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Ship Emissions and Energy and the new IMO regulations

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Abstract

With the fast increase in oil price, the fuel costs now account for up to 50% of a ship operating costs in some sectors and trades. Simultaneously shipping industry is becoming under pressure to reduce GHG (Green House Gases) emissions like CO_2, being already under way a number of mechanisms such as MBI's (Market Based Instruments) based on Emission Trading Schemes and a carbon tax system, and the IMO MEPC (Marine Environment Protection Committee) MEPC.1/Circ.684 from 17 August 2009. This work addresses the latest regulations but also introduces the tools ship owners need to implement energy and emissions reduction plans. The paper also presents and analyses real ship energy and emissions data, gathered by VEEO (Voyage Energy and Emissions Optimiser), an author developed ship performance monitoring systems installed on board container vessels.

Keywords: ship operating costs; emissions; IMO; monitoring systems; container vessels.

Introduction

The maritime industries have continuously made an effort to optimize ships' fuel consumption, e.g., through the development of more efficient engines and propulsion systems, optimized hull designs and larger ships, and thereby achieved a noteworthy reduction in fuel consumption and resulting CO_2 emissions on a capacity basis (tonne-mile).

Although ships are the most fuel efficient mode of mass transport, the Second IMO GHG Study 2009 identified a significant potential for further improvements in way the energy is used on board therefore impacting on the ship operation energy efficiency mainly by the use of already existing technologies.

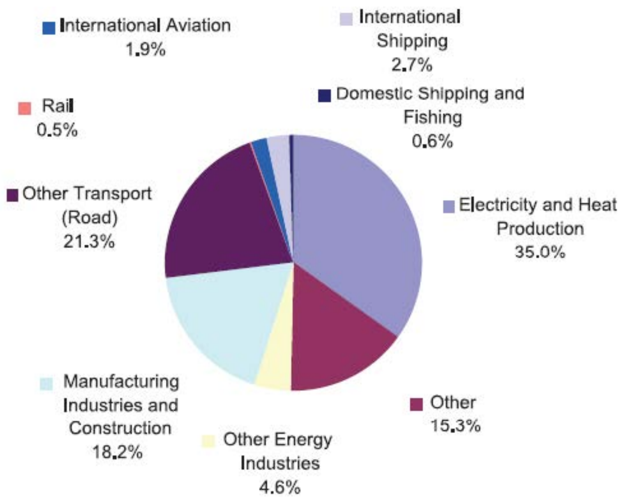

Figure 1 - Emissions of CO_2 from shipping compared with

Additional improvements in hull, engine and propeller designs, together with reduction in operational speed, may lead to considerable reductions as illustrated in the Figure 1.

Looking at a ship as a "whole energetic" system, and based on the recent operational data, only around 27% of the energy input for propulsion is effectively used to propel the most ships, this is illustrated in Figure 1. Considering the engine itself, energy flows are illustrated on the Sankey diagram of Figure 2, which considers one of the most common two stroke engines in use at sea today, while Table 1, summarizes the energy flows and their thermal quality. As it is evident, from the above mentioned figures and table, approximately 50% of the energy input is available, but only a percentage of it, the one with high quality is recovered today for auxiliary ship services.

