Development of Parabolic Concentrator- Based Thermoelectric Generator

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Abstract

Thermoelectric generator (TEG) is one of the solutions to produce energy from waste heat and produce pure DC voltage. TEG is based on solid state technology with no moving parts and works on the principle of Seebeck effect. In this work, TEG was combined with a solar concentrator to produce a device that able to convert solar energy to electrical energy. The concentrator was used to concentrate thermal energy from the sun onto one side of the thermoelectric module which acts as the hot side. The assembled system is able to produce maximum power output up to 0.157W with 0.479% of an efficiency achieved.

1. Introduction

Increasing pressure on the demand and increased costs related to energy and sustainability has further increased the need for the implementation of more efficient power generation systems which not only benefited to humans but also to the development of a country. Because fossil fuels such as coal, oil, and natural gas are the largest used energy sources, an intense demand exists for economically and commercially viable renewable energy source [1]. The used of fossil fuels to generate electricity is very important to the world including Malaysia. Power Generation in Malaysia is largely dependent on pipeline gas, Liquefied Natural Gas (LNG) and coal. Tenaga Nasional Berhad (TNB), the largest Malaysian energy provider releases that Gas and LNG, coal and oil/distillates required about RM 18 billion for total fuel cost only in 2014 [2]. These high expenditures are only for the running costs to light up Malaysian houses. Besides increasing in energy demand as a factor, the escalated of gas prices and government's gradual rationalization of subsidies for regulated domestic gas also contribute in high expenditures for the reliable power system [3]. The fuel cost expenditures for TNB shows a big increase from RM11.2 billion in 2013 to RM13.3 billion in 2014 [4]. All of this facts and numbers proved that large cost is needed to support the energy demand and were expected to not decrease.

One of the alternative energy solution to reduce the use of fossil fuels in generate electricity is by using TEG. TEG may be utilized to recover waste heat from systems which then will be convert into electrical power [5] without the need of moving components. Presently, it is used as a low power application as remote and off-grid power generators for unmanned sites, solar PV back-up and waste heat recovery for automobiles. Even though the efficiency for TEG is relatively small, yet this device still can be considered to enter high power application. As a comparison to Photovoltaic (PV) Generator, TEG is much smaller, lighter and it doesn't require big space. With the increasing cost of fossil fuels and waste heat recovery technology causes TEG become better known, especially in the applications in the rail system as well as in the communication system [6].

In addition, more researchers have been engaging in these semiconductor materials since it was discovered in 1950s because of their better thermoelectric performance than pure metals [7]. After the energy crisis in 1970s, the researches on TE power have been a spotlight all over the world [8]. Nowadays, with the increasing gap between limited supply and increasing demand of power, researches on waste heat recovery by TEG becomes critical. The available waste heat sources includes industrial heat-generating process, the exhausted waste heat of transportation vehicles, solar energy, combustion of solid waste and geothermal energy and so on [9]. A typical TEG driven by solar power usually consists of a thermal collector which used to absorb heat from the solar radiation and the heat will be carry through a groups of flow pipes to the TEG.

Building Scientific Research Center (BSRC) [10] presented a new concept of roof design named "The Thermoelectric Roof Solar Collector (TERSC)", be made up of thermoelectric modules (TEM), a rectangular fin heat sink, a copper plate, a transparent acrylic sheet and air gap. Research results showing that 1.2W power can be obtained using 10 TEM in 0.0525 m^2 surface area, under solar radiation intensity of about 800 W/m^2 at ambient temperature between 30 and 35^{o}C. Even with the electrical conversion efficiency is low as 1-4%, it is still popular in remote areas and some special fields. In this paper, a TEG system based on solar concentration is proposed as an effective way in