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Reducing GHG Emissions at Military Vessels

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Abstract. The shipping industry is responsible for 3% of global greenhouse gas (GHG) emissions, emissions mainly resulting from the combustion of fuels in naval energy aggregates.
The current requirements for a 50% reduction in GHG emissions by 2050 represent a challenge for maritime transport, as there is no effective solution to reduce this emissions from ships.
Thus, the current problem is represented by insufficient methods to reduce CO_2 emissions on board ships, in particular for ships which are in service for more than 10 years, which are the most affected by these environmental requirements, since their design did not take into account the reduction of ecological parameters.
In this context, even if military vessels are not subject to IMO GHG emission reduction requirements, they must be aligned with global emissions reduction efforts.
This article presents actually operational and technological solutions to reduce CO_2 emissions that can be deployed on board military vessels, until other technical solutions or power supply solutions for non-polluting renewable energy aggregates are identified.

Keywords: pollution, military vessels, GHG emissions, CO_2 emissions marine environment

1. Introduction:

The most harmful of the total chemical compounds in the exhaust gases of the ship's energy aggregates are the NOx, SOx, CO and GHG emissions (greenhouse gases), due to the long-term effects on the health of the population, especially those living near ports and coasts, as well as, their effects on the climate by contributing to the heating phenomenon overall.

The increasing pressure of international authority to reduce polluting emissions and, in particular, GHG emissions (see agreement at the last Paris climate conference in 2015) requires measures to be taken within the maritime transport sector on polluting emissions, especially reducing CO_2 emissions, the main emissions responsible for greenhouse gas emissions.

As a result of these environmental requirements, I.M.O. (International Maritime Organization), has developed regulations for the maritime transport fleet to reduce CO_2 emissions. Thus, through

Resolution MEPC.203 (62) from 2011, energy efficiency standards were imposed to reduce CO_2 emissions on-board vessels for the period 2015-2030 [8].

The current problem is represented by the insufficient methods to reduce CO_2 emissions on board ships, in particular for ships which are in service for more than 10 years, which are the most affected by these environmental requirements, since their design did not take into account the reduction of ecological parameters.

Therefore, finding solutions that have a major impact on reducing CO_2 emissions from ships, especially those which are in service for more than 10 years, is the current concern of all shipbuilders and naval energy aggregates constructors, as well as decision makers in the maritime transport sector.

Military fleets around the world, although not required to comply with environmental regulations imposed by the IMO to comply with the current GHG emission reduction requirements, are concerned with reducing CO_2 emissions from their ships.

An example in this regard is the US Navy, through the "Green Sea Fleet" initiative, which aims to reduce the use of fossil fuels in its fleet until 2020, by replacing it with biofuels up to 50% [4]. Thus, in December 2011, Maersk and the US Navy announced their collaboration to test marine biodiesel on Maersk's Kalmar container vessel, but the test results are not available [8]. In 2012, Solazyme company was deliver microalgae-based biofuel blends for the US Navy (700,000 gallons of HRD-76 biodiesel and 200,000 gallons of HRJ-5 jet biofuel). Also, in September 2014 Emerald Biofuels was awarded a contract with the US Navy to produce HEFA biodiesel fuels competitive with distillate fuels [10].

2. Solutions to reduce CO_2 emissions that can be implemented by military vessels

Solutions to reduce CO_2 emissions on board military vessels must meet the following conditions required by their specificity, as follows:

- Higher efficiency of CO_2 emission reduction;
- Technical compatibility with on-board energy aggregates;
- Not to require spaces for on-board equipment;
- Not to affect other emission categories;
- Not to modify navigation parameters.

The costs for solution implementation on board military ships should not, as far as possible, affect the operating costs of the ship.

In the specialized literature there were identified approximately 17 operational and technological CO_2 reduction solutions with potential deployment on board ships [6,7]. In Table no. 1 these solutions have been grouped in operational, technical and alternative solutions – using of alternative fuels.

