Waste Heat Recovery to Reduce Engine Emissions

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Spark-ignition (SI) internal combustion engines are typically 20% thermally efficient. Some lost energy actually exits as unburned hydrocarbons, which in automobiles pass through a catalytic converter to reduce these tailpipe emisisons. Despite operating at temperatures between 300°C to 870°C, these devices do not achieve 100% distruction efficiency. This project designed, constructed and tested a proof-of-concept assembly to capture exhaust system waste heat with a thermoelectric generator (TEG) chip paired with a dry fuel cell used as an electrolyzer. The produced hydrogen injected into the engine's air intake reduced emissions. The study was performed on a small scale, using a 3500 watt (i.e. 6.5 HP) SI engine. Its muffler was used as a proxy heat source in lieu of a catalytic converter. An improved "Seebeck Effect" TEG chip with heat conductive graphite foil coverings matched its specifications to all key physical conditions, operational temperature range, temperature gradient available and suitable electrical output to adequately power the electolyzer. This prototype confirmed demonstrated lower tailpipe emissions. Operational improvements identified in the 1977 NASA study on hydrogen enhanced combustion (HEC) found lower engine emissions, better fuel economy and improved flame-front speed. While not directly correlated in the NASA study, the impact to flame-front speed suggests HEC would lower fuel octane requirements which would save billions of dollars per year in the US alone (0.5 octane number = $3 billion). An internet and literature search performed suggests this is likely the first ever application of these three technologies in combination to improve engine operations.

Awards Won:

Fourth Award of $500