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ABSTRACT

Today, to stay competitive, car manufacturers are stepping up their efforts in reducing the total cost of ownership (TCO) of their vehicles. One possible optimization action is to recover the wasted heat of exhaust gases via the thermoelectric conversion based on Seebeck effect in order to improve the vehicle energy efficiency and reduce the CO2 emissions. A thermoelectric generator is a thermal/electrical converter which recovers the wasted heat and converts it directly into electricity thanks to the properties of thermoelectric materials (Seebeck effect and Peltier effect). In an actual thermoelectric generator, there are also two internal irreversibilities due to heat conduction and Joule's effect.

A physical model of thermoelectric generator has been created in AMESim environment and then implemented into a fuel consumption model based on vehicle load and powertrain parameters. In order to maximize the fuel savings associated with the use of thermoelectric generator, an optimal power management based on Pontryagin's minimum principle has been developed.

We assessed the fuel savings over three driving cycles (traffic jam, urban, and road) for different power levels of auxiliary electric consumers (325W, 650W and 800W). We have also tested the synergy between the energy recovery by Seebeck effect and the energy recovery by regenerative braking. We obtained a maximum fuel saving of about 1.23L/100km on traffic jam driving cycle in the case where the power of the electric consumers is equal to 800W. Moreover, the simulation results show that the thermoelectric generator could be an interesting improver of the regenerative braking through the alternator control. However, the simulation shows also that in cases where the power of electric consumers is not very important, it is not worth to implementing these two energy recovery technologies within one vehicle unless we can electrify some components e.g. power steering, water pump, AC compressor, etc.