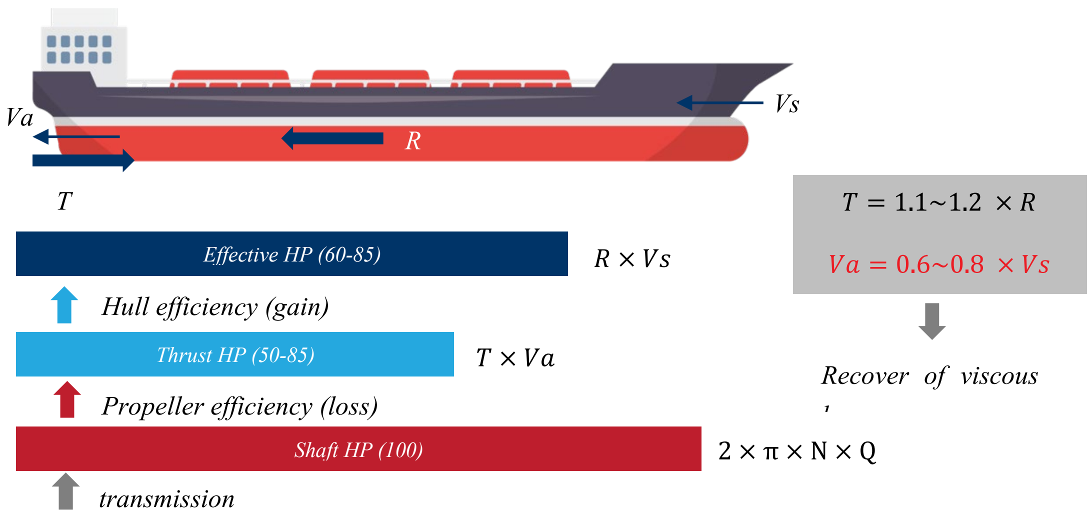

Figure 2 - Deterioration of energy effectively used for propulsion.

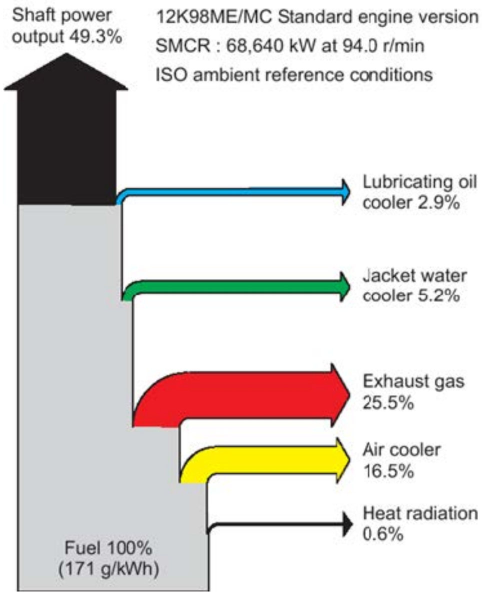

Figure 3 - Sankey diagram of a two stroke 12K98ME/MC engine

Table 1 - Heat quality and associated power

Main Engine	% Heat rate	Temperature (ºC)	Heat (kW)
Lube Oil	2,9	90	1.990
Jacket Water Cooling	5,2	85	3.589
Exhaust Gases	25,5	300	17.503
Air Cooling	16,5	160	11.325
Radiation	0,6	-	835

IMO GHG Activities

IMO's working group on Greenhouse Gas Emissions (GHG) from ships developed a number of studies to highlight the measures to enhance energy efficiency of the shipping in general. The group defined an Energy Efficiency Design Index (EEDI) for new ships and it is already testing and debating the Energy Efficiency Operational Index (EEOI), which is focused on ships in operation. A draft for Ship Energy Management Plan (SEMP) resulted from the group meeting in March 2009 with the aim to improve the efficiency of the international shipping, by defining a number of indices.

EEDI (Energy Efficiency Design Index) objective is to stimulate innovation and the technical development of all the elements influencing the energy efficiency of a ship, thus making possible to build more energy-efficient ships in the future.

EEOI (Energy Efficiency Operational Index) objective is to enable ship operators to measure the energy efficiency of their ships. This index is expressed in tons of CO_2 per ton mile. The index translates the efficiency of specific ship, thus enabling comparisons between similar ships.

SEMP (Ship Energy Management Plan) objective is to incorporate the best practices into the operation of each ship, including voyage planning, speed and power optimization, optimized ship handling, improved fleet management, cargo handling and energy management.

EEOI calculation of a ship in operation has been recommended but it is not compulsory yet, and this can be calculated manually, using spread sheets and crew handled data.

SEEMP reproduces the actions taken by the ship operator to optimise the ship operation in terms of energy; however, these actions can be arranged in groups according to their cost and technical and economic feasibility.

EEDI implications on the EEOI

From the above equation it is possible to understand that EEOI, has a strong dependence on performance and operation of the vessel, being penalized by the decisions at the design stage used for each ship, whereas the operation plays only a partial role.

