Thermal Load Comparison of Marine Diesel Engines Converted to Renewable and Low-Carbon Fuels Across ISO 8178 Engine Load Cycles

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Abstract

The decarbonization of maritime transport, guided by IMO and EU regulations, is primarily aimed at reducing greenhouse gas emissions (CO_2, CH_4, N_2O) and improving the energy efficiency of ship power plants [MARPOL 73/78 (Annex VI); COM (2021) 562-final 2021/0210 (COD)]. However, ensuring engine reliability remains closely tied to addressing localized issues affecting the operability of individual components, particularly when engines are adapted to alternative fuels.

This study emphasizes the need for methodological tools to evaluate thermal loads on critical components—specifically the cylinder–piston group—during the retrofitting of marine diesel engines. Such assessments support the optimization of engine performance when using renewable and low-carbon fuels (LCF), balancing both efficiency and reliability considerations.

The paper presents comparative investigations of thermal load variations in ship engines operating on LCF, applying a combined analytical method developed by the authors. The approach focuses on priority fuels for the medium-term outlook toward 2030, including LNG (bio-LNG), biodiesel, and methanol. The study further assesses the effectiveness of established diesel engine enhancement practices, such as adjusting the excess air coefficient, modifying compression ratios, and refining fuel combustion characteristics.