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Modeling the Greasing System for Naval Engine

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Abstract. The two-stroke internal combustion engine used in cargo ships, due to regulations imposed by international conventions and classification societies, is subject to continuous technical evolution in order to reduce manufacturing, operating, and operating costs, ensuring a degree of reliability high and the elimination of pollutant emissions. The lubrication system of the main propulsion engine supports improvements resulting from the calculations of the sizing of the elements of the installation and the choice of automatic variants for measuring, adjusting and controlling the parameters of the lubricating oil.

Keyword: two-stroke internal combustion, lubrication system, controlling parameters.

1. Introduction

The internal combustion engine is a thermal machine that aims to transform thermal energy into mechanical energy. The second principle of thermodynamics states that there can be no processes in which heat can be transformed into mechanical work without inevitable losses to the environment (cold source).
The amount of heat that is released depends on the theoretical cycle of the engine, which is a thermodynamic, simplified scheme of the engine operating cycle with no heat loss other than the inevitable transfer to the cold source. The elaboration of the theoretical cycles and their study allow the establishment of the limit of the use of heat in different cycles and the comparison of the economics of the different thermal cycles.
The thermal calculation takes into account the establishment of the state parameters, characteristic of the thermal processes in the engine, with the help of which the indicated diagram of the operating cycle will be drawn to determine the main characteristic sizes of the chosen engine.

The kinematic calculation accurately shows the displacement, speed and acceleration of the components of the engine mechanism. The dynamic calculation shows the degree of stress of the engine produced by the pressure forces and the inertia forces.
The elements of the pressure force such as the diameter of the piston and the pressure in the cylinder at a certain degree of the angular position of the crank are decisive for the calculated values. The two-stroke internal combustion engine used in cargo ships, due to regulations imposed by international conventions and classification societies, is subject to continuous technical evolution in order to reduce manufacturing, operating and operating costs, ensuring a degree of reliability high and the elimination of pollutant emissions. The lubrication system of the main propulsion engine supports improvements resulting from the calculations of the sizing of the elements of the installation and the choice of automatic variants for measuring, adjusting and controlling the parameters of the lubricating oil.

The existence of friction and wear between the friction torques of the internal combustion engine favors the occurrence of consequences such as heating and various types of wear with a major impact on the condition of the contact surfaces of the torques. To overcome friction, a quantity of energy is consumed, a significant part of which is transformed into heat. Improper operation of the friction between the contact surfaces leads to an increase in the speed and load of the temperature to the melting point of one of the basic elements of the torque, while proper operation regulates the internal combustion engine temperatures at a normal thermal regime where games, power, and performance fall within the preferred range. Adhesion, abrasion, fatigue, and corrosion are the most common types of wear that act on the engine elements causing significant damage. The negative effects resulting from rubbing and wear by means of a lubricant present between the surfaces in contact are considerably reduced. The formation of the oil film between the friction torques is ensured by the engine lubrication system.

2. Modeling the lubrication system for an internal combustion engine

The lubrication system analyzed is an installation with a dry crankcase under pressure characterized by: the existence of a service tank outside the engine where the oil accumulates gravitationally from the crankcase and the circulation of the oil under pressure by the suction pumps. The components that make up the installation are an oil storage tank, service tank, suction pumps, piping, oil cooler, oil filter, and devices for measuring, controlling, and adjusting the operating parameters of the oil. The role of the installation is to achieve the conditions for the formation of fluid friction between the torques with relative movement of the motor mechanism to achieve: decrease the force required to overcome friction, reduce the temperature resulting from friction, protect surfaces against wear, and evacuate a significant amount of heat. Proper operation of the lubrication system must be considered for a long service life of the engine.

