

**SHIP EQUIPPED WITH THERMAL ENERGY RECOVERY MEANS
AND RELATED PROCESS**

The present invention pertains in particular to a
5 ship provided with at least one diesel engine and at
least one item of equipment, separate from the engine,
which consumes thermal energy.

Ships today, in particular heavy tonnage passenger
ships, are traditionally equipped with one and even
10 several, high-power diesel engines to propel the ship.

As with any engine, some parts they contain or
which are associated therewith are cooled by the
circulation of a liquid coolant.

In this particular case of ship diesel engines,
15 there are two separate liquid cooling circuits, one so-
called higher temperature circuit and another so-called
low-temperature circuit. These two circuits, may, in
some cases, have common parts.

The characteristic which essentially
20 differentiates these two circuits from each other is
the temperature of the coolant entering the engine.

The temperature of the coolant in the high-
temperature circuit is higher than that of the liquid
in the low-temperature circuit.

25 By way of indication, these temperatures are in
the order of 70 and 38°C respectively.

The high-temperature circuit is intended to cool
parts such as the engine cylinders, whilst the low-
temperature circuit is intended to cool parts such as
30 an oil cooler.

This "duplication" of the cooling circuit can be
accounted for by the fact that the functioning and/or
structure of some engine components could be affected
by cooling that is too harsh.

Additionally, passenger ships are provided with items of equipment, separate from the engine, which consume thermal energy. These may be an air heating installation for example, or a water heating
5 installation, a fresh water generator, or a system for heating swimming-pool water.

It has already been proposed to recover, at least in part, the calories conveyed by the liquid of the high-temperature circuit, to supply heat to at least
10 one of these items of equipment.

As for the liquid in the low-temperature circuit, this is cooled by heat exchange with seawater, before being « re-circulated » inside the engine.

It will easily be appreciated that this entails a
15 loss of energy that is non-negligible in a context of the high cost of fossil energy sources.

The present invention sets out to solve this problem, making use of simple, efficient, low-cost means.

20 Therefore a first aspect of the invention relates to a ship provided with:

- at least one diesel engine of which some internal, even external, parts are cooled by a first liquid cooling circuit called a high-temperature
25 circuit, whilst others are cooled by a second so-called low-temperature liquid cooling circuit, these circuits differing by the difference in temperature of the coolant entering said engine,

- at least one item of equipment, separate from
30 said engine, which consumes thermal energy,

- means to recover at least part of the calories conveyed by the liquid in the high-temperature circuit, in order to supply heat to said equipment,

characterized by the fact that it further
35 comprises means to recover at least part of the

calories conveyed by the liquid in the low-temperature circuit, to supply heat to said equipment.

Therefore, through the invention, the ship's overall energy balance is greatly improved.

5 According to other advantageous, non-limiting characteristics:

- said equipment comprises at least two equipment items, at least one being supplied with heat by the high-temperature circuit, whilst the other is supplied
10 with heat by the low-temperature circuit;

- the equipment supplied with heat by the low-temperature circuit particularly consists of an air heating installation, a water heating installation, a system for heating swimming-pool water;

- 15 - it comprises means to regulate the temperature of the coolant in the low-temperature circuit after it leaves the engine;

- said recovery means comprise at least one heat exchanger within which a liquid to be heated is
20 circulated;

- it comprises means to adjust the flow rate of said liquid, to supply heat to said items of equipment.

The invention also relates to a process to recover thermal energy within a ship which is provided with:

- 25 - at least one diesel engine of which some internal, and even external, parts are cooled by a first so-called high-temperature liquid cooling circuit, whilst others are cooled by a second so-called low-temperature liquid cooling circuit, these circuits
30 differing by the difference in temperature of the coolant entering said engine;

- at least one item of equipment, separate from said engine, which consumes thermal energy;

- means to recover at least part of the calories conveyed by the liquid in the high-temperature circuit, to supply heat to said equipment;

characterized by the fact that it consists of
5 recovering at least part of the calories conveyed by the liquid in the low-temperature circuit to supply heat to said equipment.

According to other advantageous, non-limiting characteristics:

- 10 - the high-temperature circuit supplies at least one item of the equipment, whilst the low-temperature circuit supplies at least one other item of equipment;
- the flow-rate of the liquid to supply said items of equipment can be adjusted as required.

15 Other characteristics and advantages of the present invention will become apparent on reading the following description of a preferred embodiment. This description is given with reference to the appended drawings in which:

20 - figure 1 is a simplified diagram of a first part of an installation assembly integrated in the ship according to the invention;

- figure 2 is also a simplified diagram of a second part of an installation assembly integrated in
25 the ship according to the invention.

With reference to figure 1, the dot-dashed line represents the delimitation of a diesel engine 1 equipping the ship.

Evidently, if there are a larger number of
30 engines, four for example, the assembly in figure 1 is duplicated the same number of times.

The circulation of the coolant in the so-called high-temperature circuit is shown as a solid line, whilst the circulation of the coolant in the so-called
35 low-temperature circuit is shown as a dotted line.

