ENERGY EFFICIENCY OF OFFSHORE SUPPORT VESSEL

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Abstract
The paper presents the identified problems related to the development of energy efficiency assessment methodology for support vessels in terms of oil rigs. Based on the operational data, collected at an Anchor Handling Tug Supply vessel, such an assessment has been carried out. The function (technical support for oil rigs) of the vessel has also been taken into consideration. In order to assess the energy efficiency, the Energy Efficiency Operational Indicator has been applied. This indicator was developed and implemented by the International Maritime Organization, but the authors have adjusted it to the characteristic and the specification of the analyzed vessel. This is the first elaboration regarding Offshore Support Vessels which include Anchor Handling Tug Supply vessel.

Key words: *offshore support vessel, energy efficiency, energy efficiency indicator*

Introduction

The offshore support vessels market is subject to dynamic changes and the volume of new orders for the construction of new vessels is dependent on the oil prices [http://www.portalmorski.pl].
It also affects the employment rate for offshore supply vessels which is correlated with the cost of services provided by them. The forecast increase of orders in the period of 2005-2020 for new vessels and offshore supply vessels started to fluctuate, and the number of orders for the services has dropped [http://www.dbs.com.sg]. The employment rate of OSV (Offshore Support Vessel) in 2016 is presented in Table 1. In the case of division of the OSVs into PSV (Platform Supply Vessel) and AHTS (Anchor Handling Tug Supply Vessel), their use depends on their dimensions.

Tab. 1 Employment rate for OSV operating at the North Sea in 2016 [10]

OSV type	Employment rate %
PSV (medium)	71
PSV (large)	80
AHTS (medium)	29
AHTS (large)	55

The Employment of the vessels and the number of orders for services provided by the OSVs will be consequently related to the prices of the offered services and obtainable technical options. The prices are affected mainly by fuel cost which equals to 50-80% of vessel total operational and maintenance costs. Therefore, only companies and vessels that manage the energy efficiently will survive on the market. The improvement of the energy efficiency should affect not only the service price but mainly should minimize the negative impact on the environment caused by the fuel combustion process. This matter has been raised by the IMO (International Maritime Organization) since a very long period and the following resolutions enforce the implementation of the SEEMP (Ship Energy Efficiency Management Plan) at ships. The analysis presented below is aimed at the assessment of the energy efficiency of a selected AHTS vessel during its operation. The analysis has been based on the operational data, measured and collected at the vessel. The authors have applied also the indicator implemented by the IMO, namely the EEOI, which is used to specify the energy efficiency for ships. It is also applied during drawing up the SEEMP.

MATERIALS AND METHODS

The vessel selected for the purpose of the analysis is the *Kingdom of Fife*. This vessel is classified as AHTS vessel. This type of vessel is a variant of PSV vessel that has been modified. Among the most significant changes one may find:

- Increased power of the main engine;
- Assembly of a dynamic positioning system;
- Assembly of lifts and auxiliary winches;
- Assembly of a high-pull anchor and towing winch.

Due to the structural changes made, from typical supply vessel (PSV), a versatile vessel was constructed (ATHS). It offers both transport and supply services and is capable of the buoy and anchor handling, general assistance duties and towing (also for Royal Navy [http://www.maritimejournal.]).
The technical and operational data of the vessel in question is presented in Table 2 [http://www.briggsmarine.com]

Tab.2 Technical and operational data for AHTS – the *Kingdom of Fife*

Parameter	Value
Type	AHTS
Year Built	2008
Length Overall	61,20 m
Breadth	13,50 m
Max. draft	4,75
Deadweight	1266 BRT
F.W. Capacity	246 m^3
Speed	13,7
Main Engine Type	2 x Caterpillar C286-6
Generators	2x438 KVA
Thrusters	Caterpillar 392 kW
Output	2 x 2030 kW
Fuel	MDO F76
Fuel Conversion Ratio	3,5
Fuel Consumption per Day	12 t
Max Speed	13,7 kts

The *Kingdom of Fife*, presented in Figure 1, is not equipped with a software to monitor energy efficiency. It is understandable since the regulations imposing on shipowners the obligation to apply energy efficiency monitoring systems came into force in 2013. Whereas, the vessel was constructed in 2008. Therefore, it was not covered by the IMO requirements. The lack of an opportunity to evaluate the current vessel energy efficiency has prompted the authors to address the problem. The efficiency has been assessed on the grounds of the data being collected for 28 days (this is a period of working time of one crew). The operational data was collected every day at midday and at the start and the end of maneuvers and operational tasks (loading, buoy handling, navigation without load) performed by the vessel.

