FUEL CONSUMPTION STUDY FOR AUXILIARY ENGINES THAT EQUIP AN OIL TANKER

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ABSTRACT

The paper deals with an oil tanker whose propulsion system with internal combustion engine during navigation was investigated. For a power plant with internal combustion engines we distinguish the subsystems: the internal combustion engine; consumer (s); mechanisms and auxiliary installations of the internal combustion engine power plant. The energy required for the proper functioning of the energy system is provided by the engines it is equipped with. During the voyage, the ship has several conditions for navigation, and the main engine and auxiliary machinery do not work all the time on the same charge.

KEYWORDS: auxiliary machinery, fuel consumption, internal combustion engine, voyage, oil tanker

1. Introduction

The operating mode of the propulsion engine depends on: the type of ship, navigation conditions, ship body construction, propellant type, on the mode of transmission of energy from the engine to the propeller.

In the paper is calculated the fuel consumption of auxiliary engines that equip a ship.

The measurements were made on an oil tanker equipped with a single propeller.

2. Case study

We must take into account the fact that during a voyage the ship has more navigational situations and the main engine and auxiliary machinery do not always work at the same load.

The propulsion of the ship is provided by a six-cylinder MAN B & W Diesel Engine.

Engine power 9480 [kW], engine speed 127 [rpm]; ship speed 15.38 [Nd].

The ship is equipped with three Diesel generators, each of 6 cylinders in line 960 kW power, 900 rpm.

The main engine of a ship is the main fuel consumer and the major energy producer on board ships.

For a naval propulsion plant with internal combustion engines, an independent variable which gives its operating regimes is considered.

The study was conducted for several operating modes for full load and ballast. Ballast tanks are built into the hull of a ship in order to help maintain its stability by filling them with seawater.

We calculated the fuel consumption for auxiliary engines for each navigation situation (a. ship's march; b. loading the ship; c. maneuvers through straits; d. stationary with loading; e. stationary with unloading) [1].

a. $$P_{MA,1} = \mu_{MA,1} \cdot P_{e,MA} \cdot 2 \text{ [kW]} \quad (1)$$

- $\mu_{MA,1}$ = 0.47 - the charge coefficient of the auxiliary motors;

$$\dot{m}_{MA,C,1} = P_{MA,1} \cdot CS_{MA,C} \text{ [kg/h]} \quad (2)$$

- $\dot{m}_{MA,C,1}$ - fuel consumption of auxiliary engines

- $CS_{MA,C}$ - specific fuel consumption of auxiliary motors = 0.180 [kg / kW.h] [5]

$$\tau_{MA,m,1} = \tau_{m,7} + \tau_{b,3} \text{ [h]} \quad (3)$$

$\tau_{m,7}$ - the time of march to the port of origin;

$\tau_{b,3}$ - the march time to the destination port;

$\tau_{MA,m,1}$ - the number of engine operating hours;

$$CC_{MA,1} = \dot{m}_{MA,C,1} \cdot \tau_{MA,m,1} \cdot 10^{-3} \text{ [t]} \quad (4)$$

$CC_{MA,1}$ - fuel consumption of auxiliary engines;

b. $$P_{MA,2} = \mu_{MA,2} \cdot P_{e,MA} \cdot 2 \text{ [kW]} \quad (5)$$

$\mu_{MA,2}$ = 0.495 - the charge coefficient of the auxiliary motors;

$$\dot{m}_{MA,C,2} = P_{MA,2} \cdot CS_{MA,C} \text{ [kg/h]} \quad (6)$$

$\dot{m}_{MA,C,2}$ - hourly fuel consumption of auxiliary engines;

$$\tau_{MA,m,2} = \tau_{m,i} + \tau_{b,i} \text{ [h]} \quad (7)$$

$\tau_{MA,m,2}$ - the number of operating hours of the auxiliary motors;
$\tau_{m,i}$ - running time of auxiliary engines (full load);
$\tau_{b,i}$ - operating time of auxiliary motors (ballast);

$$CC_{MA,2} = \dot{m}_{MA,C,2} \cdot \tau_{MA,m,2} \cdot 10^{-3} \text{ [t]} \quad (8)$$

