IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

SIMULATOR BASED RESEARCH ON FUEL CONSUMPTION ON SHIPS DURING COLOMBO MANEUVERING

[1]John D.P., [2]Devinda S., [3]Sedrick, P., [4]Perera, H., Medawela Disanayaka, S.[5] Widyalankara, R.[6]
[1 2 5] Lecturer, simulator instructor and trainer, Dept. of Marine Simulation [3] Associate Dean of the Faculty of Maritime Sciences and Marine Simulation [4] Head of the Dept. of Marine Simulation and Senior Lecturer in Marine Simulation [6] Professor consultant Dept. of English

CINEC Campus (Pvt.) Ltd., Malabe, Sri Lanka

Abstract: Saving energy and reducing carbon gas emissions simulation models are developed to estimate real performance of ships in the actual sea conditions to diminish air pollution. The simulator research team of CINEC Campus, Malabe, Sri Lanka, evaluates/discovers the best possible way to reduce the air pollution caused by the ships which arrive to Colombo harbor. As instruments this simulator based study utilizes the Technological Simulator 5000 Version 8.7.4530.147 and as the Engine Simulator, the Technological Simulator 5000 Version 8.7.4530.147 along with the Bridge Simulator: NT PRO 5000.
Engine Types used included MAN B&W 6S60MC-C, two strokes, slow speed, turbocharged, reversible engine, MCR 18,420 BHP at 105 RPM and Fixed Pitch Propeller. The methodology consisted of a population of 05 seafarers: 01 Harbor Pilot, 01 Senior Master and 03 Chief Mates selected under purposive sampling procedures. Data collection included the number of engine movements, recorded rudder angles and fuel consumptions utilized by different operators. Analyzing the data, the findings state that the more sea time experience of the seafarers results in less number of movements to arrive to the berth. However, main engine movements are the dominant factors for reducing the fuel consumption during the period of maneuvering. Additionally, the time taken come to the berth is also proportional to the fuel consumption during that period. The findings conclude that if the vessel operator can come to the berth with less main engine and rudder movements and with a shorter period of time the fuel consumption undergoes reduction.

Index Terms **- Fuel Consumption, maneuvering, sea time experience**

I. INTRODUCTION

Shipping is a major mode of mass transport of cargo around the world and is considered as the most efficient form of commercial transport. In Figure 1 below depicts the International Chamber of Shipping comparison of the different emissions between vehicles used for freight.

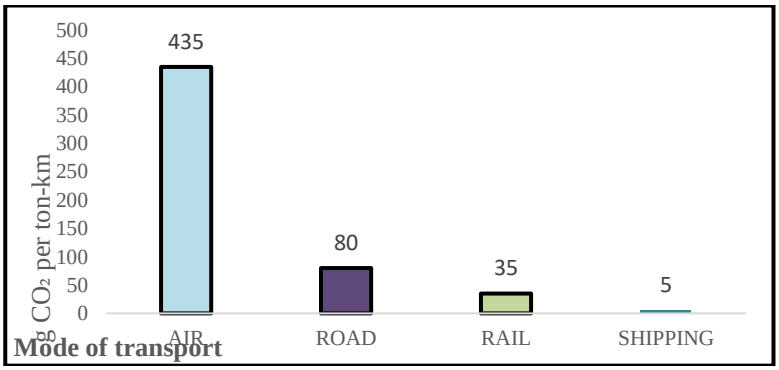


Figure 1: CO_2 emissions from vehicles used for freight (Adapted from IMO Green House Gas Study (GHG), 2009) [1]