Fig. 1 AHTS vessel – Kindom of Fife at operation at the North Sea (*photo Briggs Marine)*

The engine room is modern and fully automated. It is supervised by two engineer. The vessel is serviced by external companies but day-to-day failures are repaired by the officers upon the prior agreement with the shipowner. The engine room is presented in Figure 2.

Fig. 2 Engine room of the *Kingdom of Fife* (*photo Briggs Marine*)

For the purpose of the operational effectiveness assessment of the AHTS vessel, the EEOI has been applied. It has been modified and adjusted in order to make such an assessment of the vessel when a specific operational task was being performed, not for the entire voyage *[Głowacki, B., Behrendt, C., 2015]*.
The EEOI calculation method for a current operation, taking into consideration the current energy load and freight being onboard, is presented by formula 1:

$$EEOI = \frac{FC_i C_F}{m\ D} \qquad [tCO_2/tNm] \tag{1}$$

where:
FC_i – mass of fuel consumed by main and auxiliary engines during a single task performance[t],
C_F - conversion rate expressed as a relation of CO_2 mass generated during used fuel combustion process [t_{CO2} / t_{fuel}],
m – mass of freight onboard [t],
D – distance expressed in nautical miles that the vessel travelled during the performance of a specific task [Nm – nautical mile].
As it may be noted, formula 1 relates also the amount of consumed fuel with the amount of CO_2 emitted to the atmosphere.

RESULTS AND DISCUSSION

The energy efficiency has been determined using the test results of consumed fuel and the work time of main engines and the auxiliary engines. The main engines generally work when the vessel navigate without load and performs operational tasks (loading and unloading supplies, buoy and anchor handling and towing, etc.). Since the main hydraulic pumps are suspended on the main engines, it has been noted that the main engines were working for 2-4 hours during unloading process in a port. It is related to the employment of the hydraulic deck cranes and their higher demand for power. The data included in Table 3 refers to the work time of the internal-combustion engines assembled at the vessel. The data has been collected based on the entries in the engine room log book. The internal-combustion engines at the vessel are the only devices fed with marine fuel. The *Kingdom of Fife* is not equipped with an oil-fired boiler and every heating process for the purpose of social heating (heating of cabins, water) and technical heating (warming the engines and tanks) is performed by electric heat exchangers.

Tab. 3 Work of main engines and power generators in the analyzed period

Engine	Use
Period of monitoring	28 days
Number of monitoring hours	672 h
Main engine No. 1 work time (ME 1)	295 h
Main engine No. 2 work time (ME 2)	297 h
Power use rate for main engine No. 1 (ME 1)	44%
Power use rate for main engine No. 2 (ME 2)	44%
Power use rate for diesel generators No. 1 and No. 2 (DG1 i DG2)	(63%) (37%)
Bow Thruster work time (BT)	97 h

Based on the data in Table 3, Figure 3 has been drawn up. It shows the main engine work hours on individual days during the vessel operation. When analyzing Figure 3, it may be noted that the main engines are in operation for 24 hours per day only when the vessel is on the move to a specific port or activity area. During buoy and anchor handling etc. the main engines are operated the most frequently for 8-12 hours. Between 5 p.m. and 6 p.m., when the vessel is at the destination, the main engines are not in the operation and the vessel does not carry out any tasks. This is proven by the data in the engine room log book. At that time, the crew prepares the vessel to the next assignment and inspects the technical condition of the marine devices and machines. Certain small repairs and service works are also performed. The 9-10 hour periods, presented in Figure 3, of the main engines work refer to the activities carried out at the destination point consisting in deployment and picking up the navigation buoys.

