ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE XI – SHIPBUILDING. ISSN 1221-4620
2015

CONSIDERATIONS ON THE COOLING SYSTEMS FROM NAVAL DIESEL ENGINES

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ABSTRACT

Cooling liquids used in cooling systems from naval Diesel engines are subjected to important processes like the cavitations process. These processes involve studies concerning coolants, additives used for coolants, materials used for manufactured cylinder liners, cylinder block and functional parameters from Diesel engines. Water is the most used liquid for naval cooling systems. The cavitations process is seen in different domains such as hydro and thermal energy, nuclear technologies, chemical industry, where there are liquids in movement which are influenced by the mechanical properties of the liquid.

Keywords: cooling system, naval Diesel engine, cavitations processes, cylinder liner, cylinder block.

1. INTRODUCTION

Every liquid is characterized by density, viscosity, adhesion on solid surfaces, compression resistance, superficial tension, elasticity, thermal conductivity, absorption and gas emission.

The limit pressure when cavitations processes occur, named cavitations limit, depends on a lot of parameters, such as: salts and dirties dissolved in water cooling systems, temperature pressure and superficial tension of the cooling liquid.

There is a "negative" pressure for each liquid, rightly determined when the rupture of liquid appears. For example, the volumetric resistance for pure water is 1000 MPa, for water prepared for a cooling system is 27 - 28 MPa and for the distilled water which comes in contact with atmosphere only few units of MPa.

From a chemical point of view, cavitational process is dependent on the quantity and the size of gas bubbles and different salts and dirties. The liquids used in naval cooling systems have the tendency to absorb exhaust gases that come in coolants by leaks.

The bubbles growing process represents a thermodynamic based process, with specific shapes on boiling and cavitation. The occurrence of steam bubbles creates a new interface liquid - steam, that leads to the consumption of the mechanical power. So, the liquid that is in the position A_1 can be transformed in the status corresponding to the point A, which is situated under normal vaporization curve by tension liquid (without vaporization of cooling liquid). (Figure 1). When the liquid tension reaches a critical value (cavitation limit), in the cooling liquid ruptures appear or a lot of cavitation bubbles.

Cavitation and boiling differ by the way in which they reach metastable state A and by the further evolution character of the formed bubbles, in the cavitation case, and by the thermal transfer, in the boiling case. So, in the cavitation case, the appearance of the bubbles is due to the reduction of the local pressure (below the vaporization value p_v) due to the motion of the liquid with certain speed. The steam bubbles are transported by the cooling liquid into the region where the pressure is bigger than the vaporization pressure (interior pressure of the bubble). So, the subsidence of wall cavities occurs at their interior. In Table 1 the variations of vaporization pressure are presented function of water temperature.

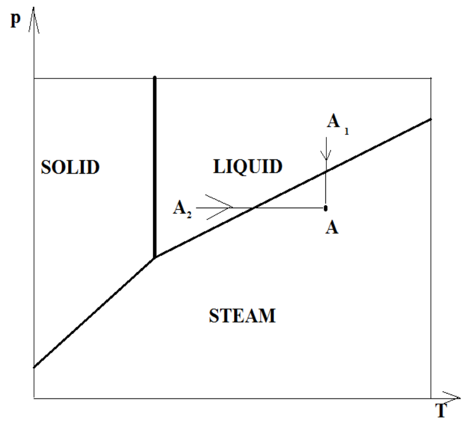

Fig.1. Phase diagram

Table1. Pressure variation with vaporization temperature

t, [°C]	0	10	20	30
p_v/γ	0.062	0.152	0.238	0.433
t, [°C]	40	60	80	100
p_v/γ	0.752	2.031	4.828	10.33

(p – water pressure; γ – water specific weight)

According to [1], cavitation may be explained by four hypotheses:

1. **Mechanical hypothesis** - consists in strong noise and great local pressure values; this hypothesis cannot explain why the materials with lower mechanical resistance are more resistant to cavitation than materials with strong resistance (for example, bronx than steel);
2. **Chemical hypothesis** - consists in destroying materials by the chemical effect; this hypothesis shows that water steam and gases release the atomic oxygen (from the chemical point of view) that will corrode the metal;
3. **Thermodynamic hypothesis** - this hypothesis will associate the appearance of great values of temperature (thousands of degrees) determined by the condensation of steam that will make the metal lose its resistance.
4. **Thermodynamic hypothesis** - explains the appearance and the development of the cavitation process with the potential difference between gas bubbles and cooling liquid.

