Journal of Marine Science and Application (2023) 22: 659-661
https://doi.org/10.1007/s11804-023-00384-0

Editorial

Decarbonization of Ship Operations

C. Guedes Soares

The need to reduce the trends associated with climate change imposes measures to reduce the emissions of greenhouse gases to the atmosphere and increase the efficiency of the use of energy. The International Maritime Organization (IMO) has been active since 1997 in promoting the implementation of measures that lead to more efficient ship operation with less fuel consumption and less emissions (Tadros et al., 2023a). The measures include improved ship design and improved operational practices. Several indexes have been created to quantify different aspects of these improvements. The shipping industry has been very actively implementing several actions aiming at the decarbonization of ship operation and more need to continue being implemented.

This special issue addresses several of the issues of importance in the process of decarbonization of ship operations. The more effective measures are the long-term ones based on new types of fuels that produce much lower emissions or eventually no harmful emissions at all. However, several fuel types, like methanol and ammonia, are not fully available yet and even after being available, it is still necessary to have a supply infrastructure implemented in several ports to allow ships to operate with that type of fuel (Ramsay et al., 2023).

Engine manufacturers represent the other important component of the problem as they need to develop the technology of engines that can operate with those fuels and they must produce them industrially so that they can be routinely installed on ships. Recent advances have already been made with dual fuel engines, which are already installed in a good number of ships that operate with liquified natural gas (LNG) as the second fuel that will be used in certain areas. While LNG operation is accepted everywhere, it involves important risks in its operation and several risk analysis studies have been made to assess the existing levels as well as the measures to ensure high safety levels (Abdelmalek and Guedes Soares, 2023).

The various design and operational indices established by IMO (Tadros et al., 2023a) allow assessments to be made of the level of compliance of ships with the required conditions for decarbonization. This has been the approach adopted by Kanberoğlu et al. (2023) to assess the level of decarbonization of the Turkish fleet.

The short-term measures prescribed by IMO include various ways of improving the hydrodynamic efficiency of the hulls through the optimization of the hull shape of the addition of special features that lead to lower energy consumption. Several papers in this special issue address this type of problem.

Liu et al. (2023) study the fuel consumption in seaway accounting for the dynamic interaction among environment-hull-propeller-engine. The diesel engine is modelled by a first-order transfer function with a delayed response and a governor is applied to maintain the pre-set engine's rotational speed and to control the engine fuel rate. The developed code is used to study the influence of different types of governors on ship speed and fuel consumption.

Tadros et al. (2023b) have developed another computational model to evaluate the ship and propeller performance in terms of fuel consumption as well as cavitation and noise produced. This tool is used to compare single and twin-screw propulsion systems of a bulk carrier, demonstrating how the tool can be used to select a suitable propeller to improve the energy efficiency of the ships.

Saini et al. (2023) look also at the behaviour of the whole propulsion system but they have the viewpoint of improving the availability of the marine power plant using metaheuristics algorithms, which is an important problem for planning maintenance of the systems.

Gopinath and Vijayakumar (2023), study the effect of hull appendages in reducing the hull resistance. They look into the use of the Hull Vane® in reducing wave-making resistance for vessels with high Froude Number. This is important for medium-speed vessels, where the wave-making component accounts for almost 50% of total resistance. The study is a computational analysis of a containership model using the VOF method and RANS solver, which shows the changes in sinkage

✉ C. Guedes Soares
c.guedes.soares@centec.tecnico.ulisboa.pt

[1] Centre for Marine Technology and Engineering (CENTEC), Instituto Superior Técnico, Universidade de Lisboa, 1409-001 Lisboa, Portugal

and trim and the associated changes in resistance.

Ceylan (2023) has studied the emission performance of a two-stroke diesel engine as a function of the season, showing the effect of minor temperature variations on the combustion characteristics, fuel efficiency, and emissions of the ship's main engine.

In high-speed transportation, the use of hydrofoils is a solution adopted to reduce hull resistance and thus fuel consumption. Jiang et al. (2023) deal with this very specific problem, analysing the vibration characteristics of hydrofoils at different flow velocities and angles of attack, which makes it possible to explore the impact of different trailing edge shapes on hydrofoil vibration, which limits the operation of the vessel.

Campora et al. (2023) compare the engine exhaust gas waste heat recovery and hybrid turbocharger technologies, which are used to improve the efficiency of a dual-fuel four-stroke marine engine. Two steam plant schemes are considered: the single steam pressure and the variable layout (single or dual steam pressure plant). In both cases, a heat recovery steam generator is used for the electric power energy generation through a steam turbine. A mathematical model of this system is developed and applied to study the performance of the two types of fuel, natural gas and high diesel fuel, showing better efficiency of the natural gas for all the engine working conditions.

Karatuğ et al. (2023) deal also with dual-fuel four-stroke marine engines and propose a novel framework for evaluating an alternative LNG fuel system installation onboard from both environmental and economic perspectives. Two different analyses are conducted in the case study (i) considering just fuel cost saving of investment for economic benefit and (ii) considering both environmental financial and fuel cost savings for economic benefit. The environmental financial benefits of the LNG adaptation are determined based on the reduced amount of emissions compared to VLSFO usage.

The special issue includes then several papers that deal with the performance of different types of engines when powered with different types of new fuels.

Fuel cells represent one of the possible technologies that can be used to reduce the emissions related to the present fuels. Qu et al. (2023) have made a study of solid oxide fuel cells, which have the highest thermal efficiency and operate at remarkably high temperatures, enabling combined heat and power in some scenarios.

