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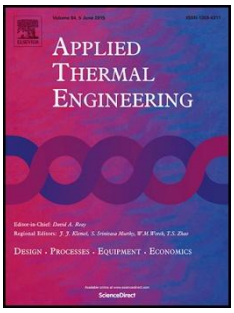

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A review of car waste heat recovery systems utilising thermoelectric generators and heat pipes

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Abstract

The internal combustion engine (ICE) does not efficiently convert chemical energy into mechanical energy. A majority of this energy is dissipated as heat in the exhaust and coolant. Rather than directly improving the efficiency of the engine, efforts are being made to improve the efficiency of the engine indirectly by using a waste heat recovery system. Two promising technologies that were found to be useful for this purpose were thermoelectric generators (TEGs) and heat pipes. Both TEGs and heat pipes are solid state, passive, silent, scalable and durable. The use of heat pipes can potentially reduce the thermal resistance and pressure losses in the system as well as temperature regulation of the TEGs and increased design flexibility. TEGs do have limitations such as low temperature limits and relatively low efficiency. Heat pipes do have limitations such as maximum rates of heat transfer and temperature limits. When used in conjunction, these technologies have the potential to create a completely solid state and passive waste heat recovery system.

Keywords: Waste heat recovery; Heat pipes; Thermoelectric generators

1. Introduction

Before a new car is released to the market, testing is undertaken to ensure it meets the latest emissions regulations. The regulations differ from country to country but they are always getting more stringent. The CO_2 emissions of a car are proportional to its fuel consumption. Therefore, to meet these tightening regulations, car companies must reduce the fuel consumption of their cars. Current ICEs are on average approximately 25% efficient [1] under typical driving conditions (i.e.: European driving cycle) but can range from 20% to 45% depending on the engine type and operating conditions. The remaining 55% to 80% will be wasted as heat in both the coolant and the exhaust gases. A waste heat recovery system has the potential to convert some of this waste heat into electricity and consequently reduce the fuel consumption of the car by reducing the load on the car alternator. Heat pipes and TEGs could be used in conjunction for use in a waste heat recovery system. Their compact size and solid state design make them ideal for automotive applications.

TEGs make use of what is known as the Seebeck effect which is explained in figure 1. A TEG is made up of many elements of N type and P type semiconductor material which are connected electrically in series but thermally in parallel. When one side of the TEG is heated and the other side cooled, a voltage is generated. The voltage generation means there are applications for these TEGs to generate electricity where temperature differences are present. Their efficiency is typically 5% [2] and they can generate power from any temperature difference. Their efficiency is