



Ammonia and Ammonia-Oxygen Mixtures for Cleaner and More Efficient Dual-Fuel Combustion

Author AA¹, Second-Author BB^{1*}, Third CC², So-on DD²

Mhadi A. Ismael^{1*}, Mohammed El-Adawy¹, Medhat A. Nemitallaha^{1,2}

*lead presenter: Mhadi.harroun@kfupm.edu.sa

1 Interdisciplinary Research Center for Hydrogen and Energy Storage (IRC-HES), King Fahd University of Petroleum and Minerals (KFUPM), Dhahran 31261, Saudi Arabia

2 Aerospace Engineering Department, King Fahd University of Petroleum & Minerals, Dhahran, Saudi Arabia

This study investigates the effects of Energy Fractions (EF) of premixed ammonia-air and ammonia-oxygen mixtures on combustion and emissions in a dual-fuel engine. Results show that premixed ammonia-air reduces peak in-cylinder pressure by 4.53% (EF20NH₃) and 4.26% (EF40NH₃) compared to diesel (D100), due to ammonia's high auto-ignition temperature, lower flame temperature, and polytropic coefficient. In contrast, adding oxygen (EF40NH₃+O₂) increases peak pressure by up to 10.2%. EF40NH₃+O₂ also improves heat release rate (HRR), cumulative heat release (CHR), mass fraction burned (MFB), and achieves the highest indicated mean effective pressure (IMEP) of 14.75 bar, surpassing D100 and other mixtures. Emissions analysis shows that CO₂, CO, and NO_x decrease with higher ammonia content but increase with oxygen addition due to higher combustion temperatures, though HC emissions are significantly reduced. Overall, the results demonstrate that while ammonia's introduction can reduce peak pressures due to its combustion properties, using a premixed ammonia-oxygen mixture significantly enhances combustion performance and efficiency, especially at higher loads. While ammonia shows promise for reducing CO and CO₂, optimizing ammonia-oxygen fuel mixtures and combustion parameters is crucial for achieving balanced HC reduction and engine performance improvements.