Journal of ELECTRONIC MATERIALS, Vol. 42, No. 7, 2013
DOI: 10.1007/s11664-012-2454-2

Effect of the Sequence of the Thermoelectric Generator and the Three-Way Catalytic Converter on Exhaust Gas Conversion Efficiency

CHUQI SU,[1] NAIQIANG TONG,[1,2] YUMAN XU,[1] SHAN CHEN,[1] and XUN LIU[1]

1.—Hubei Key Laboratory of Advanced Technology for Automotive Components, Automobile Engineering Institute, Wuhan University of Technology, Hongshan District, 205 Luoshi Road, Wuhan 430070, China. 2.—e-mail: 339020230@qq.com

The potential for thermoelectric exhaust heat recovery in vehicles has increased with recent improvements in the efficiency of thermoelectric generators (TEGs). The problem with using thermoelectric generators for vehicle applications is whether the device is compatible with the original vehicle exhaust system, which determines the quality of the exhaust gas treatment and the realization of energy conservation and emission reduction. Based on ANSYS CFX simulation analysis of the impact of two positional relationships between the TEG and three-way catalytic converter in the exhaust system on the working efficiency of both elements, it is concluded that the layout with the front three-way catalytic converter has an advantage over the other layout mode under current conditions. New ideas for an improvement program are proposed to provide the basis for further research.

Key words: Thermoelectric generator (TEG), three-way catalytic converter, impact on efficiency, ANSYS CFX simulation analysis

INTRODUCTION

Currently, about 30% of the total energy from automotive engines is used to drive the vehicle, whereas another 30% is consumed by the cooling system, and the remaining 40% is emitted as heat by the exhaust system. A normal sedan wastes 20 kW to 30 kW of heat at uniform speed when the engine is under common working conditions.[1] Part of this waste heat can be recovered and reused to reduce the fuel consumption of the vehicle as well as environmental pollution. Automobile exhaust waste heat thermoelectric power generation systems can be used on vehicles to recover part of this energy. Although not reaching zero emissions, such systems are appropriate for the current state of energy recuperation technology.[2,3]

An automobile exhaust waste heat thermoelectric power generation system consists of a hot-side heat exchanger, a cold-side water tank, and a clamping device.[4] Thermoelectric modules made of semiconductor material are placed between the hot-side heat exchanger that is connected to the engine exhaust pipe and the cold-side water tank, enabling the conversion of the temperature difference between the hot and cold side into power.[5] Based on the Seebeck effect, thermoelectric modules can make use of a difference in temperature between their two ends to generate power. In this work, we use low-temperature modules made of Ti_2Be_3, which are capable of withstanding hot temperatures below 300°C.[6]

However, such addition of a thermoelectric generator (TEG) to the automotive exhaust system will affect the overall system, especially the three-way catalytic converter.[7] Since the TEG and three-way catalytic converter perform properly when the temperature reaches a certain level, simulation analysis of the relative positional relationship of these two elements was carried out to determine a reasonable layout. This research also provides the

(Received July 7, 2012; accepted December 28, 2012; published online February 9, 2013)