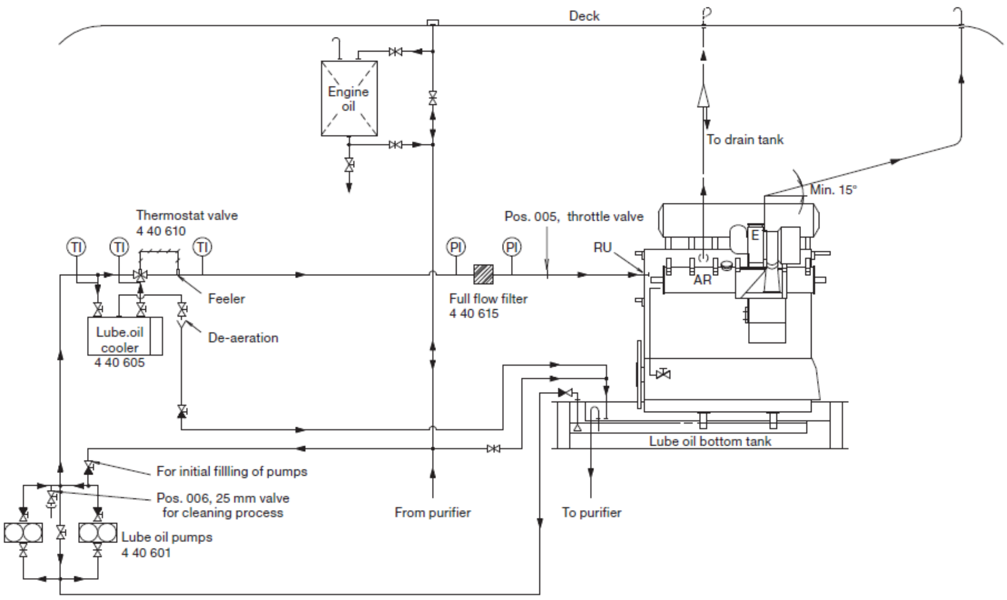

Fig.1. Diagram of MAN KSZ 105/180 engine lubrication system

In the diagram of the lubrication system in Figure 1, the oil is pumped from the oil tank under the engine by means of gear pumps (4 40 601), to the heat exchanger (4 40 605), the thermoregulating valve (4 40 610), main filter (4 40 615) inside the engine through the RU hole. From this point the oil is used to achieve the fluid friction regime between the following couplings: the bearing shaft and the bearings of the bearings, the crankshaft and the bearing of the connecting rod foot, the spindles of the crosshead and the bearings of the connecting rod, the friction surfaces of the cross head skids and slides and for cooling the piston.

2.1. Calculation of lubricating oil pumps

The pump defined as a machine that performs the passage of mechanical energy received from the source of hydraulic energy of the conveyed fluid, in a plant is required to ensure the necessary energy parameters (flow, pressure) and a number of qualities valid for the field used (safety in operation, ensuring the required hydraulic parameters, simple maintenance).
The pumps that transport the lubricant to the engine lubrication system are geared pumps whose operating principle is based on the volume variation of the agent conveyed by the working member in its rotational motion.
Figure 2 illustrates a gear pump with the notations: 1 - drive wheel, 2 - driven wheel, 3,4 - shafts, 5,6 - wedges, 7 - threaded holes, Oa - suction hole, Ca - suction chamber, Cr - discharge chamber, Or - discharge hole, ω1 - angular velocity of the drive wheel, ω_2 - angular velocity of the driven wheel, a, b, c, d, a ', b', c ', d' - wheel teeth teeth. The two wheels in rotating motion with the angular velocities (ω_1) and (ω_2) respectively in the direction shown in the figure, will act in the working chambers transforming the mechanical energy received from the shaft of the driving wheel into energy of the transported fluid.
By taking a volume of fluid from the suction chamber by the working organs equal to the volume between the teeth (a-b) and ("a'-b ')", a depression is created in this chamber as a result of the increase in volume causing the penetration. of fluid from the suction port (Oa) into the suction chamber (Ca). In the other chamber (Cr) pin the fluid supply equal to the volume between the teeth (c-d) and ("c'-d ')" there is an increase in pressure due to the incompressibility property of the fluids, thus achieving the penetration of the liquid into the orifice, discharge (Oz).