Analysing the solutions presented in Table 1 from the point of view of the conditions that must be fulfil in order to be introduced on board military ships it can be seen that that the use of biofuels for energy supply can be a solution for reducing CO_2 emissions. The biodiesel has the greatest potential for use among existing biofuels due to: the physico-chemical properties similar to those of classical naval fuels, the availability on the fuel market, the purchase price is not very high compared to naval fuels used in military vessels and its tendency is declining, and the experience of use in the road transport sector and, more recently, in the air transport sector [7].

In the last period, several studies have been carried out in order to analyse the use of biodiesel to fuel diesel engines, from the point of view of the efficiency of CO_2 reduction.

Such an experimental study was performed in the internal combustion test engine of the Department of Marine Engineering of the "Mircea cel Bătrân" Naval Academy in Constanța on a modular support Gunt CT 159 equipped with a 2 kW single-cylinder diesel engine. The fuels used in the tests were classified according to the raw material used, as follows: M (100% diesel - Euro - Diesel, type 5); B10; B15; B20; B25; B30; B40; B50 (10; 15; 20; 25; 30; 40; 50% rapeseed biodiesel blended with diesel).

The results of the experimental study are as follow:

- it is found that a 5% increase in kinematic viscosity with a 10% increase in the biodiesel fraction in diesel does not greatly influence the combustion process and therefore the emission values do not change much with the change in viscosity (Fig. 1);

- decrease in the calorific value of 1%of a 10% biodiesel fraction does not have a major influence on engine power, especially in the case of blends with biodiesel up to 20% (Fig. 2);
- CO_2 concentrations increase with increasing load for both diesel and diesel blends with biodiesel, but these are lower for the full range of loads than diesel fuel concentrations;
- the biggest differences were found at the maximum load for mixture B15, namely 10.3% (Fig. 3 and Fig. 4) [2].
-

Table no. 1 Strategic technologies and operations to reduce CO_2 emissions

Operational solutions	**Alternative solutions - use of alternative fuels**	**Technical solutions**
Propeller Cleaning	LNG	Air Filtration
Ship's body cleaning	Biofuels	Upgrading the propulsion engine
Ship's body painting		Propeller Upgrade
Reduce speed		Optimize water flow
Weather routing		Solar Panels
High Efficiency Lighting		Wind Energy
Automatic Pilot upgrade		Residual heat recovery
Speed control of pumps and fans		

With the increase in engine load, specific fuel consumption decreases for all fuel used in the study. Also, for tasks ranging from 50-90% specific consumption has the lowest values for all the fuels used in the study. The lowest specific consumption was obtained for the blend of 15% biodiesel in diesel, at engine load of 90% the fuel consumption is 26% lower than that obtained when the diesel engine is powered with diesel [2].

