Abstract

Thermoelectric Generators for Waste Heat Recovery in Heavy-Duty Vehicles

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Modern heavy-duty vehicles have to fulfill the highest demands in terms of economy and ecology, i. e. reduction of total cost of ownership, fuel consumption and pollutant emissions. A holistic technically and economically optimized waste heat recovery system in the form of a thermoelectric generator, which takes into account mechanical, electrical, thermoelectric and thermodynamic as well as economic aspects, can contribute to the achievement of these objectives.

Two application scenarios are considered, heavy-duty vehicles with conventional diesel engines and with stoichiometric natural gas engines. Thermoelectric generator concepts were developed that combine high electrical power (peak power of about 3000 W for the natural gas heavy-duty vehicle) with low negative impact on the overall vehicle.

As a result of this research study significantly higher fuel savings are achieved compared to the state of the art. For the diesel vehicle fuel reductions in dynamic driving scenarios are between 0.5 - 1.5 %, CO_2-emission reductions are between 4 – 15 gCO2/km and the minimum amortization period is 1.4 years. The economic use of the system is demonstrated considering the total cost of ownership. Better results are obtained for natural gas vehicles due to the higher exhaust enthalpy. These are 1.8 - 2.8%, 13 - 35 gCO2/km, and 0.7 years.

A functional model has successfully validated the simulation environment with an average deviation of less than 6 %. An electrical output power of up to 2700 W was measured under the boundary conditions of the natural gas engine. The results obtained increase the technological maturity level, which has been low to date, and contribute significantly to getting thermoelectrics closer to series maturity in technological and economic aspects.