The main cause for the appearance of steam bubbles is represented by the strong vibrations of cylinder liners from Diesel engines, associated with the vortex effect which occurs when coolant liquid meets obstacles when flowing inside the engine cooling space or with no uniform wall [2].

The cavitational process is accompanied by chemical phenomena (because chemical corrosive substance is formed), acoustical phenomena (strong noises) and mechanical phenomena (strong vibrations). In the collapse area of the steam bubbles, on the solid surface, corrosion effects appear as material separations (caverns) of irregular depth and contour.

The cavitation process is studied in cavitation tunnels. The behaviour of the materialduring the cavitation process, in different environmental conditions and for different cooling liquids, is investigated on magneto-striction installations. Figure 2 and Figure 3 [4] present the experimental installation developed at "Dunarea de Jos" University of Galati. The parameters of this installation are similar to the parameters of the naval Diesel engine.

2. EXPERIMENTAL STUDY

In Figure 2 the experimental installation based on D-103 Diesel engine is presented. This installation is used for determining the main parameters of cylinder liner vibrations (acceleration and displacement) in five points.

Figure 3 shows the scheme of the experimental installation with the following component elements: 1 - fuel tank; 2 - fuel level indicator; 3 - water expansion tank; 4 - water level indicator; 5 - fuel valve; 6 - fuel filter; 7- fuel pipeline; 8 -valve with three ways; 9 - fuel pipeline; 10 -scales; 11- fuel bowl; 12- fuel feed pipeline; 13 - fuel feed pump; 14 - injection pump; 15 - fuel filter; 16 - short circuit valve; 17- Diesel engine.

Fig.2 View of the experimental installation

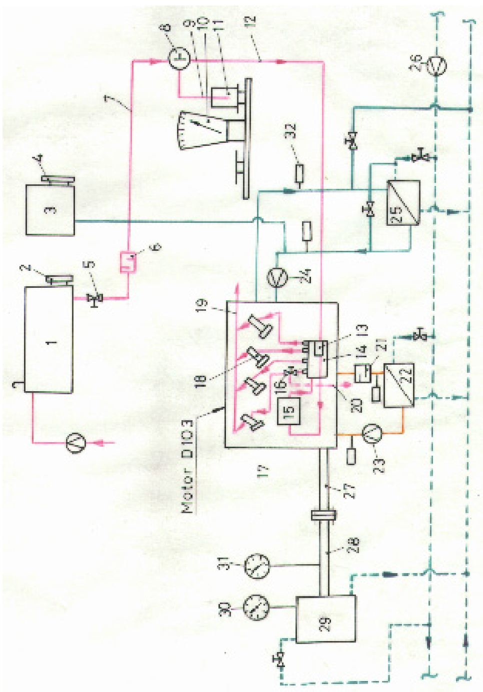

Fig 3. Experimental stand scheme for the study of the cavitational process

18 - injector; 19 - retur pipeline; 20 - fuel leakage pipeline; 21 - oil pipeline; 22 - oil cooler; 23 - oil cooling pump; 24 - water cooling pump; 25 - water cooler ; 26 - cooling water pump from the external circuit; 27 - crankshaft; 28 - hydraulic brake shaft; 29 - hydraulic brake; 30 - hydraulic brake indicator; 31 - speed rotation indicator.

In Figure [4], the scheme of the cooling system of D-103 Diesel engine is presented with the following component elements: 1- cooling water pump; 2 - thermoregulatory valve; 3 - cooling space of the cylinder head; 4 - cooling space of the cylinder block; 5 - water leakage valve; 6 - transmission for water pump from the engine crankshaft. For performing vibration measurements on the cylinder liner and on the cylinder block, leak-proof passage has been performed in order to to make possible the connection of piezoelectric transducers.

