ENERGY EFFICIENCY AND CLIMATE CHANGE MITIGATION FOR FISHING VESSELS

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ABSTRACT

Continuous efforts in the marine industry are directed towards improving energy efficiency and reducing the environmental impact of ships. The strategic document in Croatia focusing on that topic is the Operational Programme for Maritime Affairs and Fisheries of the Republic of Croatia. Based on this Programme different measures are funded from the European Maritime and Fisheries Fund (EMFF). In this paper a special focus is put on measure I.20 Energy Efficiency and Climate Change Mitigation. Through this measure the installation of new diesel engines in fishing vessels is co-financed from the EMFF. The main requirement is that the power output of the new engine is lower than that of the replaced one. This paper discusses pros and cons of such approach, provides an insight in the technical characteristics of the current fishing fleet, and proposes improvements regarding the environmental policies in the marine sector.

Keywords: energy efficiency, environmental impact, fishing vessels, EMFF

1. INTRODUCTION

Continuous efforts in the marine industry are directed towards improving energy efficiency and reducing the environmental impact of ships. These efforts are not limited only to ocean-going vessels, but include also vessels engaged in the short-sea shipping (SSS). SSS denotes transport of goods over shorter distances by sea. In the context of the EU it is defined as the transport by sea between ports in the EU, as well as ports in the Mediterranean Sea [1].

SSS offers many advantages over land-based transport as it is generally more energy efficient and has lower impact on the environment [2]. However, it has to be noted that this impact is not negligible and should be further reduced through different measures. These can include for example energy storage devices. Dedes et al. [3] investigated whether energy storage devices can be a feasible solution on-board bulk carriers. They identified that Power Take-Off/Power Take-In (PTO/PTI) system has potential when combined with batteries to increase energy efficiency, especially for Panamax and Handysize bulk carriers. In addition, for sufficiently high fuel price (520 USD/t), this solution can even be economically feasible. The cost effectiveness of an air lubrication system was discussed by Mäkiharju et al. [4], while Butterworth et al. [5] conducted experiments on a container ship model with air cavity concept. Both technologies proved to be similarly effective at lower speed, but their influence is reduced at higher speeds. Carbon dioxide Reduction Technologies (CRT) have been analysed by Calleya et al. [6]. They found that CRT have the potential to reduce CO_2 emissions, although at a relatively high cost. The technologies are implemented during voyage, but other technologies, such as cold ironing also have potential to reduce the environmental impact of ships [7].

Most of the research on the ship's energy efficiency is focused on ocean-going vessels, which sail in relatively similar conditions. But ships engaged in SSS, especially fishing vessels, sail in continuously changing conditions. The main problem for fishing vessels is to define which of these measures is the most appropriate in different situations. This is usually left to the ship-owners to decide individually. However, a better way is to aggregate these measures into strategies (national and international) which can provide a framework with clear goals and plans. The strategic document in Croatia focusing on that topic is the Operational Programme for support from the European Maritime and Fisheries Fund [8]. It introduces a set of measures oriented towards fishing vessels and fish farms. Some of these measures, specifically I.21, are focused on improving energy efficiency of fishing vessels, and reducing their environmental impact. The aim of this paper is to analyze this measure, evaluate its effect in reducing the environmental impact of fishing vessels in Croatia, and to provide some recommendations for improvement.

In next chapter a brief description of the measure is provided. Since the measure is based on the engine power output, an analysis of the engine power in the fishing vessels in Croatia is performed in subsequent chapter. The results of the analysis and its relation with the current regulation are discussed afterwards with some concluding remarks at the end of the paper.

2. OPERATIONAL PROGRAMME FOR MARITIME AFFAIRS AND FISHERIES OF THE REPUBLIC OF CROATIA

Based on aforementioned Programme, different measures are funded from the European Maritime and Fisheries Fund (EMFF). In this paper a special focus is put on measure I.21 Energy Efficiency and Climate Change Mitigation. Through this measure the installation of new diesel engines in fishing vessels is co-financed from the EMFF. The co-financing rate is set at 30% and up to 50,000.00 EUR maximum. The measure also provides a set of rules which every project proposal has to comply with in order for the financing to be approved.

The main requirement stipulated in this measure concerns the maximum continuous rating (MCR) of the new engine. For vessels having length below 12 m, the power output of the new engine must not exceed the output of the old one. For vessels between 12 and 18 m in length, the new engine has to have MCR that is at least 20% lower, and for longer ships, the new engine has to have MCR that is at least 30% lower compared to that of the replaced engine. If the reduction in output exceeds the minimum stipulated, extra points are credited in the evaluation process. Additional points are also credited for engines older than 15 years.