$CC_{MA,2}$ - fuel consumption of auxiliary engines (freight loading march);

c. $$P_{MA,3} = \mu_{MA,3} \cdot P_{e,MA} \cdot 2 \text{ [kW]} \quad (9)$$

$\mu_{MA,3}$=0.625 - the charge coefficient of the auxiliary motors;

$$\dot{m}_{MA,C,3} = P_{MA,3} \cdot CS_{MA,C} \text{ [kg/h]} \quad (10)$$

$\dot{m}_{MA,C,3}$ - hourly fuel consumption of auxiliary engines;

$$\tau_{MA,m,3} = \tau_{m,s} + \tau_{b,s} \text{ [h]} \quad (11)$$

$\tau_{MA,m,3}$ - the number of operating hours of the auxiliary motors;
$\tau_{m,s}$ - running time of auxiliary engines (full load);
$\tau_{b,s}$ - running time of auxiliary engines (ballast) (maneuver through straits).

$$CC_{MA,3} = \dot{m}_{MA,C,3} \cdot \tau_{MA,m,3} \cdot 10^{-3} \text{ [t]} \quad (12)$$

$CC_{MA,3}$ - fuel consumption of auxiliary engines;

d. $$P_{MA,4} = \mu_{MA,4} \cdot P_{e,MA} \cdot 2 \text{ [kW]} \quad (13)$$

$\mu_{MA,4}$ - 0,420- the charge coefficient of the auxiliary motors;

$$\dot{m}_{MA,C,4} = P_{MA,4} \cdot CS_{MA,C} \text{ [kg/h]} \quad (14)$$

$\dot{m}_{MA,C,4}$ - fuel consumption of auxiliary engines;

$$\tau_{MA,m,4} = \tau_{m,6} + \tau_{b,2} \text{ [h]} \quad (15)$$

$\tau_{MA,m,4}$ - the number of operating hours of the auxiliary motors;
$\tau_{m,6}$ - the loading time in the port of destination;
$\tau_{b,2}$ - the loading time in the port of origin;

$$CC_{MA,4} = \dot{m}_{MA,C,4} \cdot \tau_{MA,m,4} \cdot 10^{-3} \text{ [t]} \quad (16)$$

$CC_{MA,4}$ - fuel consumption of auxiliary engines;

e. $$P_{MA,5} = \mu_{MA,5} \cdot P_{e,MA} \cdot 2 \text{ [kW]} \quad (17)$$

$\mu_{MA,5}$ = 0.8 - the charge coefficient of the auxiliary motors;

$$\dot{m}_{MA,C,5} = P_{MA,5} \cdot CS_{MA,C} \text{ [kg/h]} \quad (18)$$

$\dot{m}_{MA,C,5}$ - fuel consumption of auxiliary engines;

$$\tau_{MA,m,5} = \tau_{m,5} + \tau_{b,8} \text{ [h]} \quad (19)$$

$\tau_{m,5}$ - download time in the port of destination;

$\tau_{b,8}$ - download time in the port of origin;

$\tau_{MA,m,5}$ - the number of operating hours of the auxiliary motors;

$$CC_{MA,5} = \dot{m}_{MA,C,5} \cdot \tau_{MA,m,5} \cdot 10^{-3} \text{ [h]} \quad (20)$$

$CC_{MA,5}$ - fuel consumption of auxiliary engines (stationary unloading);
$CS_{MA,C}$ - specific fuel consumption of auxiliary engines = 0.180 [kg/kW.h];

Fuel consumption of auxiliary engines on voyage:

$$CC_{MA,total} = CC_{MA,1}+CC_{MA,2}+CC_{MA,3}+CC_{MA,4}+CC_{MA,5} \quad (21)$$

Fuel consumption of auxiliary engines (annual):

$$CC_{MA,total,an} = CC_{MA,total} \cdot N_v \quad (22)$$

The calculations were made based on a program in Engineering Equation Solver.
Figure 1 shows the ship's speed (load and ballast). In Table 1 are presented the results obtained for the fuel consumption of auxiliary machines for several navigation situations.

