

Analysis regarding the reduction of the amount of fuel used in the combustion process to reduce polluting emissions

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Abstract. In the paper, the consumption of fuels and lubricants is calculated according to the operating regimes of the naval energy installation. Consumption was analyzed from the perspective of reducing polluting emissions. The fuel and lubricating oil for the main engine and auxiliary engines were determined. The study was done for several navigation situations.

Keywords. Diesel engine, fuel consumption, pollutant emissions, auxiliary engines

1. Introduction

Shipping can affect the aquatic environment by polluting the water with chemicals and waste.

Chemical pollution, the multiplication of shipping lanes, the noise produced, disruption of aquatic ecosystems, and accidental discharges affect the marine environment [4].

Land transport, sea transport, and air transport are responsible for the production of pollutants resulting from the burning of fossil fuels.

Diesel oil can hurt the environment through greenhouse gas emissions and air pollution [5].

Due to the high consumption of fossil fuels, maritime transport activity generates significant amounts of greenhouse gas emissions, contributing to climate change.

Hydrocarbon residues are residues from fuel or lubricating oil separators.

Through the 1997 Protocol, a new annex was added to the MARPOL 73/78 Convention, respectively Annex VI "Rules regarding the prevention of atmospheric pollution by ships", a protocol to which Romania acceded through Law no. 269/2006 [6].

Several directives have been introduced to prevent pollution from ships: Directive 2002/59/EC establishes a community monitoring and information system for maritime vessel traffic, and Directive 2009/18/EC establishes principles for the investigation of accidents in the maritime transport sector [7],[8],[9].

Directive (EU) 2016/802 on the reduction of the sulfur content of certain liquid fuels (Regulation (EU) 2023/1805 on the use of renewable and low-carbon fuels in maritime transport) [7],[8],[9].

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In 2015, maritime transport accounted for 13% of all EU greenhouse gas emissions from the transport sector [10].

All deliberate emissions of substances that deplete the ozone layer must be prohibited. -Protocol on the 1973 International Convention for the Prevention of Pollution by Ships of 17.02.1978 [11]

MARPOL 73/78 includes provisions for limiting environmental pollution by preventing accidents [1].

Ships generate substances such as sulfur oxides, nitrogen oxides, and suspended particles, which can affect people's health.

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Fuel prices vary, including surcharges on carbon dioxide emissions. Ship operators put pressure on shipowners to find effective ways to reduce consumption. These factors will enable shipyards to design and build ships more efficiently.

The liquid fuel used on board ships must meet several conditions [12].

The EU has proposed a reduction of greenhouse gas emissions by 2030 by at least 55% (compared to 1990).

Lubricating oil tanks must not have common partitions with potable water tanks [13].

The most important type of greenhouse gas emission from shipping is carbon dioxide from burning fuels. To reduce SO₂ emissions from ships, the marine fuel content was regulated in 1999.

The directive has led to reduced SO_x concentrations in European seas.

The International Maritime Organization has implemented several measures to reduce greenhouse gas emissions.

The main engines, auxiliary engines, boilers, and pressure vessels must be equipped with safety devices [13].

The use of propellers, container ships, passenger ships, and oil tankers generates the highest sound energy emissions.

The lubrication system is designed to receive, store, filter, and discharge the oil for lubrication and cooling of all engine parts to reduce mechanical losses through friction and wear.

2. Case study

A lubrication system is used to cool and lubricate control and regulation mechanisms and devices.

Internal combustion engines, used in naval propulsion, currently use almost exclusively fuels resulting from the processing of crude oil, especially diesel and fuel oil.

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Among the main advantages of using these fuels, we can list that they have a high calorific value, have a reduced tendency to self-ignite, are characterized by easy flow in pipes, and are well maintained in tanks.

2.1. Methods of reducing fuel consumption

To reduce consumption and pollutant emissions, the following should be considered: reducing the energy requirement for propulsion, reducing the resistance to the advance (reduction of ship dimensions, the reduction of total weight can be achieved by using light construction materials, which also involves reducing the length of the ship, reducing the speed)

Sailing at low speeds reduces the fuel consumption. An important role is played by the choice of propeller type and dimensions.

Operation of the propeller at a point of optimal efficiency. The propeller efficiency depends on several factors (speed of rotation and pitch). After a certain navigation time, deposits appear on the ship's hull, which leads to a hydrodynamically heavy propeller, requiring a surplus of power to propel the ship [2].

Another method of reducing polluting emissions is the use of renewable energy.

The wind is used as the primary energy source. Rotors with additional fins are an alternative technology for ship propulsion.

Solar energy can be a source of renewable energy that contributes to the energy balance of ships.

Thus, solar energy can be combined with diesel energy. However, methods for reducing fuel consumption are not always reliable.

Engine protection is achieved using sound and optical warnings in the case of exceeding the prescribed values for oil temperature and pressure.

For the cleaning of the fuel, dual filters with cleaning valves are provided in the supply facility or with self-cleaning.