Air pollution is one of the deadliest issues for the world today. It has brought severe consequences for the living being. According to the World Health Organization (WHO) guidelines (2021) [2], each year air pollution responsible for nearly seven million deaths around the globe. Nine out of ten human beings currently breathe air that exceeds the WHO guideline limits for pollutants. In accordance with the WHO guidelines, the air quality in Sri Lanka is considered moderately unsafe. The most recent data indicates the capital Colombo annual mean concentration of 2.5 PM (Particulate Matter) is 11µg/m³ exceeding the recommended maximum

level of 10µg/m³. Sri Lanka ranked 30 out of 106 countries which had the worst air quality in 2020 according to the IQAir [3]. The simulator research team of CINEC Campus tries to evaluate/discover the best possible way to reduce the air pollution caused by the ships which arrives to Colombo harbor area by this simulator based study. The commercial ships burn fuel for energy and emit several types of air pollutants as by-products, The major Green House Gas (GHG) contributing to air pollution is CO2 in which ships contribute 2.2% of the world's total CO2 emission according to the S&P Global Platts Analytics [4]. Accordingly, the CO2 emission can be reduced by reducing the fuel consumption as the CO2 emission is directly proportional to the fuel consumption. Meanwhile, The Paris Agreement (2016) [5] which is a legally binding international treaty on climate change wants to limit the global warming to well below 1.5 Celsius, compared to pre-industrial levels by reducing the Green House gas emission. IMO is also fully committed to reduce the CO2 emissions by ships and introduced SEEMP (Ship Energy Efficiency Management Plan) in 1st January 2013 [6]as a tool to monitor and improve the energy efficiency of a ship in a cost-effective manner. In 2019 IMO [7] introduced the Energy Efficiency Design Index (EEDI) a vital technical measure for new ships, along with the Energy Efficiency Operational Indicator (EEOI) and the Ship Energy Efficiency Management Plan (SEEMP), both of which aim to curb energy consumption during ship operations. This study now moves to reviewing existing research on fuel consumption on ships during maneuvering.

II. NEED OF THE STUDY

Zeraatgar, H. and Ghaemi, M. H. (2019) [8] analyze the possibility of fuel consumption reduction by using an alternative control strategy for low-speed marine diesel engines The study by Finger et al. (2020) [9] used systematized results to manually optimize the manoeuvring behaviour and to create a manoeuvre plan according to the environmental conditions. Rutherford et al. (2020) [10] investigated the effectiveness of EEXI. The findings state that if the EEXI does not limit engine power below what ships already use, it will not result in reductions in ship speed or CO2. Mizythras et al. (2017) [11] investigated the performance of a ship's propulsion system during a turning circle manoeuver. lead to poor manoeuvrability.

Thus, the need of the study arises from the fact that none of the cited studies have investigated sea time experience of the ship operators as a variable in controlling fuel consumption and the resulting reduction carbon dioxide (CO2) emissions which highlights the significance of the area of investigation in this study.

III. RESEARCH METHODOLOGY

3.1 Population and Sample

Sri Lanka's sole full mission bridge and engine simulator at CINEC Campus and experienced well-trained team placed a particular type of ship in the Colombo anchorage and maneuvered the ship to Colombo port by employing different high ranked officers who can maneuver the ship safely to the berth. The number of engine movements, rudder angles and the fuel consumptions utilized by different operators were noted down by the engine simulator department participants. Thereafter, recorded readings were analyzed to find the lowest number of engine movements and rudder movements taken to arrive to the port safely as the number of engine and rudder movements directly proportional to the fuel consumption.

3.2 Instruments: Engine Technological Simulator 5000 Version 8.7.4530.147 and Bridge Simulator: NT PRO 5000. Engine type used included MAN B&W 6S60MC-C, two strokes, slow speed, turbocharged, reversible engine, MCR 18,420 BHP at 105 RPM and Fixed Pitch Propeller (NCR, 85% MCR – 16540 BHP at 101.4 RPM)

3.3 The scenario: This placed a ship in the Colombo anchorage. The ship was maneuvered to Colombo port by employing different high ranked officers who can maneuver the ship safely to the berth. Experienced Chief Engineer and Simulator instructor from the Engine Department contributed to the collection of data.

Participants: 01 Experienced Harbor Pilot, 01 Master and 03 Chief Mates.