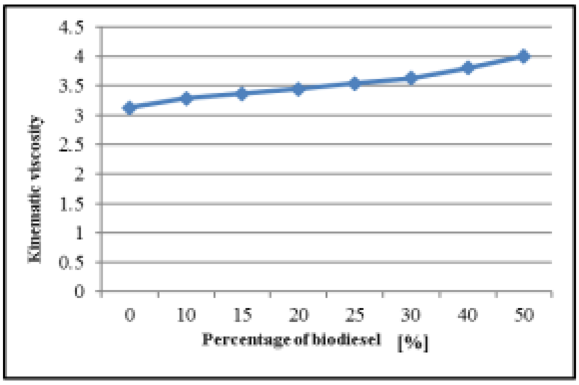

Fig. 1

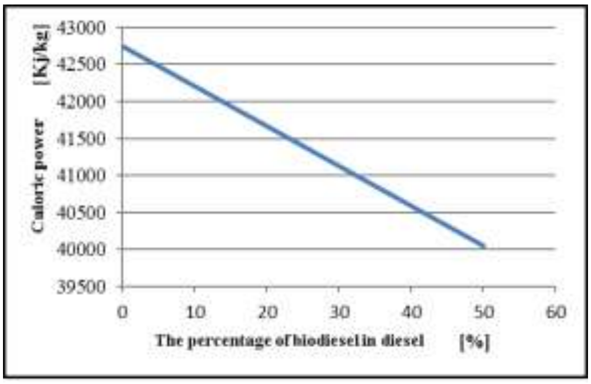

Fig.2

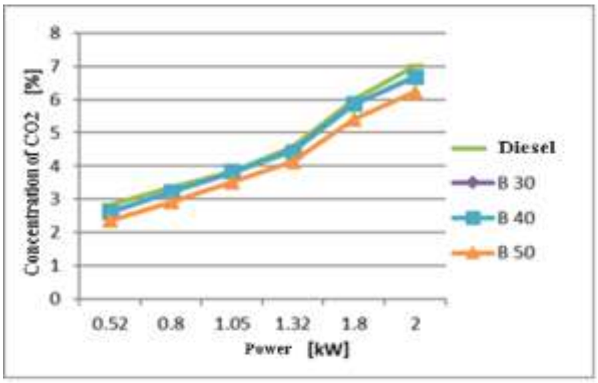

Fig.3

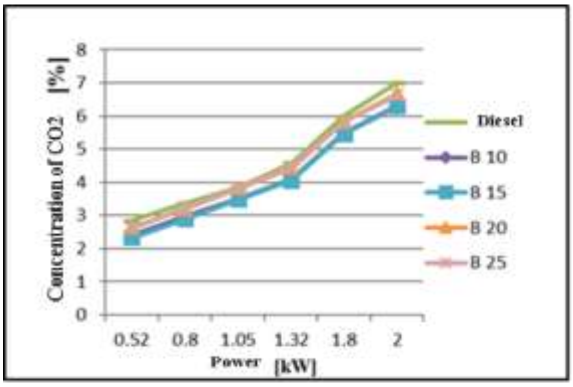

Fig.4

Due to the fact that in the tests was used a diesel fuel having a composition of 5% biodiesel, it can be stated that the optimal biodiesel concentration is 20% for the biodiesel blend with the MGO type distillate.

The SWOT analysis presented in the Table no. 2 comes to support the decision analysis to implement on board military vessel the solution of using the 20% diesel biodiesel mixture [2, 3, 5, 9,10]:

Table no. 2 SWOT analysis for the use of biodiesel

Strengths	**Weaknesses**
• biofuel are extremely low in sulphur content; • reduction of CO_2, NOx emissions; • drop-in fuels do not require major changes in the bunkering infrastructure; • does not require changes to the technique and on-board facilities due to the compatibility of biodiesel properties with those of marine distillate fuel; • research indicates a decrease in fuel consumption for engine; • Biodiesel can be used for both naturally aspirated and supercharged engines.	• marine biofuels are not cost competitive with fossil fuels; • lack of long-term fuel testing data for marine biofuels; • concerns about storage and oxidation stability of the fuel; • commercial production of high biofuel volumes required for shipping vessels is not yet established.
Opportunities	**Threats**
• regulations regarding bunker fuels and emissions have become stricter • introducing new alternative fuels in the marine fuel mix would reduce fossil fuel dependency; • drop-in marine biofuels show a strong potential to replace part of the fuel mix;	• vessel operators would have to adapt to new fuels in the fuel mix; • low price of oil has delayed biofuel development. • LNG is slowly gaining popularity as an alternative fuel

3. Conclusions:

In order to comply with the global GHG emission reduction requirements, the military fleet must have a holistic approach to implement solutions to reduce these emissions on board ships. Thus, in addition to the operational solutions for reducing the GHG emissions presented above, the solution of supplying the naval energy aggregates with the 20% biodiesel mixture in diesel fuel, can be the answer for CO_2 reduction. The implementation of this solution depends on the decision-makers in the military fleet.

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