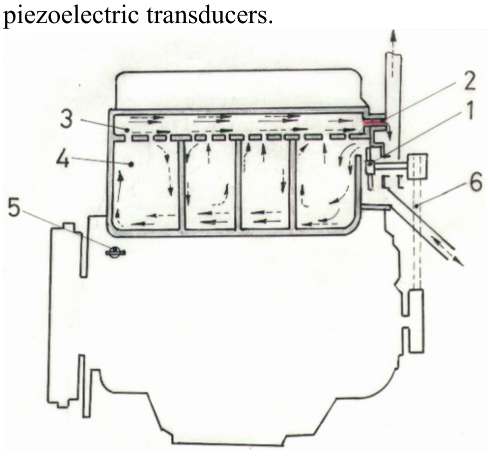

Fig.4. The cooling system of D-103 Diesel engine [5]

2. COMMENTS ON DIESEL ENGINE CYLINDERS AFFECTED BY CAVITATION

In Figure 5 and Figure 6 two examples of cylinder liners affected by cavitation damage are presented. The cylinder liner of Diesel engine 6 D 50 M is used as auxiliary Engine on board of "Altay" ship that has water inlet and outlet areas (top and bottom areas of the cylinder liner) after 10000 hours in operation.

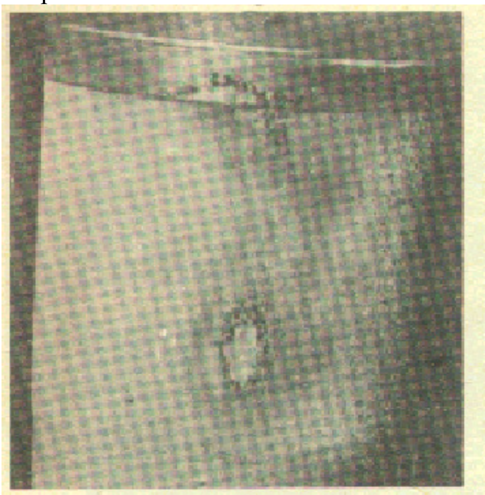

Fig.5. Damage by cavitation on cylinder liners from Diesel engine 6 D 50 M [6]

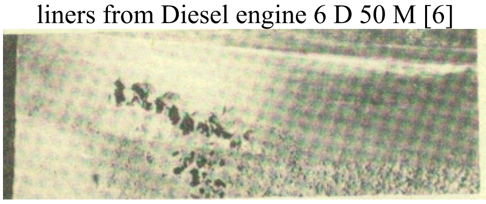

Fig.6. Damage by cavitation on top area of the cylinder liners from Diesel engine 6 D 50 M after 10000 hours [6].

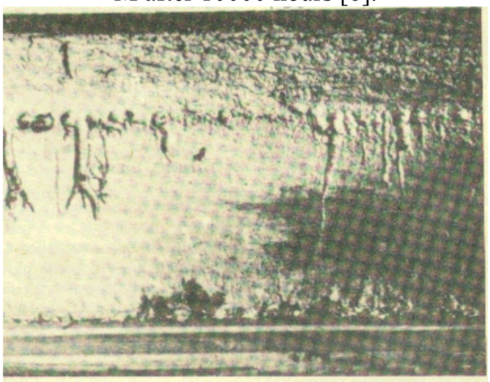

Fig.6. Damage by cavitation on bottom area of the cylinder liners from Diesel engine 6 D 50 M after 10435 hours [6].

4. CONCLUSIONS

1) In technical literature, especially in the last years, the cavitation processes of Diesel engines were less approached.
2) Encountered in many areas (chemical industry, nuclear technology, hydro-energetic field, thermo-energetic area, etc.), these domains are widespread in Diesel engines area, leading to intense wear on the external surfaces of the cylinder lines. In some cases, it was found that the damage on the external surfaces cooled by water is three-five times bigger than on the internal surfaces that come in contact with the piston rings.
3) Due to the nature of the system components (fixed element - cylinder block and mobile element - cylinder liners), the nature of interposed liquid and the nature of vibration movement, the cavitation process can be studied in laboratory on experimental models.

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Paper received on December 14th, 2015