Table 1: Sea time experience of the participants

Designation	Sea time experience
Harbor Pilot:	27 years
Ship Master	15 years
Chief mate- A	13 years
Chief mate- B	12 years
Chief mate- C	10 year

3.4 Sampling: Purposive sampling was used.

3.5 Data Collection

The number of engine movements, rudder angles and the fuel consumptions utilized by different operators were noted down by the engine simulator department participants. Thereafter, the recorded readings were analyzed to find the least number of engine movements and rudder movements taken to arrive to the port safely as the number of engine and rudder movements directly proportional to the fuel consumption.

IV. RESULTS AND DISCUSSION

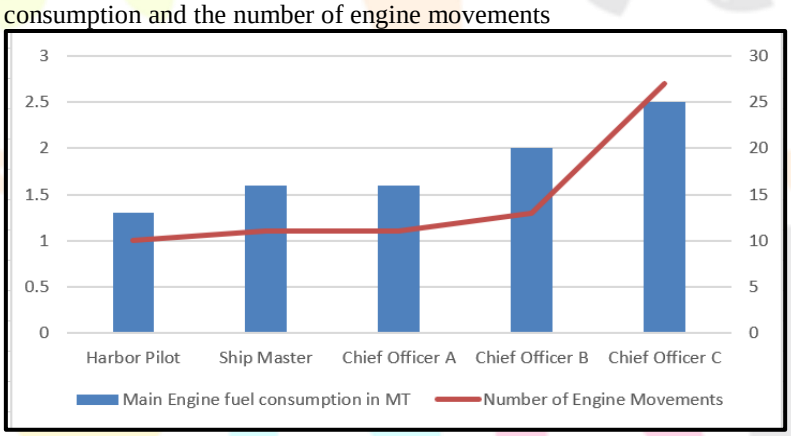
As depicted in Table 2 below when analyzing the number of engine movements and number of rudder movements given it is noted that, in general, more sea time experience of the participants results in less number of movements to arrive to the berth.

Table 2: Influence of Sea time experience on engine, rudder movements and time

Ship Operators	Sea Time Experience	Number of Engine Movements	Number of Rudder Movements, More Than 15 Degrees	Time Taken to Come Alongside in Minutes
HARBOR PILOT	27 years	10	03	52
SENIOR MASTER	15 years	11	08	55
CHIEF MATE 'A'	13 years	11	10	49
CHIEF MATE 'B'	12 years	13	06	78
CHIEF MATE 'C'	10 years	27	04	76

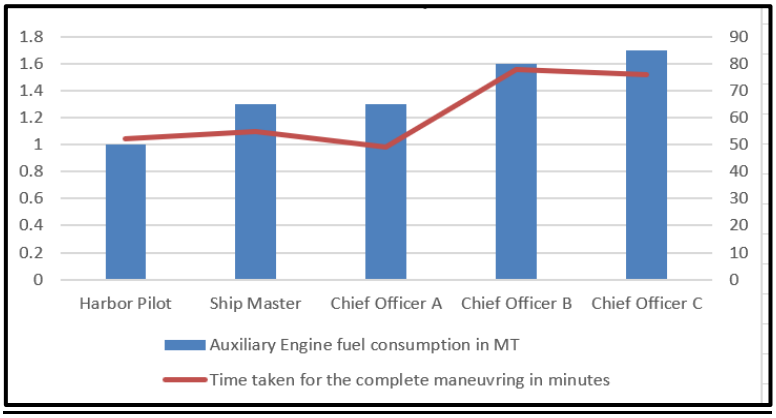
Figure 1 below depicts that the main engine fuel consumption and the number of engine movements are less when the ship is maneuvered by senior officers.

Figure 1: Main Engine fuel consumption and the number of engine movements



Additionally, Figure 2 below conveys that the Auxiliary engine fuel consumption too is less when the ship is maneuvered by senior officers. Time taken to complete the maneuvering in too was less for the senior officers who had more sea time experience.

