Thermoelectric waste heat recovery

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Due to increasing fuel prices, resource shortages and the ascending awareness in terms of climate change, the energy efficiency of passenger cars gains in importance. Apart from efforts toward the optimization of the engines internal efficiency the use of the enormous waste heat losses seems meaningful. An approach for the realization of such a recuperation system offers thermoelectricity, which up to now finds use particularly in sensor technology (thermocouple). So-called thermoelectric generators allow the direct transformation of thermal into electrical energy.

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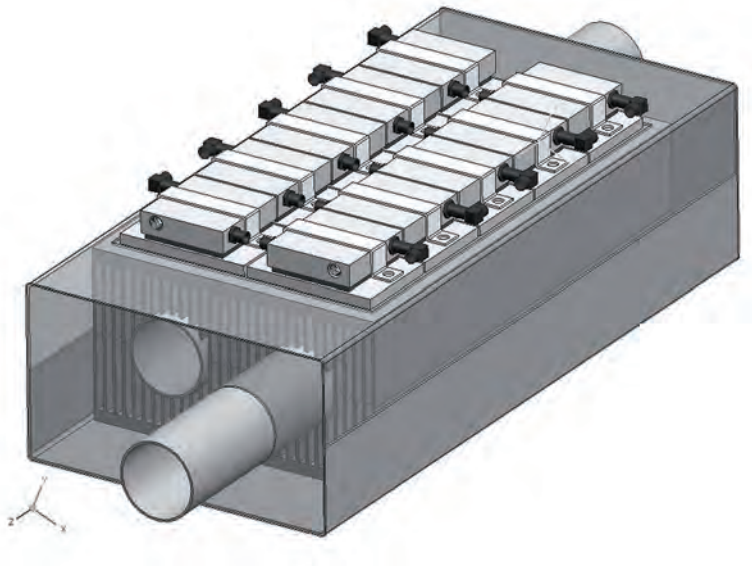
Based on the study of existing systems and project-relevant theories as well as different tests to evaluate the potential of waste heat recovery a thermoelectric system was developed. Unlike other approaches, that include a separate installation of the generator in the exhaust gas line, the concept of this work suggests the integration in the muffler of the vehicle. Instead of applying a complex bypass system that prevents backpressure caused by heat exchanger elements to rise over unacceptable values, flow resistance of an integrated generator is kept low without any additional parts. Currently available thermoelectric modules only withstand temperatures of 200 °C - 260 °C. With the lack of a bypass system that helps regulating the temperature, an appliance to avoid overheating becomes necessary. This task is solved by a mechanism employing bimetallic strips that disengages the modules of the heat source when reaching maximum operating temperature. Furthermore, a vehicles muffler can easily be modified to carry a high number of such thermoelectric elements without claiming too much space. Characterization models according to thermodynamic laws were compiled to describe the operational behaviour of the generator under simplified conditions. Thereby, the expectable electrical power in dependence of the exhaust mass flow and its temperature is of most interest. To verify the calculated values and to gain fundamental insights in the performance of such a recovery system a prototype based on the muffler of a VW Touran was built and tested. The results point out that along with improvements on the concept and developing thermoelectric modules with higher conversion efficiencies, the recovered energy will be high enough to meet the electrical requirements of a car and thus improve fuel efficiency up to 5 %.



Prototype for an integrated thermoelectric system