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Review

Energy-efficient operational training in a ship bridge simulator

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ABSTRACT

Over the recent decades, there has been an increasing focus on energy-efficient operation of vessels. It has become part of the political agenda, where regulation is the main driver, but the maritime industry itself has also been driven towards more energy-efficient operation of the vessels, due to increasing fuel costs. Improving the energy efficiency on board vessels is not only a technical issue - factors such as awareness of the problem, knowledge skills and motivation are also important parameters that must be considered.

The paper shows how training in energy-efficient operation and awareness can affect the energy consumption of vessels. The study is based on navigational, full-mission simulator tests conducted at the International Maritime Academy SIMAC. A full-mission simulator is an image of the world allowing the students to obtain skills through learning-by-doing in a safe environment. Human factors and technical issues were included and the test sessions consisted of a combination of practical simulator exercises and reflection workshops.

The result of the simulator tests showed that a combination of installing technical equipment and raising awareness - making room for reflections-on and in-action - has a positive effect on energy consumption. The participants, on average, saved approximately 10% in fuel.

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Abbreviations:

EEDI	Energy Efficiency Design Index
EEOI	Energy Efficiency Operational Indicator
GHG	Greenhouse gas
IMO	International Maritime Organization
MARPOL	International Convention for the Prevention of Pollution from Ships
SEEMP	Ship Energy Efficiency Management Plan
STCW	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers

1. Introduction

The consequences of climate changes are already apparent around the world. This means that society's focus on ways to reduce greenhouse gas emissions are growing. A study of shipping-related greenhouse gas emissions that was performed on behalf of The International Maritime Organization (IMO) states that, from 2007 to 2012, on average shipping accounted for 3.1% of annual global emissions of CO2, and an increase in maritime CO2 emissions are expected, despite the regulatory actions that have been taken (Smith et al., 2015). Depending on future economic and energy development, this could increase to between 50% and 250%. It is therefore necessary to take further action to mitigate the growth in emissions, in order to ensure continued sustainable development.

As a response to the request to reduce GHG emissions, the International Maritime Organization (IMO) succeed to make a global binding agreement on reducing CO_2 emissions from international shipping. This was effectuated by an amendment to the MARPOL Annex VI - Prevention of Air Pollution from Ships (IMO, 2011). IMO thereby introduced guidelines for calculating energy efficiency during both the design and operation phases through the Energy Efficiency Design Index (EEDI) (IMO, 2012a), the Ship Energy Efficiency Management Plan (SEEMP) (IMO, 2012b) and the Energy Efficiency Operational Indicator (EEOI) [IMO, 2009]. The amendment sets requirements for the EEDI, making sure that newly built ships are designed to be more energy efficient. The EEOI, which is a voluntary guidance tool, was developed in order to be able to compare the operation of ships and help to find best practices for fuel-efficient operations. For new and existing vessels, it became mandatory to have an SEEMP on board; the intention of the SEEMP is to improve energy efficiency in daily operations on board in a cost-effective way.

Stakeholders in the maritime industry have identified several methods to improve ships' energy efficiency, and a large number of studies estimating the cost-effective potential have been performed. Many of these measures are related to both operational and technical issues e.g. DNV GL (2014, 2015), Faber et al. (2011). These studies demonstrate how it is possible to increase the energy efficiency of vessels and thereby reduce GHG emissions by modifying ship design, installation or retrofitting energy saving or emission reduction equipment. In addition, daily energy reduction measures directly related to the operation of the ship have been identified to have great potentials for improving energy efficiency. Despite the knowledge of the cost-effectiveness of these energy efficient actions, some areas of the maritime industry are still reluctant to invest. Research has demonstrated that small shipping companies lack the resources to analyse, make decisions and implement energy efficient solutions e.g. work performed by Johnson et al. (2014), Poulsen and Johnson (2016). Energy optimisation has been a focus of research in larger shipping companies for a number of years. Based on the large amount of data and the resources in these companies, performance systems have been developed. In particular, in the case of liner vessels, the comparable routes and more equally designed sister ships represent the opportunities for designing a useful tool for optimisation. However, even though some companies have departments that solely focus on this issue, route optimisation seems to be the primary energy efficiency operational tool. For working vessels, the complex and flexible operation profiles make the use of traditional route optimisation difficult to evaluate and compare in order to maximise savings. This limitation, combined with high levels of uncertainty in future fuel prices, makes it difficult to determine whether investment in new energy efficient equipment will be cost-effective, make energy efficient operation a minor, or even neglected, topic on board many working vessels of today (Maddox Consulting, 2012; Poulsen and Sornn-Friese, 2015; Faber et al., 2011; Rehmatulla and Smith, 2015). These vessels are often operated on a time charter basis, meaning that the operational costs, including the investment in fuel efficiency of the vessel, are borne by the owner, whereas the voyage costs including the fuel are paid for by the charter, which is the so-called split initiative problem (Poulsen and Sornn-Friese, 2015; Rehmatulla and Smith, 2015). Therefore, the companies operating these vessels do not focus on fuel consumption; in contrast their primary focus is on safety issues and optimising the time available for conducting working tasks.

In the DNV GL Energy management study from 2015 (DNV GL, 2015), the question "*What matters to actually increase energy efficiency in ship operation?*" was raised. Based on input from ship managers, owners and operators from 24 countries, the report showed that the companies struggle with the implementation and finally concluded "*that people make the difference*". This conclusion was based on the fact, pointed out by forty percent of the companies, that lack of education and resistance to change are the primary barriers for improving the energy efficiency of ships.

The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) (IMO, 1978), sets the standards of competence for seafarers internationally. The latest revision of the STCW convention and code was made in 2010 and entered into force on January 1, 2012 (IMO, 2010). One of the amendments highlighted in relation to energy-efficient operation was "*New requirements for marine environment awareness training and training in leadership and teamwork*". Therefore, it must be expected that future generations of seafarers will not have a lack of education nor resistance to change, as pointed out in the DNV GL Management study (DNV GL, 2015). However, it is unclear in the standards how environmental awareness will be achieved. It is up to the countries' administrations to ensure a way to obtain the goal.