Proceedings of the Canadian Society for Mechanical Engineering International Congress 2022
CSME Congress 2022
June 5-8, 2022, Edmonton, AB, Canada

Experimental Study of Hydrogen Diesel Dual Fuel Engine Characterization

Jakub Mcnally [1*], David Gordon[1], Armin Norouzi [1], Mahdi Shahbakhti[1], Charles Robert Koch[1]
[1]Mechanical Engineering Department, University of Alberta, Edmonton, Canada
*jmcnally@ualberta.ca

Abstract

Concerns about climate change and air quality associated with the combustion of fossil fuels has led to a global effort to move towards zero-carbon alternatives to traditional fossil fuel combustion. One such zero-carbon alternative is hydrogen, which is an attractive option in comparison to batteries for heavy freight vehicles and other industrial applications due to its high energy density. Blue hydrogen, produced in Alberta from natural gas where the CO2 is sequestered, is currently cost competitive on an energy basis with diesel fuel. Dual-fuel engines provide a smooth conversion pathway to a hydrogen economy as the technology allows for the usage of existing combustion systems and allows hydrogen infrastructure to grow with increasing demand. Due to the high efficiency and durability of the diesel engine, they are an excellent platform to begin dual-fuel testing and implementation. However, to determine if hydrogen-diesel combustion is viable in not only meeting current emissions regulations but also future reduction targets, its combustion characteristics must be determined.

This study aims to characterize the combustion stability, efficiency, knock intensity, and NOx/soot emissions of a hydrogen-diesel dual-fuel engine. To do this, a production Cummins industrial 4.5 liter diesel engine was modified to include port-injected hydrogen along with the direct diesel injection. The diesel injection is used as a pilot to initiate the combustion of the hydrogen-air mixture. The engine is operated naturally-aspirated where per cycle fuel energies of up to 4000 Joules were tested at hydrogen energy replacement ratios between 0 to 95% under steady-state operation. The testing range investigated is equivalent to medium load. It was found that combustion stability, knock intensity, specific NOx output, and particulate emissions were improved at increased hydrogen replacement values when total fuel energy was held constant. A maximum acceptable knock threshold was reached when hydrogen composed 3700 Joules of the cylinder energy content. Combustion efficiency was found to mildly decrease with increasing hydrogen fraction when cycle energies were held constant. Under the naturally-aspirated medium load conditions tested, hydrogen replacement had a significant advantage over pure diesel for maximum volumetric specific power output, and for carbon oxide emissions which decreased linearly with the hydrogen energy ratio.

Word count: 357