Also, the equipment positioned on these two circuits carries numerical references followed by the initials A or B, respectively corresponding to the high and low-temperature circuits.

5 Generally, in the whole of the description, the references VA, CL and VB respectively designate a shut-off valve, a flow control valve and a three-way regulating valve.

10 With reference to figure 1, reference 10A designates a hydraulic pump which ensures the circulation of a high-temperature coolant such as water within members encased in the engine 1, such as cylinders 11A and a stage 12A of a charge air cooler.

15 Pipes 100A and 101A is used for the transfer of liquid from one to another.

At the outlet of stage 12A of the charge air cooler, pipes 102A and 103A ensure evacuation of the coolant, which has been heated, to outside the engine and at this point, the temperature of the liquid is
20 servo-controlled to attain a predetermined value, 90° for example. For this purpose, at least one temperature sensor TT is positioned on the piping.

A heat exchanger 2 is connected at the engine outlet, in which a heat-exchange liquid circulates in
25 counter-flow direction, as will be seen below, which is intended to supply thermal energy to an item of ship equipment consuming this energy.

The pipes upstream and downstream of this exchanger 2 are denoted 104 and 106A.

30 A return loop 107A, via a valve VA, allows recycling of the liquid which is cooled when passing through the exchanger 2, towards the pump 10A.

Between pipes 103A and 104A, there is a three-way regulation valve VB and also a pipe 105 connected to
35 the above-mentioned return loop 107A.

This pipe 105 can belong to the means regulating the temperature of the coolant as it leaves the engine. Since it is connected to the return loop 107A, it can be used to « draw off » part of the cooled liquid
5 passing through this loop, for the purpose of bringing the liquid leaving the engine down to the controlled temperature. This temperature control is preferably achieved automatically, in particular in relation to temperature measurements taken by sensors, notably the
10 measurements taken by the above-mentioned sensor, aided by regulating valves VB.

The engine 1 is also provided with a second pump 10B, of the same type as the previous pump, connected via piping 100B to the second stage 13B of the above-
15 mentioned charge air cooler system. A coolant such as water also passes through this pump and this apparatus, this being a low-temperature cooling circuit.

At the outlet of equipment 13B, a pipe 101B delivers the liquid to an engine oil cooling system 14
20 and, via pipe 102B, conveys the heated liquid towards an exchanger 3, through which a heat-exchange liquid passes in counter-flow direction and which is coupled to an item of equipment consuming thermal energy.

According to one advantageous characteristic of
25 the invention, the temperature of the liquid in the low-temperature circuit is controlled on leaving the engine.

For this purpose, a three-way regulating valve VB positioned at the outlet of the exchanger 3 is used to
30 bypass part of the cooled liquid via a loop 103B.

As with the high temperature circuit, this control is preferably carried out automatically e.g. to obtain a regulated temperature of 50°C.

At the outlet of the exchanger 3, a pipe 106B is
35 coupled to a second exchanger 4 through which seawater

passes in counter-flow direction. The function of this exchanger is to further cool the coolant, if necessary, before it is re-circulated in the engine.

At the outlet of this second exchanger, a three-
5 way regulating valve VB is used to by-pass part of the liquid via pipe 109B to obtain the proper temperature at the inlet to the pump 10B, and hence at the outlet of the engine.

A water tank 5 is connected to pipe 109B. It is
10 used as thermal expansion means and for loading the installation.

It will be noted that just before the inlet into the second pump 10B, a branch line 111B is connected which conveys part of the coolant towards a third pump
15 10'B to which a cooling system for an alternator 15B is connected via pipe 112B. It is connected via piping 113B to the outlet of the above-mentioned exchanger 3. The reason for this connection after the exchanger 3 is that the temperature of the liquid leaving the
20 alternator is not sufficient for worthwhile heat recovery.

A pipe 104B is connected both onto pipes 102B and 107A and is used to inject liquid from the high-temperature circuit into the low-temperature circuit,
25 which increases the temperature of the liquid in the low-temperature circuit, and hence the quantity of recoverable energy.

Conversely, a second pipe 108A is connected to pipes 102B and 106A and is used to "draw off" part of
30 the liquid from the low-temperature circuit to inject it into the high-temperature circuit, so as to lower the temperature of the liquid in the latter before it is re-circulated in the engine.

As already pointed out, the temperature of the coolant in the low-temperature circuit is regulated on leaving the engine 1.

This regulated temperature is in the order of 50°
5 for example.

In this manner, we have a liquid that is always of the same temperature, and therefore the energy that can be recovered will always be optimum irrespective of engine load.

10 On the other hand, the temperature of the liquid which returns to the related pump is of variable temperature. However, this is not detrimental since the engine equipment through which this liquid passes can withstand such a variation in temperature.

15 A second part of the installation can be seen figure 2. Only that part of the installation relating to energy recovery on the low-temperature circuit is illustrated. The part relating to energy recovery on the high-temperature circuit is identical and is not
20 illustrated for reasons of simplification.