Li et al. (2023) studied the spray and combustion characteristics of diesel-butanol blended fuels within a high-temperature and high-pressure constant-volume chamber equipped with a single-hole injector. They found that with the increase of the n-butanol ratio, the soot production in the combustion process decreases significantly. Due to the shorter ignition delay period, the soot distribution of pure diesel reaches a steady state earlier than that of the blends.

Wei et al. (2023) studied the emissions produced in the operation of a low-speed engine fuelled with biofuel. Christopher Selvam et al. (2023) discuss different types of biodiesel that could eventually be used in engines.

Not all types of fuels that are currently been considered as possible ones have been included in the set of papers in this special issue, but the variety of papers related to different types of fuels should reflect the wide variety of options that are being considered. The adoption of future fuels will require a large-scale production and also a wide network of supply stations in the main ports, and thus it is not enough to determine how the engines perform with the various types of fuel. The feasibility of the fuel type will depend on those factors, which means that only a small number of options will be pursued in the future.

It is hoped that the collection of these papers dealing with various aspects of decarbonization of shipping, will help to provide a useful overview of the problem area.

References

Abdelmalek M, Guedes Soares C (2023) Review of Risk Analysis Studies in the Maritime LNG Sector. Journal of Marine Science and Application, 22(4): 693-715. https://doi.org/10.1007/s11804-023-00376-0

Campora U, Coppola T, Micoli L, Mocerino L, Ruggiero V (2023) Techno-Economic Comparison of Dual-fuel Marine Engine Waste Energy Recovery Systems. Journal of Marine Science and Application, 22(4): 809-822. https://doi.org/10.1007/s11804-023-00368-0

Ceylan BO (2023) Investigation of Seasonal Effects on Two-Stroke Marine Diesel Engine Performance Parameters and Emissions. Journal of Marine Science and Application, 22(4): 795-808 . https://doi.org/10.1007/s11804-023-00383-1

Christopher Selvam D, Yuvarajan D, Jayaba R (2023) The Potential of Inedible Biodiesel as an Eco-Friendly and Sustainable Alternative Fuel for Marine Diesel Engines in India. Journal of Marine Science and Application, 22(4): 870-881. https://doi.org/10.1007/s11804-023-00382-2

Gopinath S, Vijayakumar R (2023) Computational Analysis of the Effect of Hull Vane on Hydrodynamic Performance of a Medium-Speed Vessel. Journal of Marine Science and Application, 22(4): 762-774. https://doi.org/10.1007/s11804-023-00378-y

Jiang YC, Wang CS, Li JG, Wang CX, Wang Q (2023) Study on Flow-induced Vibration Characteristics of 2-DOF Hydrofoil Based on Fluid-Structure Coupling Method. Journal of Marine Science and Application, 22(4): 795-794. https://doi.org/10.1007/ss11804-023-00380-4

Kanberoğlu B, Turan E, Kökkülünk G (2023) Decarbonization of Maritime Transportation: A Case Study for Turkish Ship Fleet. Journal of Marine Science and Application, 22(4): 716-727. https://

doi.org/10.1007/s11804-023-00370-6
Karatuğ Ç, Ejder E, Tadros M, Arslanoğlu Y (2023) Environmental and Economic Evaluation of Dual-Fuel Engine Investment of a Container Ship. Journal of Marine Science and Application, 22 (4): 823-836. https://doi.org/10.1007/s11804-023-00381-3
Li WH, Xuan TM, He ZX, Wang Q, Li WM (2023) Combustion Characteristics of Diesel/Butanol Blends Within a Constant Volume Combustion Chamber. Journal of Marine Science and Application, 22(4): 850-860. https://doi.org/10.1007/s11804-023-00348-4
Liu SK, Beh KH, Papanikolaou A (2023) Predicting the Fuel Consumption of a Ship in Seaway Considering the Dynamic Interaction Among Environment-Hull-Propeller-Engine. Journal of Marine Science and Application, 22(4): 728-740. https://doi.org/10.1007/s11804-023-00373-3
Qu JB, Feng YM, Wu YJ, Zhu YQ, Wu BY, Xiao ZX (2023) Design and optimization of an integrated power system of solid oxide fuel cell and marine low-speed dual fuel engine. Journal of Marine Science and Application, 22(4): 837-849. https://doi.org/10.1007/s11804-023-00377-z
Ramsay W, Fridell E, Michan M (2023) Maritime Energy Transition: Future Fuels and Future Emissions. Journal of Marine Science and Application, 22(4): 681-692. https://doi.org/10.1007/s11804-023-00369-z
Saini M, Patel BL, Kumar A (2023) Stochastic Modelling and Performance Optimization of Marine Power Plant with Metaheuristic Algorithms. Journal of Marine Science and Application, 22(4): 751-761. https://doi. org/10.1007/s11804-023-00371-5
Tadros M, Ventura M, Guedes Soares C (2023a) Review of the IMO Initiatives for Ship Energy Efficiency and Their Implications. Journal of Marine Science and Application, 22(4): 662-680. https://doi.org/10.1007/s11804-023-00374-2
Tadros M, Ventura M, Guedes Soares C (2023b) Fuel Consumption Analysis of Single and Twin-Screw Propulsion Systems of a Bulk Carrier. Journal of Marine Science and Application, 22(4): 741-750. https://doi.org/10.1007/s11804-023-00372-4
Wei CF, Jiang GH, Cui L, Wu G, Zhong SS (2023) Combustion Analysis of Marine Low-Speed Engine Fueled with Biofuel. Journal of Marine Science and Application, 22(4): 861-869. https://doi.org/10.1007/s11804-023-00375-1