Many authors suggested the possibility of changing some ship components and physical characteristics to obtain, the improvements that were not considered at the design stage, like propellers, and in some cases the hull forms. However, most of the existing ships exist before the quasi compulsory environmental positions, being the result of a compromise between what was requested and what was delivered.

The energy saving actions for existing ships can be categorized into three categories, the first corresponding to those actions that can be implemented without cost or very little cost, such as operation of Diesel generators, Correction of power factor, Luminaries of better quality, Good voyage planning, Slow steaming with optimization of respective engine, inside the second category may be considered the propeller re-pitch, or enhanced paint schemes, and finally on the third category fall those actions that have higher costs such as the application of an heat recovery system, or the transformation of hull lines just to mention some. To decide if these actions may be taken forward, a clear knowledge of the ship operational energy profile is required to sustain the technical and economic decisions.

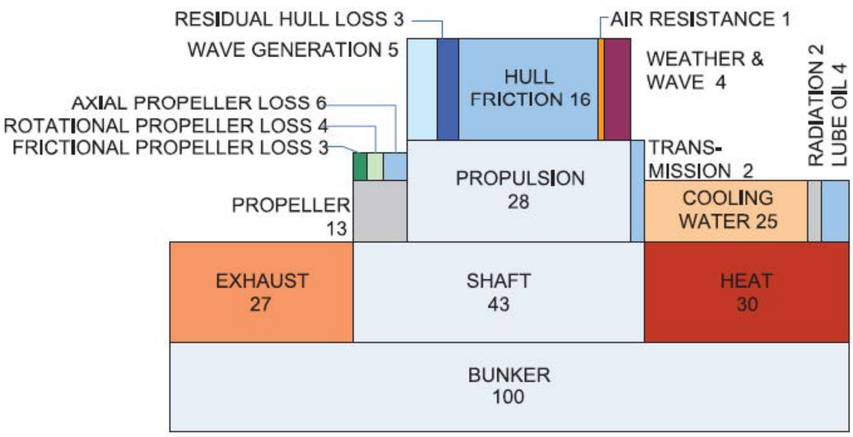

Figure 4 - Use of propulsion energy on board a small cargo

How to gather the required data to support the investments on energy actions.

“The one that does not measure has only a vague idea.” First of all, the investor, needs to know as much as reliably how the cost of fuel will be in its ship expected future, then he needs to know the impact of each energy saving action on its operational costs, which can be achieved only on the basis of a credible ship characterization, based on a period of its operation in its typical trade route.

To accomplish such an objective TecnoVeritas and APL/NOL have been working together in the development of a system, comprising hardware and software, and on ship energy audits, in such a way, that reliable ship operation data is always captured for further analysis and monitoring of ship improvements.

The system developed is named as VEEO Voyage Energy & Emissions Optimizer and has been in service since March 2009. The system is being installed on board of 24 container vessels some of them with capacities of 4000 TEU, operating worldwide.

VEEO is acquiring, treating and logging the main engines fuel consumption, propeller shaft energy transferred to the propeller, propeller thrust, power production on alternators, ship speed, nautical miles, all different fuels usage, engines performance, boiler performance, incinerators performance, trim, and weather condition. VEEO is also taking care of fuel bunkering operations and fuel managements. Then, VEEO allows the ship’s crew (once trained) to decide upon energy management actions, as the ship’s crew has access to the ship’s real time energy consumption and emissions.

