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Review

Energy efficiency of working vessels – A framework

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ABSTRACT

For many years, there has been a growing focus on the energy efficient operation of vessels, and several performance systems are available on the market. However, most of these systems have been developed for long-distance sailing, and cannot be used directly on working vessels. The aim of the paper is to present a conceptual framework, which describes the overall decision structures in connection with energy efficient operations of working vessels. The framework consists of three models: the first model describes the operational modes and activity states of a vessel; the second model describes the conceptual dependency between the different actors in the operational context and the last model presents the conceptual solution model, which integrates the two other models. The models are developed based on nearly 50 interviews conducted with seafarers and office staff, procedure descriptions, and observations during fieldwork on board the ships. The proposed framework will form the basis for a future multi-layered decision support system.

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1. Introduction

There has been an increasing interest in the energy-efficient operation of vessels. Stakeholders in the maritime industry have identified several methods of improving energy efficiency, and a large number of studies has been conducted, assessing ways to improve the cost-effectiveness. See for example the DNV GL Energy management study from 2015 (DNV GL, 2015). The study is based on input from ship managers, owners and operators from 24 countries – answering the key question “To actually increase

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energy efficiency in ship operation, what really matters?" Another example is the Green House Gas study performed by CE Delft (Faber et al., 2011), presenting a literature survey and reports on interviews that aim to analyze the reason for the existence of a cost-effective abatement potential in the maritime industry. The increasing pressure from environmental problems, human health and global climate change has also resulted in new legislation being adopted, to reduce greenhouse gas emissions. The International Maritime Organization (IMO) has introduced guidelines for calculating energy efficiency during both the design and the operation phase, using 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 regulation, which applies to vessels exceeding 400 gross t, came into force in January 2013 with the adoption of amendments to MARPOL Annex VI – adding a new chapter on regulations concerning energy efficiency for ships (IMO, 2011). Whereas the EEDI lays down the design limits for new vessels, the intention of the SEEMP is to improve daily operation on board. The SEEMP is mandatory for all vessels – including non-transport vessels, such as working vessels, whereas only cargo carrying vessels are included in the EEDI approach of today. The conventional transport vessels, such as container vessels, tankers and bulk carriers, are easy to categorize – they are intended for a single purpose, with a single design point specifying a given cargo load and design speed. The more specialized vessels, such as offshore supply vessels, are not covered by the regulations. It can be very difficult to define a fixed design point for such vessels, as propulsion type, speed and operations vary during operation. The EEOI is a voluntary guidance tool for existing ships that can help to identify best practices for fuel-efficient operation. The EEOI can also be used for comparison and for developing the SEEMP. The EEOI is based on transport work (cargo transported per nautical mile per ton of fuel), which makes it unusable for working vessels. The European Union has pushed forward an EU-wide legislative framework for monitoring, reporting and verification (MRV) of CO_2 emissions from maritime transport (EU, 2015). This regulation, which was adopted on 29th April 2015, applies to larger vessels (over 5000 gross t), calling at EU ports from 1st January 2018, and its aim is to collect data on CO_2 emissions and subsequently publish it. The European Commission estimates that the MRV system will lead to a 2% cut in CO_2 emissions (EC, 2015).

The importance of monitoring the energy consumption of ships, as proposed by the EU, has been known for decades. In 1967, Drinkwater (1967) described the need for developing instruments for logging of parameters during service, ten years later Holtrop (1977) developed a method for propulsion power prediction based on measurements on ship models and of trial measurements made on board ships. Later the International Towing Tank Conference (ITTC, 1999; ITTC, 2005) has made guidance for measurement and procedures for predicting the power performance of a ship. Many commercial performance systems for optimizing the energy efficiency are available on the market, e.g. Marorka Marine Energy Management (Marorka, 2016), Kongsberg Vessel Performance System (Kongsberg, 2016) and the onboard decision support system SeaTrend (Force Technology, 2016). These systems have mostly been developed for long-distance sailing and cannot be used directly in vessels having unpredictable and flexible operating profiles.

Despite the fact that knowledge about cost-effective improvements is widespread in the industry, energy-efficient operation is only a minor topic on board many working vessels of today. Optimizing the energy efficiency of these vessels can be very difficult. Working vessels are known for being involved in different operations, and, as a result, have a very complex operating profile, which is difficult to evaluate and compare. Furthermore, monitoring the energy consumption or considering the topic of energy efficiency has normally not been an issue for vessels of this kind. The focus has primarily been on safety issues and optimizing the time available for performing offshore work, as the offshore work is normally very time-consuming and well-paid compared to the fuel oil costs.

The number of offshore vessels is increasing. The OECD (2014) concludes that in the period from 2014 to 2025 there will be a growing demand for energy, which will affect the offshore shipping market. For example, the demand for offshore support vessels deployed as platform supply vessels is expected to grow by 50% and the demand for wind turbine installations vessels by 117%. The numbers are at present challenged by the drop in the oil prices, but long-term studies show that there will be a growing demand (OECD, 2014). For the year 2012, the total shipping emissions were approximately 923 Mt CO_2, which account for 2.6% of the global CO_2 emissions. The total emissions for offshore and service vessels is estimated to be 6% of the total shipping emissions (Smith et al., 2015). Therefore, there is a need for a special focus on these vessels and on developing systems that help the crew and ship owner optimize operations, and reduce the energy consumption.

The aim of the current paper is to present a framework that describes the overall structure of a decision support system for energy optimization of working vessels with flexible operating profiles. To establish a successful system for best practices within energy management it is necessary to identify and evaluate cost-effective energy saving initiatives. For this purpose, a model that fits the working vessels and their flexible operational working patterns needs to be established, and it is important to have a more holistic approach than for transport vessels, having long ocean passages on comparable routes and schedules. The study requires a deep insight into the operation of a ship, and there has therefore been a high level of involvement of people with operational knowledge during the process of developing the model. Data has been collected through interviews, workshops, reading up on procedures, and observations on board.

The paper is structured as follows: In Section 2 the main characteristics of working vessels are explained. Section 3 describes the process of developing the framework, including data collected, people involved, analyses, findings and a developed operational flowchart. The section ends with a description of potential barriers to energy efficiency. Section 4 outlines a conceptual model and a simplified solution model. Section 5 contains a short discussion and Section provides the conclusions.

2. Working vessels - characteristics

Ships can be divided into two primary groups with different working characteristics. The first group covers conventional shipping, where the goods are loaded onto ships at a port, and these ships then make the sea passage and unload the goods at the next port. The other group - the working vessels, which are dealt with in the present paper, consists mostly of offshore and service vessels. The offshore vessels that support the industry of energy exploration and offshore production activities consist of a variety of vessels assisting oil and gas platforms and offshore wind farms throughout their entire lifetime. These vessels can be deployed for towing and anchor handling (AHTS), cable laying, bringing supplies as platform supply vessels (PSV), transferring crew, performing maintenance, and as standby vessels equipped with safety and fire-fighting equipment. The vessels can be designed for multiple functions, and a ship can often change purpose, e.g. from AHTS to PSV, repeatedly during its lifecycle. The working pattern is often very complex, and the vessel can be deployed for many different tasks

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