invention.

The drawing shows schematically an internal combustion engine 1, which comprises a cooling system 2. The internal combustion engine 1 can be a large piston engine, for example a large diesel engine. Large piston engine refers here to such engines that can be used for instance as main and auxiliary engines in ships or in power plants for production of heat and/or electricity. The cooling system 2 comprises a first, a low-temperature (LT) cooling circuit 3, in which coolant, e.g. cooling water, is circulated. The cooling system 2 further comprises a circulating pump 4 for circulating the coolant in the LT cooling circuit 3. The circulating pump 4 can be installed in a cooling unit 7. The cooling unit 7 is separate from a base 22, on which an engine block 11 is mounted. At least one cooler of the engine 1 is connected to the LT cooling circuit 3. In the embodiment shown in the drawing, a charge air cooler 5 and a lubricating oil cooler 6 are connected to the LT cooling circuit 3. The charge air cooler 5 is connected to the LT cooling circuit 3 upstream of the lubricating oil cooler 6. The charge air cooler 5 and the lubricating oil cooler 6 can be mounted on the base 22.

The cooling system 1 comprises a second, a high-temperature (HT) cooling circuit 8, in which coolant, e.g. cooling water, is circulated. The HT cooling circuit 8 is arranged to cool an engine block 11 and/or cylinder liners 9 and/or cylinder...
heads 10 of the engine 1. The engine block 11 comprises cooling channels through which coolant is arranged to flow. If the engine 1 comprises high and low-temperature charge air coolers, the high temperature charge air cooler can be connected to the HT cooling circuit 8 downstream of the engine block 11 in the flow direction of the coolant. Coolant temperature in the HT cooling circuit 8 is at a higher level than in the LT cooling circuit 3. Further, coolant pressure in the HT cooling circuit 8 is at a higher level than in the LT cooling circuit 3. The flow directions of coolant are shown by arrows.

The LT cooling circuit 3 is in flow connection with the HT cooling circuit 8. The coolant is first arranged to flow through the LT cooling circuit 3 and thereafter at least part of the coolant is arranged to flow through the HT cooling circuit 8.

The cooling system 2 is provided with a turbine driven pump unit 12 for circulating coolant in the HT cooling circuit 8. The turbine driven pump unit 12 comprises a pump 13 arranged in force transmission connection with a turbine 14. The pump 13 and the turbine 14 can be mounted on a common shaft. The pump 13 is connected to the HT cooling circuit 8, for example upstream of the first object to be cooled (engine block/cylinder liners/cylinder head in the drawing) in the flow direction of the coolant. The pump 13 is a centrifugal pump. The turbine 14 is connected to the LT cooling circuit 3, for example upstream of the first object to be cooled (charge air cooler 5 in the drawing). The turbine 14 is rotated by the coolant flow in the LT cooling circuit 3. The turbine driven pump unit 12 can be mounted on the base 22.

The cooling system 2 comprises a central cooler 16 for cooling the coolant discharged from the HT cooling circuit 8. The central cooler 16 is arranged upstream of the circulating pump 4. The central cooler 16 is installed in the cooling unit 7. The cooling system 2 further comprises a bypass passage 17, through which coolant can bypass the central cooler 16. The flow amount of coolant through the bypass passage 17 and the central cooler 16 can be adjusted by a control valve 21. The control valve 21 is a three-way thermostatic valve.
The HT cooling circuit 8 is provided with a thermostatic valve 15, by which the coolant temperature in the HT cooling circuit 8 can be adjusted. The thermostatic valve 15 is a three-way valve. The thermostatic 15 valve is connected to HT cooling circuit 8 downstream of the last object to be cooled (engine block/cylinder liners/cylinder heads in the drawing). The thermostatic valve 15 is arranged to open when the temperature of the coolant in the HT cooling circuit 8 reaches a predetermined limit value, typically 92-98°C. In the open position the coolant can flow through the thermostatic valve 15 to the central cooler 16. Part of the coolant is circulated from the thermostatic valve 15 through a circulating passage 19 back to the HT cooling circuit 8. First end of the circulating passage 19 is connected to the thermostatic valve 15 and the second end to the HT cooling circuit 8 at a location upstream of the pump 13. The thermostatic valve 15 can be mounted on the base 22.

The cooling system 2 is provided with a one-way valve 20. The one-way valve 20 is connected between the LT cooling circuit 3 and the HT cooling circuit 8. The one-way valve 20 prevents the coolant flow from HT cooling circuit 8 to the LT cooling circuit 3, but allows the coolant flow from the LT cooling circuit 3 to the HT cooling circuit 8.