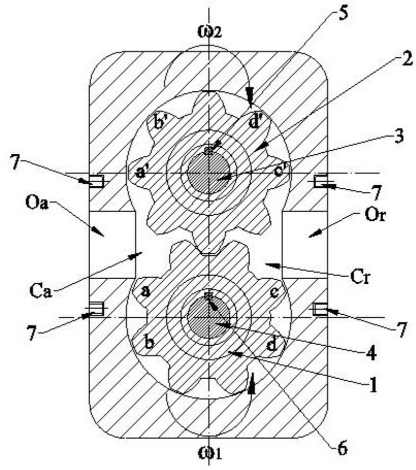

Fig. 2. Cross section of a gear pump.

To calculate the parameters of a gear it is necessary to know:

a. mode m, value that determines the size of the teeth;

b. the number of Z teeth, which show the size of the wheel.

Module m represents the ratio between step p and the number π, parameter with standardized values: I choose the module m = 18, and the number of teeth was chosen Z = 24. For this type of gear the specific displacement coefficient x = 0, which assumes that the reference line is tangent to the dividing circle. The discharge pump flow rate is determined by the relation:

$$Q_r = q \cdot P \qquad (1)$$

where:

q - specific flow,

P - engine power.

The value q is chosen based on experimental data, where in the case of high power motors with a high degree of load q = (2…10)[l/hp.h].

2.2. Heat exchanger modeling

The heat exchanger is a device in which heat exchange is exchanged between heat-carrying fluids due to the difference in temperature between them. The conditions that such a device must satisfy are: ensuring a heat exchange as intense as possible between thermal agents, observing the temperature regime required by the technological process, raising safety, security and reliability in operation and making the device in a construction simpler, more compact, and economical in terms of investment and operation.

When the two thermal agents pass through the apparatus, the heat exchange takes place from the higher temperature agent (primary) to the lower temperature agent (secondary), thus changing their initial temperatures during the exchanger until the fluids come out, working temperatures have the desired temperatures. The primary agent has the inlet through the connection (3) circulates to the outside of the pipe bundles in the apparatus and the discharge through the connection (4), while the secondary agent has the inlet through the connection (1) circulates inside the pipe bundles through the apparatus and the outlet through the connection (2).

The heat exchanger (4 40 605) in Fig. V.1 is a tubular cooler in which the primary agent is the engine lubricating oil and the secondary agent is most of the time seawater. The amount of heat dissipated by the cooler (4 40 605) is determined by the relation:

$$Q = k \cdot A_{rac} \cdot \Delta t \qquad (2)$$

Where:

Q – is the amount of heat discharged by the cooler,[kcal/kW.h]

k - heat transfer coefficient of the cooler, [kcal/m^2 grd h];

A_{rac} - area of the cooler surface, bathed by cooling water,[m^2];

Δt - logarithmic mean temperature difference,[C].

