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MODELLING THE IMPACTS OF HYDROGEN-METHANE BLEND FUELS ON A STATIONARY POWER GENERATION ENGINE

Kimia Haghighi[1], Gordon McTaggart-Cowan[1*]
[1]School of Sustainable Energy Engineering, Simon Fraser University, Surrey, Canada
*gmctagga@sfu.ca

ABSTRACT

To reduce the greenhouse gas implications of the natural gas grid, utilities are investigating the potential to add hydrogen to methane. This will impact grid-connected equipment, including engines used to provide backup power in both commercial and residential applications. Hydrogen and natural gas mixtures (HCNG) have shown promising results regarding engine power output, hydrocarbon and carbon monoxide emissions and thermal efficiency in dedicated vehicle engines. Less information is available on the implications of varying hydrogen ratios in methane in engines used in stationary applications.

This work investigates the effects of adding hydrogen to the natural gas fuel for a spark-ignited engine used in a commercial backup/stationary power generation application. The focus of the work is to assess the sensitivity of the engine's power output, efficiency, and pollutant emissions at specific operating to blends of methane with 0-30% (by volume) H_2.

An engine model has been developed in the GT-Suite modelling environment to assess the effects of using different mixtures of hydrogen and natural gas as the fuel. This model represents an existing commercially available natural gas fueled stationary power generation engine fitted with a 3-phase generator. The modelled engine was originally optimized for natural gas and was selected as representative of a medium-sized commercial application. The modelled engine is 4-cylinder, naturally aspirated, and uses a lean premixed combustion process with a centrally mounted spark plug. The premixed, spark-ignition combustion model in GT-Suite has been modified to account for the faster flame speed caused by the hydrogen in the natural gas fuel. Sensitivity analyses were conducted to assess the impacts of combustion phasing and fuel composition on engine power output and emissions.

The analysis focused on a comparison of pollutant emissions, power output, and thermal efficiency between natural gas and HCNG in the same application. The addition of hydrogen increased the flame speed, leading to a potential for leaner overall combustion mixtures at part load. At a fixed equivalence ratio, the resulting increase in combustion temperatures impacted the NO_x emissions. As hydrogen concentrations increased, the charge displacement effect became more significant, influencing the achievable power for a given mixture fraction. Understanding the effect of fuel change in existing systems can provide insight on utilizing HCNG as the primary fuel without the need for major changes in the engine.