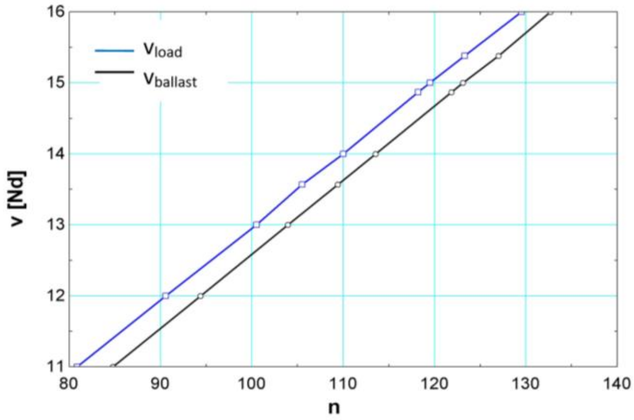

Fig. 1. *Speed of the ship*

Table 1. *Fuel consumption for the studied navigation situations*

Regime	CCMA;tot [t/voiaj]	CCMA,1 [t]	CCMA,2 [t]	CCMA,3 [t]	CCMA,4 [t]	CCMA,5 [t]
regime 1	98,870	85,390	2,737	2,592	2,423	5,722
regime 2	97,990	84,520	2,737	2,592	2,423	5,722
regime 3	93,175	79,700	2,738	2,592	2,423	5,722

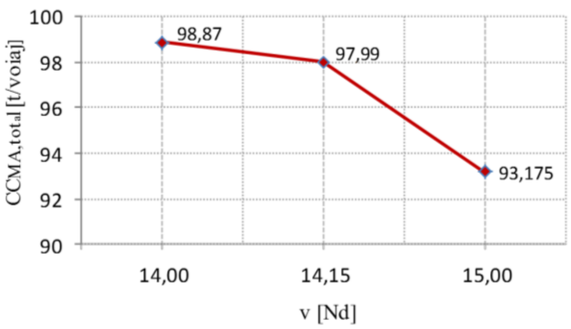

Fig. 2. *Fuel consumption*

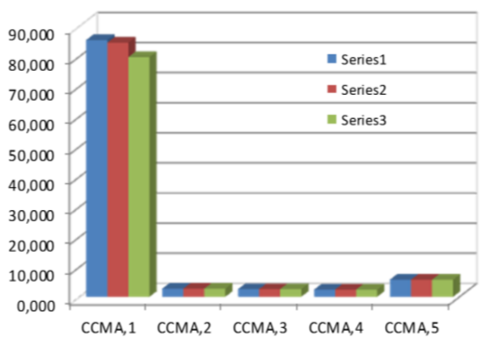

Fig. 3. *Fuel consumption for the studied navigation situations*

3. Conclusions

The fuel consumption of the auxiliary engines is the lowest for operating at speed v = 150 [Nd].

For the operating mode with: speed of the ballast ship vb = 15 Nd, the fuel consumption is: CCMA, total = 93,175 [t/voyage]. The calculations were made based on a program in Engineering Equation Solver.

The vessel must operate at the parameters for which it was designed and built, thus meeting all technical and economic requirements.

References

[1]. Lupchian Mariana, *Analysis of the operating regimes of power plants for different situations naval navigation*, SECTION I – Navigation and Maritime Transport, Constanţa Maritime University Annals, vol. 19, p. 51, Editura Nautica, 2013.

[2]. Lupchian Mariana, *The profit made by a oil tanker after a voyage*, CIEI 2011, The 8th International Conference On Industrial Power Engineering, Aprilie 14-25, ISSN-L 2069-9905, Bacău, 2011.

[3]. Simionov Mihai, *Instalaţii de propulsie navale. Linii de arbori*, Editura Evrika, Brăila, 2001.

[4]. ***, *The Motor Ship, Waste management is a grey area for owners*, 2001.

[5]. Simionov M., *Instalaţii de propulsie navală*, Galati University Press, 2009.

[6]. Ceangă V., Mocanu C. I., Teodorescu C., *Dinamica sistemelor de propulsie*, Editura Didactică şi Pedagogică, Bucuresti, 2003.