As disadvantages of fuels obtained by distillation oil, the following can be mentioned: it manifests itself through vaporization at relatively low temperatures, with the danger of triggering explosions, and in the case of fires, it is impossible to extinguish them with water.[3]

The basic requirements that the fuels used in marine engines must fulfill are: to ensure an easy and safe start of the engine; to present good spraying qualities; have the minimum self-ignition delay period; no soot should result from the combustion process (have complete combustion); not to cause calamine deposits in the combustion chamber of the engine; and the corrosion action on the walls of the elements through which it flows is minimal.

2.2. Consumption of fuels and lubricants

In the paper, an oil tanker is studied, the consumption of fuels used in the combustion process.

The studied ship had only one propeller, and the propulsion of the ship was provided by a MAN B&W diesel engine with six cylinders and three diesel generators.

The software application EES (Engineering Equation Solver) was used for the calculation.

The actual specific fuel consumption was calculated according to the hourly consumption and the effective power [3].

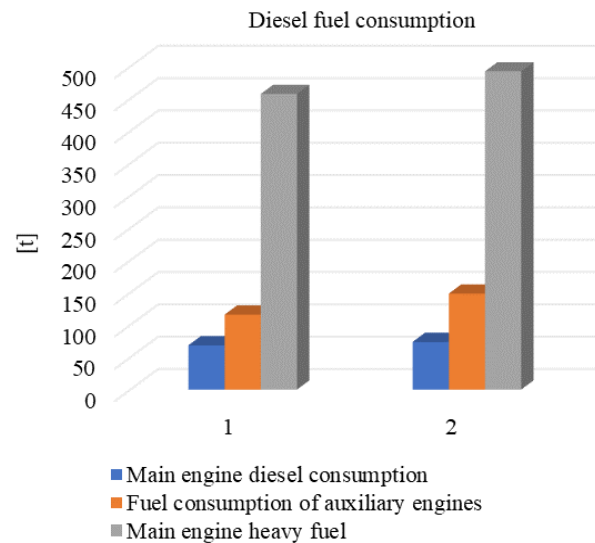


Figure 1. Fuel consumption

Figure 1 shows fuel consumption for the main engine and auxiliary engines (1 ballast and 2- full load) by the studied ship.

Several operating regimes were analyzed for the ship study.

The ship has several navigation situations, the propulsion engine and the auxiliary engines do not work all the time at the same load.

Figure 2 shows the consumption of lubricating oil for the main engine and auxiliary engines (1-for the case with full load and 2- ballast).

The oil consumption of the auxiliary engines was determined for several navigation situations.

Fuel and lubricant consumption were calculated considering the number of operating hours of the main engine and auxiliary engines.

Methods of reducing fuel consumption include reducing the necessary propulsion power, reducing the power required for onboard installations, using the energy generated by fuels in a more efficient way for propulsion and for the equipment on board the ship, and the use of alternative fuels through renewable energies, such as wind and solar energy.

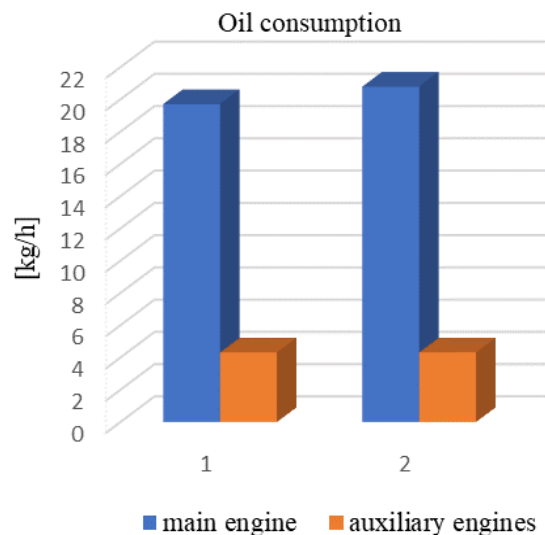


Figure 2. Oil consumption for the main engine and auxiliary engines

Possible technological optimizations: speed reduction, operating ships at low speeds, reducing fuel consumption, increases travel time.

After a certain time of navigation, deposits appear on the hull of the ship that leads to a hydrodynamically heavy propeller. A surplus of power is required to propel the ship.

The naval "green" naval propulsion has gained great development. And here we can define the following forms: nuclear energy (used for propulsion of military ships, submarines, aircraft carriers, ports, oil); solar energy, wind energy (small boats); and the energy resulting from the combustion cells (Fuel Cells).

3. Conclusion

Engines and their auxiliary installations were designed, built, and installed by the best practices in the field.

The main engines, auxiliary engines, boilers, pressure vessels, and their accessories must be equipped with safety devices. Lubricating oil tanks and their pipes must be arranged and located in such a way as not to allow accidental penetration of lubricating oil or lubricating oil vapor inside the ship.

The maximum permissible viscosity of fuel used in marine engines depends on the temperature and fuel preparation equipment.

The injection is electronically controlled which offers the reduction of operating costs, reducing polluting emissions.

As diesel oil can hurt the environment, cleaner and more efficient fuel alternatives are being sought, such as biofuels and electric energy technologies.

Reducing the impact of transportation on the environment by establishing environmental objectives and policies.

Environmental regulators are taking an increasing number of measures to reduce pollution from transportation.

Among these measures and objectives can be mentioned: the use of electric or hybrid vehicles that emit less carbon dioxide and the promotion of cleaner means of transport.

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