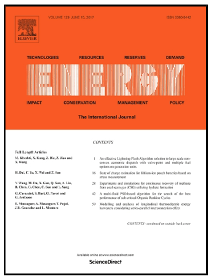
Accepted Manuscript



Thermoelectric performance optimization when considering engine power loss caused by back pressure applied to engine exhaust waste heat recovery

Wei He, Shixue Wang

PII: S0360-5442(17)30891-5

DOI: 10.1016/j.energy.2017.05.133

Reference: EGY 10941

To appear in: *Energy*

Received Date: 20 June 2016

Revised Date: 16 April 2017

Accepted Date: 22 May 2017

Please cite this article as: Wei He, Shixue Wang, Thermoelectric performance optimization when considering engine power loss caused by back pressure applied to engine exhaust waste heat recovery, *Energy* (2017), doi: 10.1016/j.energy.2017.05.133

Thermoelectric performance optimization when considering engine power loss caused by back pressure applied to engine exhaust waste heat recovery

Wei He[b], Shixue Wang[a*]

[a] *Key Laboratory of Efficient Utilization of Low and Medium Grade Energy, Tianjin University, Tianjin 300072, PR China;*

[b] *School of Mechanical Engineering, Tianjin University of Commerce, Tianjin 300134,PR China*

Abstract: A numerical model of a thermoelectric generator (TEG) is developed using the finite element method, and the convective heat-transfer coefficient and back pressure are calculated. The effect of the back pressure on the engine power loss is analyzed at different rotating speeds using GT-POWER simulation software. The optimal thermoelectric performance is analyzed considering the maximum net power output as the optimization objective. Results show that the net power output of the TEG can be considerably higher than the engine-power loss by optimizing the dimensions of the exhaust exchanger. When the rotating speed changes, the optimal height changes slightly; however, the optimal length and width change considerably. Considering the average values of the optimal length and width, the percentage deviation in the net power (approximately 4.2%) is the lowest for the following optimal dimensions: height=0.005 m, length=0.68 m, and width=0.76 m. Further, a design height of less than 0.015 m also is acceptable if the corresponding optimal length and width are chosen, as a relatively high output power can be obtained with *dev*<10%. In brief, a high net power can be achieved by optimizing the design of the exhaust exchanger, regardless of the change in the rotating speed of the engine.

Keywords: engine; exhaust exchanger; back pressure; thermoelectric generator; net power

1. Introduction

Technologies that help save energy and reduce emissions are currently employed in various industries. Waste-heat recovery has become an important method of saving energy and reducing emissions in the automobile industry. Thermoelectric generators (TEGs) have good potential for converting low-level thermal energy into electrical power. They are easy to operate, are compact, have a long service life, and require low maintenance cost. Thermoelectric devices are environmentally friendly; thus, they attract considerable attention as a green and flexible source of electricity [1]. Recently, waste-heat recovery systems incorporated in TEG technology have been gaining attention in terms of utilizing the power from exhaust gases [2, 3]. The working principle of the TEG is based on the Seebeck effect, wherein a voltage difference is generated between two different metals or semiconductors in the presence of a temperature difference. However, the conversion efficiency is low, and this is a crucial factor restricting the development of TEGs.

Numerous studies have been conducted on theoretical models to improve the conversion efficiency of TEGs. Fankai et al. [4] introduced a numerical model of a commercial TEG with finned heat exchangers, considering internal and external multi-irreversibility. Rezania et al. [5] studied the effect of the TEG geometry on the heat-transfer characteristics of a micro heat sink. Yilbas et al. [6] presented the influences of slenderness ratio and external load parameters on the thermoelectric power and efficiency of a TEG. With regard to the TEG structure, the power output from a module can be increased significantly by modifying the geometry of the thermoelectric elements. Meng et al. [7] developed a three-dimensional transient model to investigate the dynamic-response characteristics of TEGs. Chen et al. [8, 9] analyzed the effects of finite-rate heat transfer between a thermoelectric device and its external heat reservoirs on the performance of a single-element TEG by employing finite-time thermodynamics. Gou et al. [10] established a model of a low-temperature waste-heat system for a TEG and indicated that placing thermoelectric models in series would enhance the system performance. Furthermore, a dynamic model was developed to analyze the influences of a heat reservoir and heat sink; the results show that enhancing the heat dissipation on the cold side is crucial in improving the output performance of a TEG [11]. Our previous study [12] focused mainly on the characteristics of a large temperature gradient in the fluid-flow direction by introducing a TEG model built using the finite element method. An optimal dimension for the exchanger was proposed, for which the power output of the TEG was maximized.

Numerous results were obtained from these theoretical models; however, in the models, the

[*] Corresponding author. Tel.: +86-22-27402567; fax: +86-22-27402567.

E-mail address: wangshixue_64@tju.edu.cn.