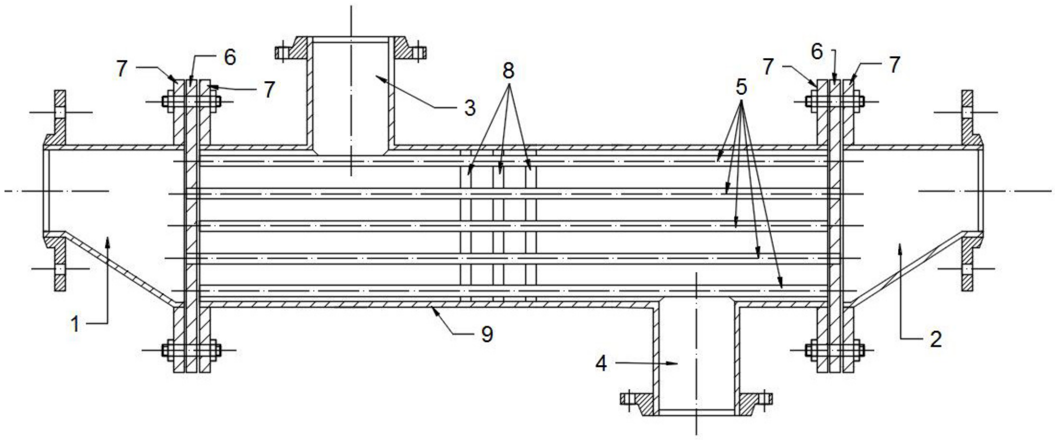

Fig.3. Longitudinal section of a heat exchanger:
1 - connection for the admission of the thermal agent in the appliance, 2 - connection for the evacuation of the thermal agent from the appliance, 3- connection for the admission of the thermal agent circulating outside the pipes, 4- connection for the evacuation of the thermal agent circulating outside the pipes, 5- pipes, 6- tubular plate, 7- flange, 8- pipe support, 9- jacket.

The amount of heat dissipated in the oil is chosen:

$$Q_{CPh} = 80 \text{ [kcal/kW·h]}$$

For the calculation example engine MAN KSZ 105/180 A with P_e= 27540,848 [kW]::

$$Q = Q_{CPh} \cdot P_e = 28070,481\ 80 = 2245638,48 \text{ [kcal/h]} \quad (3)$$

Heat exchanger surface, cooled by cooling water:

$$A_{rac} = \frac{Q}{k \cdot \Delta t} = \frac{2245638,48}{990 \cdot 20} = 113,416 \text{ [m}^2\text{]} \quad (4)$$

For ordinary heat exchangers, the thickness of the pipe walls varies between (0.5… 2.5) [mm] and their diameter (12… 50) [mm]. For a number of cooler pipes n = 277 and their inside diameter di = 0.035 [m] determine the length of the pipes:

$$L = \frac{A_{rac}}{n \cdot \pi \cdot d_i} \quad (5)$$

Where:

A_{rac} – is the area of the cooler surface, bathed by cooling water, [m^2];
n - number of pipes of the cooler;
di - inner diameter of pipes, [m].

$$L = \frac{113,416}{277 \cdot 3,14159 \cdot 0,035} = 3,724 \text{ [m]} \quad (6)$$

To determine the inside diameter of the heat exchanger, the following relation is used:

$$D_0 = 0,635 \cdot \sqrt{\frac{A_{rac} \cdot d_e}{L \cdot \psi}} \cdot \beta_1 \beta_2 \cdot \sin(\varphi), \text{ [m]} \quad (7).$$

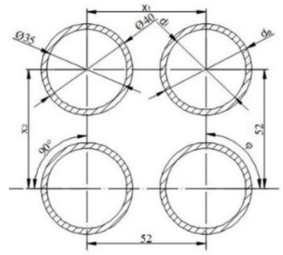

Fig.4. Pipe beam characteristics.

Where:

A_{rac} - heat exchange surface,[m^2];
de - outer diameter of pipes, [m];
L - length of pipes, [m];
ψ - coefficient of proximity of the inner surface

d_e=0,040 [m]; ψ=0,8 [-].

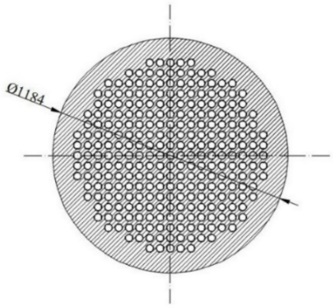

Fig.5. Laying the pipes on the tubular plates in a square grid.

Conclusions

The lubrication system serves the main propulsion engine to reduce mechanical friction, to increase the wear resistance of the friction parts and to cool the engine. The calculation of this installation provides essential data for the correct sizing of the elements of the installation. The calculations may result in specifications: lubrication pump, piping, service tank, oil cooler and main oil filter.

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