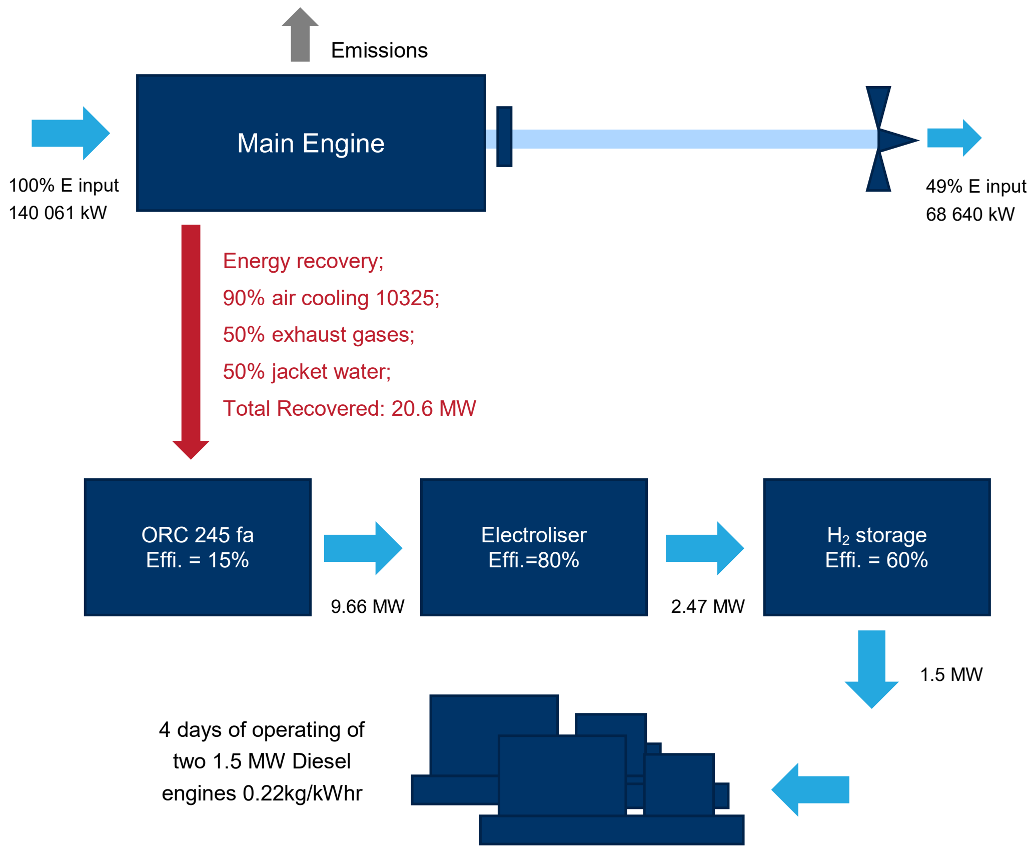

Figure 5 - Energy on board

One important factor for ship energy characterization is the called and defined by IMO Circ 684, as "Rolling average indicator" As a ship energy efficiency management tool, the rolling average indicator, when used, should be calculated by use of a methodology whereby the minimum period of time or a number of voyages that is statistically relevant is used as appropriate. "Statistically relevant" means that the period set as standard for each individual ship should remain constant and be wide enough so the accumulated data mass reflects a reasonable mean value for operation of the ship in question over the selected period. As a result, of the energy audits carried and the implementation of VEEO system of these 25 container ships fleet, the company managed to reduce their energy costs by 9%, and corresponding impact on the emissions in the first year, being identified the great importance of the human factor on the ships operation.

Conclusions

Ship owners will be pushed to lean energy ship operation, not only because of energy costs, but also because of stringent emissions regulations but also because of emissions market mechanisms.

To achieve fuel costs reductions it is important and fundamental to properly characterize the ship in its operation profiles, that can be done during a first stage by energy audits implementation but for a long term compliance with coming maritime emissions international laws, through the installation of on line monitoring systems, that take the ship as a whole energy system, allowing the energy optimization of the ship operation at a glance. However, the need for ship energy management staff training it is of highest importance, as a fleet optimization plan, needs to handle enormous amounts of data and also decisions.

Another important aspect is that of the Net Calorific Value of the fuels has a direct impact on the quantity of the fuel being used during the voyage, and therefore on the CO_2 emission, as this is calculated based on the mass of fuel used. Therefore, fuel Net Calorific Values need also to be considered, being recommended a new index, the ETEI (Energy Transportation Efficiency Index) an ship operation energy efficiency indicator, expressed in kWh/(Ton cargo NM). This proposed index reflects the effort of the ship energy management into reach a lean operation.

In case EEOI is to be used for taxation on CO_2 it should be complemented with the respective ETEI. Ships energy costs are better controlled at the design stage with maximum integration of ship systems, and by implementation of design decisions that otherwise cannot be implemented on existing units due to excessive costs.

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