Four exchangers 6 are shown: these are the exchangers that are associated with the four engines equipping a ship.

This installation essentially comprises two
25 hydraulic pumps 7, through which water passes which, via a set of pipes 122, 123 and 124 passes through a couple of exchangers in counter-flow direction.

In the same way, an additional pipe 137 is connected onto pumps 7 and, via a pipe 136, serves two
30 other exchangers 6B.

The outlet pipes 125, 126 and 139 from the exchangers 6 are connected to a twin pipe 127 which communicates with heaters 8 supplied with steam. These heaters are used, if necessary, to supply additional
35 calorific energy to the liquid heated inside exchangers

6. This steam is generally derived from recovery boilers installed on the exhausts of the diesel engines, or from a fired boiler.

Pipes 128 and 129 are connected via pipes 130,
5 131, 133 and 134 to exchangers 9 et 9', which are associated with items of the ship's equipment consuming thermal energy.

The valves VA'' which equip these exchangers are designed to cause the flow-rate of the liquid to vary
10 inside the exchangers, in relation to energy demand.

The return pipes 132 and 135 as well as 140 are used to bring the cooled liquid back towards the pumps
7.

One advantageous characteristic of the invention
15 is therefore that the recovery circuit operates at "variable flow-rate", making it possible for the temperature of the return liquid to be relatively cool, irrespective of calorie demand by consumer equipment 9, 9'. On this account, recovery of energy at the
20 exchangers 2 or 3 is always optimum.

Those items of consumer equipment requiring a high water temperature are connected on the high temperature recovery loop.

These items may be, for example, a boiler, a
25 system to heat ambient air or a system to heat sanitary water.

On the low-temperature recovery loop, the items of equipment connected are those which require water of average heat.

30 These may be a system to heat swimming-pool water or a pre-heating system for air-conditioning.

With the device of the present invention, the recovery of thermal energy on diesel engines is optimized.

35 This therefore allows savings on fuel.

Without this system, the steam required to heat all energy-consuming items is derived either from recovery boilers or from fired boilers, the latter being fuel-consuming equipment.

5 The ship's energy balance is thereby largely improved.

CLAIMS

1. Ship equipped with:

- at least one diesel engine (1) of which some internal parts (11A, 12A), even external parts,
5 are cooled by a first liquid cooling circuit, called a high-temperature circuit, whilst others (13B, 14B, 15B) are cooled by a second liquid cooling circuit called a low-temperature circuit, these circuits differing by the difference in temperature of the liquid entering
10 said engine (1),

- at least one item of equipment (9, 9'), separate from said engine (1), which consumes thermal energy,

- recovery means (2) to recover at least part of the calories conveyed by the liquid in the high-
15 temperature circuit, to supply thermal energy to said items of equipment (9, 9'),

characterized by the fact that it further comprises recovery means (3) to recover at least part of the calories conveyed by the liquid in the low-
20 temperature circuit, to supply thermal energy to said items of equipment (9, 9').

2. Ship according to claim 1, characterized by the fact that it comprises at least two items of
25 equipment, at least one being thermally supplied by the high-temperature circuit, whilst the other (9, 9') is thermally supplied by the low-temperature circuit.

3. Ship according to claim 2, characterized by
30 the fact that said item of equipment (9, 9') thermally supplied by the low-temperature circuit notably consists of an installation to heat air, an installation to heat water, a system to heat swimming-pool water.

4. Ship according to any of the preceding claims, characterized by the fact that it comprises means to regulate the temperature of the coolant in the low-temperature circuit, as it leaves the engine (1).

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5. Ship according to any of the preceding claims, characterized by the fact that said recovery means (2, 3) comprise at least one heat exchanger within which a liquid to be heated is circulated.

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6. Ship according to claim 5, characterized by the fact that it comprises flow control means (VA") to adjust the flow-rate of said liquid thermally supplying said equipment.

15

7. Process to recover thermal energy within a ship which is equipped with:

- at least one diesel engine (1) of which some internal parts (11A, 12A), even external parts, are cooled by a first liquid cooling circuit called a high-temperature circuit, whilst others (13B, 14B, 15B) are cooled by a second liquid cooling circuit called a low-temperature circuit, these circuits differing by the difference in temperature of the liquid entering said engine (1),

25

- at least one item of equipment (9, 9'), separate from said engine(1), which consumes thermal energy,

- recovery means (2) to recover at least part of the calories conveyed by the liquid in the high-temperature circuit, to supply heat to said items of equipment (9, 9'),

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characterized by the fact that it consists of recovering at least part of the calories conveyed by the liquid in the low-temperature circuit, to supply heat to said items of equipment (9, 9').

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8. Process according to claim 7, characterized by the fact that the high-temperature circuit supplies at least one item of equipment, whilst the low-temperature circuit supplies at least one other item of
5 equipment (9, 9').

9. Process according to either of claims 7 and 8, characterized by the fact that the flow-rate of the liquid supplying said items of equipment can be
10 adjusted as required.