Proclaimed goal of the measure I.21 is to reduce the ships' impact on climate change and to improve their energy efficiency. Therefore the reasoning behind such measure is clear: Croatian government believes that new engines having lower MCR will be more energy efficient, consume less fuel and hence reduce the emissions of harmful substances as well as reduce the impact on the environment. The power of the engine is indeed one of characteristics which affects the engine environmental impact, but hardly the only one. Fishers would like to receive co-financing for the installation of a new engine, but are reluctant to install engines with lower MCR, primarily due to safety concerns, especially in harsh weather conditions. Thus an analysis of the engine power should be performed in order to identify which ships are suitable candidates for an engine replacement.

3. THE ANALYSIS OF THE ENGINE POWER OF FISHING VESSELS IN CROATIA

The analysis of the engine power is performed for fishing vessels registered in Croatia and which have a license to perform fishing operations in the Adriatic Sea. The aim of this analysis is to establish a correlation between the engine power and some other ship technical characteristic. Based on such correlation, a group of potential candidates for measure I.21 could be identified.

3.1. Source of data

The data used for the analysis can be obtained from the Registry of the fishing fleet of the Republic of Croatia, which is available online. The data is publicly available free of charge, but is not appropriate for statistical analyses. Hence, data collected by the European Commission, aggregated into an Excel file, and available online [9] is used for this analysis. It includes various technical data, such as ship's length, gross tonnage (GT), hull material, power of the main engine, year of construction, as well as various administrative data.

3.2. Analyzed parameters

As mentioned in the previous chapter, the ship's environmental impact is determined not only by its engine power, but depends also on a number of different parameters, such as the fuel used and the engine's specific fuel oil consumption, which depends on the engine speed and load, which again depends on the sailing speed, ship draft, weather conditions, propeller condition etc. The database used includes only a limited number of ship characteristics, meaning that this analysis cannot take into account each parameter that determines ship's environmental impact, Fig. 1. In order to identify potential candidates for the measure I.21, a simple correlation is convenient. Since the current regulation for fishing vessels is mostly based on the ship size measured in GT (and since gross tonnage is a parameter easily recognized by fishers), it is interesting to compare how these two characteristics correlate.

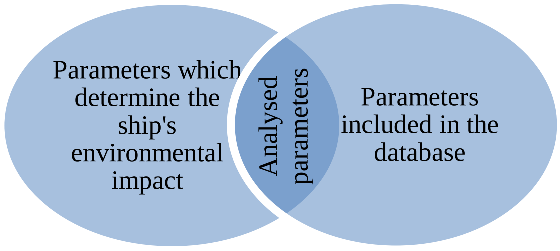

Figure 1: Analyzed parameters in this paper

3.3. Methodology

The analysis is performed based on the regression analysis and the least square method using Microsoft Excel. With in-built function a trendline can be plotted and the coefficient of determination R^2 can be determined. Based on this a correlation between the set of data and the trendline can be established. If the value of the R^2 is higher than 0,6, then there is some correlation of the trendline and the observed data set. Values of R^2 over 0,85 indicated good correlation. Values of R^2 close to 1 indicate mathematical correlation.

3.4. Results

Results of the performed analysis observing the engine power (more precisely, the main engine maximum continuous rating) and the ship's GT are presented in Fig. 2.

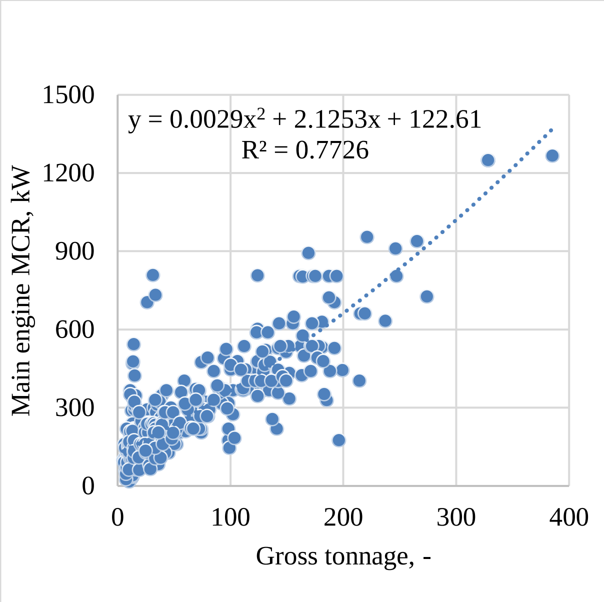

Figure 2: The correlation of the main engine MCR and the GT of fishing vessels in Croatia

Since the value of R^2 was relatively low, another analysis taking into account only purse seiners was performed. Its results are presented in Fig. 3. As expected, the correlation has improved notably.

