Abstract

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Thermal design of automobile exhaust based thermoelectric generators: Objectives 'and challenges

The potential for thermoelectric power generation (via waste heat recovery onboard automobiles) to displace alternators and/or provide additional charging to a vehicle battery pack has increased with recent advances in thermoelectric material processing. In gasoline fueled vehicles (GFVs), about 40% of fuel energy is wasted in exhaust heat, while a smaller amount of energy (30%) is ejected through the engine coolant. Therefore, exhaust-based thermoelectric generators (ETEG) have been a focus for GFV applications since the late 1980s. The conversion efficiency of modern thermoelectric materials has increased more than three-fold in the last two decades however, disputes as to the thermal design of ETEG systems has kept their overall efficiency at limited and insufficient values. There are many challenges in the thermal design of ETEG systems, such as increasing the efficiency of the heat exchangers (hot box and cold plate), maintaining a sufficient temperature difference across the thermoelectric modules during different operating conditions, and reducing thermal losses through the system as a whole. This paper focuses on a review of the main aspects of thermal design of ETEG systems through various investigations performed over the past twenty years. This paper is organized as follows: first, the construction of a typical ETEG is described. The heat balance and efficiency of ETEG are then discussed. Then, the third section of this paper emphasizes the main objectives and challenges for designing efficient ETEG systems. Finally, a review of ETEG research activities over the last twenty years is presented to focus on methods used by the research community to address such challenges.