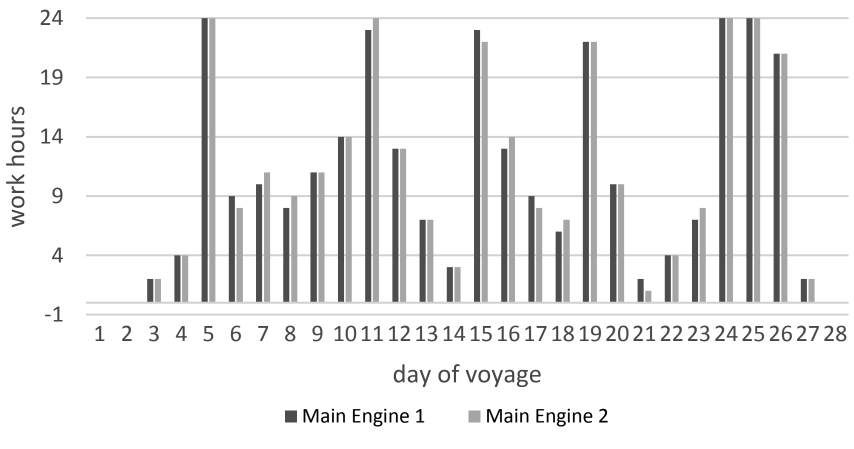

Fig. 3 Work hours of main engines during operational tasks

The energy efficiency assessment of an AHTS vessel using the EEOI is not very reliable since the distance travelled by the vessel during a buoy deployment or an anchor weighting is minimal. This affects negatively the EEOI value as the value depends on the travelled distance. The energy efficiency assessment by the EEOI for individual tasks completed by the vessel is possible only for towing a buoy or an anchor under the condition that the distance travelled is measurable. The data collected during these activities may be compared to the historical data at similar water areas. One should strive to obtain the least value of the EEOI. The comparison of the historical values with the present ones shall enable the vessel energy efficiency to be assessed.
The data in Table 4, regarding the fuel consumption of the vessel in question, has been developed on the grounds of the entries in the engine room log book and navigation data (time, distance travelled). The freight transported by the vessel during the 28 days equaled to 20 tones, which is not a significant value when compared to the amount of fuel (350 tones). For the purpose of the EEOI calculation for particular operational tasks, the mass of fuel and freight onboard have been assumed as the transported cargo mass.

Tab. 4 Fuel consumption of the *Kingdom of Fife* during operational tasks

Task	Working device	Fuel consumption t/h
Stay at port	DG1 or DG2	0,0279
Loading at port	DG1 or DG2	0,0355
Navigation without load	ME1, ME2, DG1,	0,281
Buoy deployment	ME1, ME2, DG1, BT	0,194

ME1- Main Engine No1, ME2- Main Engine No2, DG1 – Diesel Generator No1, DG2 – Diesel Generator No2, BT – Bow Thruster

Table 5 presents the data specifying the voyage stages and operational tasks performed by the vessel and the EEOI values calculated using formula 1.

Tab. 5 Operational data of the *Kingdom of Fife* during operational tasks

Task	Duration	Fuel consumption	Cargo mass	Distance	EEOI
	h	t	t	Nm	tCO_2/tMm
Stay at port	48	1,352	167,31	0	Not determined
Loading at port	8	0,284	312,71	0	Not determined
Buoy deployment	9	1,704	310,59	0	Not determined
Navigation without load No 1	29,5	8,298	311,863	300	$0,31 * 10^{-3}$
Navigation without load No 2	36	11,35	295,05	343	$0,377 * 10^{-3}$
Navigation without load No 3	91	19,28	252,12	650	$0,378 * 10^{-3}$

As per the analysis, the energy efficiency assessment of an AHTS vessel by the EEOI, recommended by the IMO, is problematic to be carried out during the most of operational tasks. In order to apply formula 1, it is necessary to hold an information on the distance travelled by a vessel. This information is unmeasurable during the operation of the dynamic positioning system and buoy and anchor handling (weighting and dropping) when engines (main and auxiliary) are heavily loaded. The EEOI for the ATHS vessel may be determined for such tasks as navigation without load and transport of buoys and anchors. The analysis included in the paper and identified problem should enable further development of the works related to drawing up the SEEMP for this type of vessels. The previous guidelines and analyses regarding the energy efficiency of vessels and ships [*PRS Nr 103/P, 2016, MEPC.1/circ.684 2010, MEPC. 203(62) 9, 2011*] have not referred to this type of vessels. The authors are experienced in assessing the energy efficiency for special vessels [Głowacki, B., Behrendt, C. 2015], which should enable further research to be carried out. Effective energy management of AHTS vessels, in relation to the large number of them being in operation [*Herdzik, J. 2012*], will contribute to the limitation of the harmful exhaust gas emission to the atmosphere and to the reduction of the maintenance costs and prices for services provided.

CONCLUSIONS

The matter of the EEOI determination and the SEEMP development for vessels is currently leading in the shipbuilding industry. It is related both to the desire to the reduction of fuel consumption and the mitigation and minimization of the threats to the environment resulting from the vessels operation.
As the analysis showed, the methods to determine the EEOI and to draw up the SEEMP should be developed for each vessel type taking into consideration their function.

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