Derivation of Ship Operational Efficiency Using AIS Data

HONGSEOK BAE(elvisfromkorea@gmail.com)[1], Dominic A Hudson[2]
[1]University of Strathcylde, [2]University of Southampton

Abstract

This study provides a simplified ship operational efficiency estimation methodology using general data: the automatic identification system (AIS), prevailing weather conditions, and technical data on the vessel (which is open to the public). The model development has been carried out and validated compared with actual data based on the target vessel; a liquefied natural gas (LNG) carrier with a single screw, 6 L/B, 4.18 B/T, and 0.19 Froude number (Fr) for service speed.

The operational efficiency model mainly consists of three parts: propulsion power estimation, auxiliary/boiler estimation, and transportation work estimation. For the propulsion power estimation, the naval architecture methods are used for each resistance and efficiency component. The Holtrop and Mennen method for calm water resistance, Townsin and Kwon method for weather resistance, Aertssen method for fouling resistance, and Wageningen B series for the propeller open water efficiency (ηo) estimation are used for this model. Through the validation compared to the actual shaft power values, good agreement was found when different weighting factors were applied to a calm water resistance of 0.7, fouling resistance of 0.28, and weather resistance of 0.25 in a condition of below Beaufort number (BN) 7. For auxiliary engine power estimation, a different load factor was used depending on operational modes, such as 0.24 for cruising, 0.21 for manoeuvring, 0.24 for anchoring, and 0.21 for a port mode. For the boiler power estimation, a fixed fuel consumption value of 2.6 ton/day was used. Transportation works were obtained from cargo capacity, by the draft changes of AIS data, and distance calculations by speed changes of the AIS.

The final calculated outputs by this model indicate an average daily fuel consumption of 41.0 ton for the main engine, 8.2 ton for the auxiliary engine, and 2.6 ton for boilers. These values are per day with an Energy Efficiency Operational Indicator (EEOI) of 12.1 gCO2/ton.nm, and are in reasonable agreement (approximately 12% difference) with the actual values. The results of the development of operational efficiency model provide a better understating of the energy efficiency components, especially of propulsion power.

Keywords: *EEOI, ship efficiency, AIS, CO2, resistance estimation, LNG carrier*

References

[1] IMO, Third IMO Greenhouse Gas Study 2014, International Maritime Organisation, London, 2014.

[2] C. Trozzi, R. D. Lauretis and e. al., EMEP/EEA Air Pollutant Emission Inventory Guidebook 2016, part B: Technical chapters 1 Energy 1.A.3.d Navigation (Shipping), Eroupean Environment Agency, 2016.

[3] T. Smith, E. O'keeffe, L. Aldous and P. Agnolucci, Assessment of Shipping's Efficiency Using Satellite AIS data, UCL Energy Institute, London, 2013.

[4] H. Chi, G. Pedrielli, S. H. Ng, T. Kister and S. Bressan, A framework for real-time monitoring of energy efficiency of marine vessels, Elsevier Energy, 2017.

[5] A. Molland, S. R. Turnock and D. Hudson, Ship Resistance and Propulsion, Practical Estimation of Ship Propulsive Power, Cambridge University Press, 2007.

[6] NOAA, National Weather Service : NCEP Central Operations, National Oceanic and Atmospheric Administration, 22 2 2017. [Online]. Available: http://www.nco.ncep.noaa.gov/. [Accessed 2018].

[7] Clarkson Research, Shipping Intelligence Network, Clarkson Research Service Limited, 2018. [Online]. Available: https://sin.clarksons.net//. [Accessed 1 8 2018].

[8] IMO, MEPC.245(66) 2014 GUIDELINES ON THE METHOD OF CALCULATION OF THE ATTAINED ENERGY EFFICIENCY DESIGN INDEX (EEDI) FOR NEW SHIPS, International Maritime Organisation, 2014.

[9] J. Holtrop and G. Mennen, An approximate power prediction method, International Shipbuilding Progress, vol. 29, no. 335, pp. 166-170, 1982.

[10] R. L. Townsin and Y. J. Kwon, Approximate Formulae for the Speed Loss Due to Added Resistance in

Wind and Waves, Transactions of the Royal Institution of Naval Architects, vol. 125, pp. 199-207, 1982.