Exhaust Gas Recirculation assisted Hydrogen-Diesel Combustion with Exhaust Heat Recovery

A THESIS

submitted by

Sarthak Nag (Roll No. S15009)

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DECLARATION BY THE RESEARCH SCHOLAR

This is to certify that the Thesis entitled **"Exhaust Gas Re-circulation assisted Hydrogen-Diesel Combustion with Exhaust Heat Recovery",** submitted by me to the Indian Institute of Technology Mandi for the award of the Degree of **Master of Science (by research),** is a bonafide record of research work carried out by me at the School of Engineering, Indian Institute of Technology Mandi, under the supervision of ***Dr Atul Dhar*** and ***Dr Arpan Gupta***. The content of this Thesis, in full or in parts, have not been submitted to any other Institute or University for the award of any Degree or Diploma.

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DECLARATION BY THE RESEARCH ADVISOR

This is to certify that the Thesis entitled **"Exhaust Gas Re-circulation assisted Hydrogen-Diesel Combustion with Exhaust Heat Recovery",** submitted by ***Sarthak Nag*** to the Indian Institute of Technology Mandi for the award of the Degree of **Master of Science (by research)**, is a bonafide record of research work carried out by him under my supervision at the School of Engineering, Indian Institute of Technology Mandi. The content of this Thesis, in full or in parts, have not been submitted to any other Institute or University for the award of any Degree or Diploma.

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Sarthak Nag

ABSTRACT

Internal combustion engines hold a crucial part in our lives due to the increased transportation needs with time. However, with the depleting oil reserves and more than ever stringent emission norms, there has been a continuous motivation for looking towards alternative fuels. Hydrogen presents itself as very promising alternative fuel for internal combustion engines due to its clean combustion properties, recyclability and enhanced engine performance. However, due to its high self-ignition temperature, hydrogen requires either higher compression ratio or a secondary fuel to initiate combustion. Diesel as a secondary fuel to initiate combustion in dual fuel mode bridges between present-day IC engines and hydrogen-fuelled engines of the tomorrow. The addition of hydrogen in diesel engines leads to an overall increase in engine efficiency and decreases emissions like carbon dioxide (CO_2), carbon monoxide (CO) and hydrocarbons (HC). However, it leads to an increase in oxides of nitrogen (NOx) emissions, which is harmful to both human health and the environment. Exhaust gas recirculation (EGR) is a NOx reduction technique, where some portion of the exhaust is put back into the combustion chamber for its participation in next combustion cycle. This technique dilutes the fresh air present for combustion with exhaust gas, and the reduced combustion temperatures lead to lower NOx emissions. EGR requires an intercooler to cool the EGR. However, this heat is being rejected to either environment or the cooling fluid. A thermoelectric generator, recovering the waste heat, can be used to generate power and can potentially replace car alternator systems with improvements in fuel economy and reductions in emissions. Moreover, an addition of an expanding section in the exhaust line attenuates exhaust noise of the engine.

Experiments were carried out on a single cylinder compression ignition engine running in dual fuel mode using hydrogen and diesel. The test setup was also modified for implementing EGR between the exhaust tailpipe and intake manifold. Hydrogen share on energy basis was varied as 0%, 10% and 30% whereas EGR was varied as 0%, 5% and 10%. Moreover, the setup also enabled to recover waste heat from the engine exhaust.

Results show that EGR assisted dual fuel engines can effectively reduce NOx emissions. Moreover, the CO_2, CO and THC emissions improved with using EGR and hydrogen in synergy. The lower loads showed a drop in thermal efficiency of the engine, but it recovered with increasing loads. The automotive exhaust thermoelectric generator designed to recover engine waste heat, recovered a maximum power of 18 W. Numerical studies on the AETEG unit also showed the further scope of improvement with enhancing the baffle number.

However, the backpressure due to increase in the number of baffles remained a concern and increased drastically. The acoustic advantage studied numerically, also showed a transmission loss of up to 54 dB_A for the most efficient geometry.

KEYWORDS

compression ignition, exhaust gas recirculation, hydrogen, dual fuel, emissions, waste heat recovery, transmission loss

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