The Energy Efficiency Operational Index – An instrument for the Marine Pollution Control

NICOLETA ACOMI1, OVIDIU CRISTIAN ACOMI2, SIMONA GHIŢĂ3
1Navigation Department; 2Mechanical Department; 3Environmental Protection Department
1,3Constanta Maritime University; 2TMS Tankers Ltd
1,3Mircea cel Bătrân Street, no.104, Constanta 900663
1,3ROMANIA, 2GREECE
parasca_n2000@imc.ro, ovidoc@yahoo.com, ghitasimona@aim.com

Abstract: - The Energy Efficiency Operational Index represents a complex factor in environmental protection area that could be decreased acting on different voyage parameters. It was developed by the International Maritime Organization aiming to provide ship-owners and ship-operators with assistance in the process of establishing a mechanism to achieve the limitation or reduction of emissions from ships in operation. The Energy Efficiency Operational Index represents the mass of CO₂ emitted per unit of transport work. The purpose of this study is to emphasize the change of Energy Efficiency Operational Index by changing different voyage parameters such as vessel speed, distance to discharge port, distance to loading port, the period of time the vessel is idle or in port and the total quantity of cargo. The method used for studying the situations above stated is the comparative analysis, varying some of the voyage parameters while the other are maintained constant.

Key-Words: - energy efficiency operational index, marine pollution, shipping,

1 Introduction

The air pollution is an actual problem that affects our society and the maritime transport is responsible for approximately for 10% of the greenhouse gases emissions of the transport sector [1]. According to the Second IMO Greenhouse Gasses study, elaborated by IMO, shipping is estimated to have emitted 1,046 million tons of CO₂ in 2007, which corresponds to 3.3% of the global emissions during 2007. International shipping is estimated to have emitted 870 million tons, or about 2.7% of the global emissions of CO₂ in 2007. [2].

In order to reduce greenhouse gas emission from international shipping, the Marine Environment Protection Committee (MEPC) from the International Maritime Organization developed technical and operational measures, helping to improve in the same time the fuel efficiency too.

Another statistic has been carried out regarding the distribution of GHG emissions per several types of ships [3].
significant time and effort in order to regulate shipping energy efficiency and thereby control the marine GHG emissions. For this purpose, it was developed a number of technical and operational measures that include [4]:
- Energy Efficiency Design Index (EEDI);
- Energy Efficiency Operational Index (EEOI);
- Ship Energy Efficiency Management Plan (SEEMP).

2 The energy efficiency operational index

The EEOI developed by the Organization is one of the internationally established tools to obtain a quantitative indicator of energy efficiency of a ship and/or fleet in operation, and can be used for this purpose. Therefore, EEOI could be considered as the primary monitoring tool, although other quantitative measures also may be appropriate.

If used, the EEOI should be calculated in accordance with the guidelines developed by the Organization [5]. If deemed appropriate, a Rolling Average Index of the EEOI values may be calculated to monitor energy efficiency of the ship over time.

The EEOI provides a specific figure for each voyage. The unit of EEOI depends on the measurement of cargo carried or the transport work done, e.g., tonnes CO$_2$/tonnes/nautical miles, tonnes CO$_2$/TEU/nautical miles or tonnes CO$_2$/person/nautical miles, etc. The EEOI is calculated by the following formula, in which a smaller EEOI value means a more energy efficient ship [6]:

$$EEOI = \frac{\text{actual } CO_2 \text{ emission}}{\text{performed } \text{transport work}} \quad (1)$$

The EEOI for a voyage is calculated as follows:

$$EEOI = \sum_{i} \frac{FC_{ij} \times CF_{ij}}{MC_{argo} \times D_i} \quad (2)$$

For a number of voyages or voyage legs, the indicator is expressed as presented below:

$$\text{Average } EEOI = \frac{\sum_{i} \sum_{j} FC_{ij} \times CF_{ij}}{\sum_{i} \sum_{j} MC_{argo} \times D_i} \quad (3)$$

Where:
- $j$ is the fuel type;
- $i$ is the voyage number;
- $FC_{ij}$ is the mass of consumed fuel $j$ at voyage $i$;
- $CF_{ij}$ is the fuel mass to CO$_2$ mass conversion factor for fuel $j$;
- $MC_{cargo}$ is cargo carried (tonnes) or work done (number of TEU or passengers) or gross tonnes for passenger ships; and
- $D$ is the distance in nautical miles corresponding to the cargo carried or work done.

The actual CO$_2$ emission represents total CO$_2$ emission from combustion of fuel on board a ship during each voyage, which is calculated by multiplying total fuel consumption for each type of fuel (distillate fuel, refined fuel or LNG, etc.) with the carbon to CO$_2$ conversion factor for the fuel(s) in question (fixed value for each type of fuel) [7].

The performed transport work is calculated by multiplying mass of cargo (tonnes, number of TEU/cars, or number of passengers) with the distance in nautical miles corresponding to the transport work done.

3 The method used for finding the optimum EEOI

This study applies the comparative analyses by varying some of the voyage parameters in order to obtain the optimum EEOI. The voyage parameters that influence the value of the Energy Efficiency Operational Index are:
- the distance sailed as recorded in the ship’s Bridge Log Book,
- the cargo mass as per Bill of Lading and Deck Log Book and
- the fuel consumption as recorded in Engine Log Book.

The characteristics of the vessel considered for this study: a handy size type, Chemical Tanker, 38000 DWT, equipped with the following main consumers: a MAN B&W 6S50MC-C Main Engine (ME) of 9480KW at 127RPM, three Wartsila Auxpac 975W6L20 Diesel Generator (DG) Sets of 975KW and 900RPM and Saacke KLN/VIC 16/10 / 16t/h Auxiliary Boiler (AB).

The program emphasizes the variation of the EEOI while reducing the speed of the vessel from 14 knots to 10 knots and also by changing the voyage parameters: manoeuvrings, anchoring or ballast voyage days (having different consumption for the main engine, diesel generators or auxiliary boilers).
The variation of the EEOI was studied for the following situations that can occur during the voyage:

A - Increasing the quantity of cargo,
B - Increasing the length of the loaded voyage,
C - Decreasing the length of the ballast voyage,
D - Avoiding idle time,
E - Loading /discharging at full rate, and
F - The “perfect” voyage.

The values of the FC/CO2/EEOI

A B C D E F
FC*100 [tonnes] 9.15 11.32 8.31 8.34 8.87 8.84
CO2/10000 28.49 35.26 25.88 25.97 27.61 27.55
EEOI 11.9 14.16 13.69 13.74 14.61 8.73
The next graphic shows the changes in EEOI values in terms of speed reduction from 14 to 10 knots, if the ship has loaded the same quantity of cargo (30000 tonnes), the number of the days in port decreased from 12 to 2.8, berthing on fixed date or on arrival.

![Graph showing the variation of EEOI in terms of speed reduction](image)

As per figure above, the minimum value of the EEOI suppose the ship to maintain a medium speed and also to avoid spending time for anchoring.

### 4 Conclusion

Analysing the variation of Energy Efficiency Operational Index with respect to different voyage parameters it could be noticed that the most preferred parameters that result in major favourable changes in its quantum are: increasing the quantity of cargo transported maintaining same route and decreasing the fuel consumption maintaining a medium speed. The greatest reduction of the EEOI, excepting the “perfect voyage”, 21.05% was obtained for increasing the quantity of the cargo for the same route.

### References:

2. IMO, *Second IMO GHG Study*, MEPC 59/INF.10, 2009
5. IMO, *Guidelines for voluntary use of the ship energy efficiency operational indicator, EEOI*, MEPC.1/Circ.684 2009