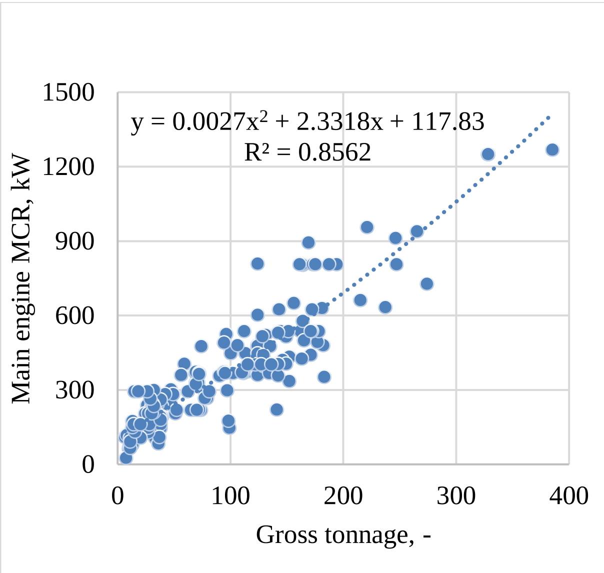

Figure 3: The correlation of the main engine MCR and the GT of purse seiners in Croatia

4. DISCUSSION

Based on the results from the previous chapter, several remarks can be given. First of all, limitations of these analyses should be highlighted. As indicated in chapter 3.2, ship's environmental impact depends on many different parameters, while the analysis is performed only for two of them: engine power and ship's GT. This is primarily due to the fact that the database used does not include any data on the ship's speed, propeller characteristics, gear used or even the engine used.

Furthermore, the environmental impact of a ship is determined by the emission of harmful substances, and not by its MCR. These emissions are produced throughout the ship's lifecycle, but mostly during ship operation. Some emissions, like CO_2 and SO_X emissions, are determined by fuel composition and consumption, while NO_X emission depends on the fuel combustion parameters. The fuel consumption and the combustion parameters depend on the engine load and speed. These two values define the engine operational point. As mentioned in the introduction, ocean-going vessels sail the majority of time near the optimal engine operating point (with the lowest specific fuel oil consumption), but ships engaged in SSS can have operational points anywhere within the engine operational map. Thus, CO_2 emission in operation can be calculated based on the engine power at a given operating point (defined by the current engine load and speed and usually lower than the MCR), specific fuel oil consumption at that point and the carbon conversion factor. The NO_X emission can be determined based on the engine power and the specific NO_X emission determined from an engine map depending on the engine load and speed. These emissions can then be normalized and aggregated into one value, such as the Index of Energy Efficiency and Environmental Eligibility (I4E) which can be used to compare different ships' environmental impact [10]. The observed measure I.21 has simplified this procedure greatly, making it much easier to use, but with questionable environmental effect.

Since it is not expected for the current measure I.21 to be amended in a way that would implement a physically valid procedure (e.g. as described in [10]), the idea behind this paper is to provide at least some guidance for fishers as to which ships could be considered for an application involving engine replacement. Based on Fig. 4, an average MCR of a purse seiner can be determined. For instance, a purse seiner of GT=150 has an average MCR of 528 kW. Thus, if a particular purse seiner is powered by an engine having significantly higher MCR, then this purse seiner should be evaluated further in order to determine if its engine should be replaced by a new one. This however requires a more detailed analysis.

But even limited analysis can provide some insight. When comparing Fig. 2 and Fig. 3, a noticeably higher correlation for purse seiners can be observed, than the one for the entire fleet. If the composition of the rest of the fleet is analyzed, it can be noted that it mostly consists of trawlers, Fig. 4. Therefore, the inclusion of trawlers actually reduces the correlation between the engine power and GT. This indicates that for trawlers engine power is less dependent on the GT. Even more, fishers often point put that the engine power is not crucial parameter when it comes to trawlers. For them the gear ratio and the propeller speed are much more important since they can generate higher bollard pull force, which is crucial while trawling. Since the database used does not include any data on these parameters, they should first be collected so a further analysis can be performed.

Figure 4: A trawler in the Adriatic Sea

On the other hand, for purse seiners, Fig. 5, the engine power can be considered as an important parameter, since it is a prerequisite to achieve the required sailing speed. Fishers also find engine power to be the crucial parameter for ensuring safety when sailing in rough weather conditions. Further actions should be directed towards fishers, precisely in educating them about the ship power system improvements and the benefits of installing new engines, especially the benefits of hybrid and integrated power systems. The trendline shown in Fig. 3 can be used as a tool for quick evaluation of their propulsion system power and as an indicator that engine power could be reduced. This could encourage fishers to install new engines and even consider alternative configurations which could not only reduce the environmental impact, but also reduce their costs.

Figure 5: A purse seiner in the Adriatic Sea

5. CONCLUSION

In this paper the measure I.21 aiming to increase the energy efficiency and to reduce the environmental impact of fishing vessels is discussed. The measure considers only the engine power and requires its reduction for new engines. Fishers are reluctant to reduce the power of their engine primarily due to safety concerns, so the effect of the measure is limited. Since it is not feasible to change the measure, this paper presents a method to roughly estimate the average engine power of a purse seiner based on the GT. This can be used to determine if the observed fishing vessel has higher power than average. This could then indicate that the ship is a potential candidate for the installation of an engine having lower power output and encourage the fishers to at least consider its replacement.

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