Figure 2: Auxiliary Engine fuel consumption and time taken to complete the maneuvering in minutes



.

In sum, all the main variables: main and auxiliary engine fuel consumption; the number of engine movements and time taken to complete the maneuvering are less when the ship is maneuvered by senior officers. This is mostly due to the fact that the experienced senior officers have been handling ships for a much longer period of time.

The fuel consumption is directly proportional to the CO2 emission. Therefore, this data analysis clearly shows that the environmental pollution can be reduced when a ship is maneuvered with less number of engine and rudder movements. These findings further indicate how energy- efficient navigation can be carried out at sea which is required by IMO's resolutions on Shipboard energy efficient management plan (SEEMP).

When a lesser number of engine movements and rudder movements given the fuel consumption in Main & Auxiliary engine will be lesser. However, main engine movements is the dominant factor for reducing the fuel consumption during the period of maneuvering. Similarly, the time taken come to the berth also proportional to the fuel consumption during that period. Therefore, if the vessel operator can come to the berth with less Main engine and rudder movements as well as with shorter period of time then the fuel consumption will be lesser. Thereby, the adverse effects on the environment can be reduced with lesser fuel consumption.

V. Acknowledgment

This research was supported by the Accelerating Higher Education Expansion and Development (AHEAD) Operation of the Ministry of Higher Education funded by the World Bank.

.

References

[1] IMO (2009). Second IMO Greenhouse Gas Study. https://www.imo.org/en/OurWork/Environment/Pages/Greenhouse-Gas-Study-2009.aspx

[2] World Health Organization. (2021) https://www.who.int/news/item/22-09-2021-new-who-global-QAir air-quality-guidelines-aim-to-save-millions-of-lives-from-air-pollution

[3] QAir (2020) https://www.iqair.com/sri-lanka/western/colombo

[4] S&P Global Platts Analytics (2021) https://www.spglobal.com/commodityinsights/en/products-services/natural-gas/platts-greenhouse-gas-emissions-service

[5] The Paris Agreement. (2016). https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

[6] IMO (2013). Module 6 – Energy Management Plans and Systems https://wwwcdn.imo.org/localresources/en/OurWork/Environment/Documents/Air%20pollution/M6%20energy%20management%20plan%20and%20system%20final.pdf

[7] IMO (2019), Energy Efficiency Measures, www.imo.org/en/ OurWork/Environment/PollutionPrevention/AirPollution/Pages/Technical-and-Operational-Measures.aspx..

[8] Zeraatgar, H. and Ghaemi, M. H. (2019)). The analysis of overall ship fuel consumption in acceleration manoeuvre using hull-propeller-engine interaction principles and governor features. *Polish Maritime Research* 1 (101) 2019 Vol. 26; pp. 162-173 10.2478/pomr-2019-001

[9] Finger, G., Schubert, A. U., Riebe, T., Fischer, S., Gluch, M. and Baldauf, M. (*2020*)."Consumption and Emission Minimised Ship Manoeuvring," *Global Oceans 2020: Singapore – U.S. Gulf Coast*, 2020, pp. 1-6, doi: 10.1109/IEEECONF38699.2020.9389278.

[10] Rutherford, D., Mao, X. and Comere, B (WORKING PAPER 2020-27). Potential CO2 reductions under the Energy Efficiency Existing Ship Index. https://theicct.org/sites/default/files/publications/Marine-EEXI-nov2020.pdf

[11] Mizythras, P., Pollalis, C., Boulougouris, E., Theotokatos, G. (2017). Simulation of a Ship Propulsion System Performance during Manoeuvring in Shallow Waters. I*nternational Society of Offshore & Polar Engineers* (ISOPE) .https://strathprints.strath.ac.uk/61211/8/Mizythras_etal_IOPEC_2017_Simulation_of_a_ship_propulsion_system_performance_during.pdf