When the engine 1 is running, coolant is fed by the circulating pump 4 into the LT cooling circuit 3. The coolant flows through the turbine 14. The turbine wheel is rotated by the coolant flow. After passing through the turbine 14, the coolant is fed into the charge air cooler 5 and thereafter through the lubricating oil cooler 6. After passing through the last cooler (the lubricating oil cooler 6 in the drawing) the coolant flow is divided into two streams. One stream is led into HT cooling circuit 8. The other stream is led through a connecting passage 18 into the HT cooling circuit 8 and mixed with the coolant discharged from the thermostatic valve 15.
Coolant flowing through the circulating passage 19 is mixed with coolant coming from the LT cooling circuit 3. Thereafter, the coolant is pumped by the turbine driven pump 13. Coolant flow is directed into the cooling channels of the engine block 11. Cylinder liners 9 and/or cylinder heads 10 of the engine are cooled by the coolant flowing in the cooling channels.

After passing through the cooling channels of the engine block, coolant flow is led to the thermostatic valve 15. The thermostatic valve 15 opens when the coolant temperature rises to the predetermined limit value. Correspondingly, the thermostatic valve 15 closes when the coolant temperature drops below the limit value.

Coolant temperature in HT cooling circuit 8 can be maintained as desired by the thermostatic valve 15.

Part of the coolant flowing through the thermostatic valve 15 is mixed with the coolant flowing through the connecting passage 18. Thereafter the coolant flow is directed to the central cooler 16. Coolant is cooled by the central cooler 16 and fed back to the LT cooling circuit 3 by the circulating pump 4. Part of the coolant can bypass the central cooler 16 through the bypass channel 17. Thus, the temperature of coolant fed to LT-cooling circuit 3 can be adjusted as desired.
Claims

1. A cooling system (2) for an internal combustion engine (1), which cooling system (2) comprises a low-temperature cooling circuit (3) and a high-temperature cooling circuit (8) for coolant, and a circulating pump (4) for circulating coolant in the low-temperature cooling circuit (3), characterised in that the cooling system (2) comprises a turbine-driven pump unit (12) for circulating coolant in the high-temperature cooling circuit (8), which turbine-driven pump (12) unit comprises a turbine (14) connected to the low-temperature cooling circuit (3) and a pump (13) connected to the high-temperature cooling circuit (8).

2. A cooling system according to claim 1, characterised in that the low-temperature cooling circuit (3) is in flow connection with the high-temperature cooling circuit (8).

3. A cooling system according to claim 1 or 2, characterised in that the turbine (14) of the turbine-driven pump unit (12) is connected to the low-temperature cooling circuit (3) upstream of a first object to be cooled (5).

4. A cooling system according to claim 1, 2 or 3, characterised in that the pump (13) of the turbine-driven pump unit (12) is connected to the high-temperature cooling circuit (8) upstream of a first object to be cooled (9, 10, 11).

5. A cooling system according to any preceding claim, characterised in that the high-temperature cooling circuit (8) is provided with a thermostatic valve (15), which is arranged to open when the coolant temperature in the high-temperature cooling circuit (8) reaches a predetermined limit value.

6. A cooling system according to claim 5, characterised in that the thermostatic valve (15) is connected to the high-temperature cooling circuit (8) downstream of a last object to be cooled (9, 10, 11) in the coolant flow direction.

7. A cooling system according to any preceding claim, characterised in that a charge air cooler (5) and a lubricating oil cooler (6) of the engine are connected to the low-temperature cooling circuit (3).
8. A cooling system according to any preceding claim, **characterised** in that the high-temperature cooling circuit (8) is arranged to cool cylinder liners (9) and/or cylinder heads (10) of the engine.
### A. CLASSIFICATION OF SUBJECT MATTER

**INV. F01P5/12 F01P7/16**

ADD.

According to International Patent Classification (IPC) or to both national classification and IPC.

### B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F01P

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 practical, search terms used)

EPO-Internal

### C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<tr>
<td>A</td>
<td>JP 53 000347 A (TOYOTA MOTOR CO LTD) 5 January 1978 (1978-01-05) abstract; figures</td>
<td>1</td>
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<tr>
<td>A</td>
<td>US 3 934 644 A (JOHNSTON LAIRDR E) 27 January 1976 (1976-01-27) column 2, line 44 - line 63; figure 2</td>
<td>1</td>
</tr>
<tr>
<td>A</td>
<td>DE 198 34 135 AI (DAIMLER CHRYSLER AG [DE]) 3 February 2000 (2000-02-03) abstract; figure 1</td>
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Date of the actual completion of the international search

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<tr>
<td>A</td>
<td>J P 1 073109 A (NI PPO DENSO CO; TOYOTA MOTOR CORP) 17 March 1989 (1989-03-17) abstract; figure</td>
<td>1</td>
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<tr>
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<td>JP 53000347</td>
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<td>US 3934644</td>
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<td>BR 9804691 A</td>
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