DEVELOPMENT OF HYBRID THERMOELECTRIC AND PHOTOVOLTAIC POWER GENERATION

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ABSTRACT

Hybrid photovoltaic and thermoelectric systems more effectively convert solar energy into electrical energy. Two sources of energy are used in this project. One of the energy is solar energy that converts radiant light to electrical energy. The other one is heat energy, which converts heat energy into electrical energy. Therefore, this project will utilize both of the solar radiation and heat from the sun as to generate more electricity. The aim of this project is to build a hybrid system that will increase the efficiency of the power generation system. In this research, the output power of the hybrid is equal to the sum of the maximum output power that produced separately from the individuals of the PV module and TE generator devices. The maximum output power that can be generated was up to 99.27 watts respectively. Overall, by using hybrid PV-TE generator system, the output that can be generated is better than the individual system.

Keywords: Photovoltaic, Thermoelectric, hybrid system, solar radiation.

1. INTRODUCTION

8th Malaysia Plan (2001–2005) has targeted to generate 5% of the country's electricity from renewable energy sources by 2005. However, only 0.3% was achieved. This was further emphasized in the 9th Malaysia Plan where the efforts in the utilization of renewable energy resources and efficient use of energy were extensively promoted [1]. The actual harvesting of solar energy is still below their full potential. Therefore, by applying a hybrid system could help to increase the conversion efficiency.

This paper will explore the possibility of integrating the PV system with thermoelectric (TE) generator in order to increase the power generation. The two sources of energy which are solar and heats will be utilized to convert into electricity. PV directly converts into electricity from sunlight (solar radiation) while TE generates electricity when there is a different temperature occurs at the junction of two conductors according to the Seebeck effect. There is a huge potential of employing TE generator in which various wasted heat sources can be harvested to convert into electricity. One of advantage of TE generator is that it is free of maintenance and ease in operation just like a PV system.

This paper will deeply focus on the designing and modelling a hybrid TE and PV power generation system. The remainder of this paper is organized as follows: Section 2 discusses the basic theoretical studies of TE. The research methodology is given in Section 3. Then, result and discussion are given in Section 4 and finally concluding remark appears in Section 5.

2. PV AND TE POWER GENERATOR

TE power generator is a device that will convert heat into electrical energy by applying the Seebeck effect. TE is one of the technologies that are to be deemed to recover and convert the industrial process of waste energy into more useful electrical energy. It will generate electric current when there is a difference in temperature between its both sides. In one study, it shows the possibility to take benefit from the waste heats produced by manufacturing industries in Thailand by generating electrical energy harvested using TE generator system. Besides, the economic viability of the TE generator can also be increased when used for the waste heat recovery [2].

2.1 Principle of TE

There are four main energy processes taking place in the TE pellets, which are thermal conduction, Joule heating, the Peltier cooling/heating effect, and the Seebeck effect. The phenomenon of thermal conduction is a Fourier process that is described by the thermal conductivity κi of the material. For a TE with N thermocouples, the heat transfer of thermal conduction in a TE is described by

$$Qth = -\Delta T \kappa th \quad (1)$$

where κth is the thermal conductivity of TE and ΔT is a different temperature between hot and cold side. The total Joule heat dissipated in an N-couple TE is

$$Q_J = I^2 R \quad (2)$$

where R is its electrical resistance. I is the electric current that flow through TE. Irrespective of the temperature gradient, the Joule heat can be considered as equally divided between the two sides of the TE. The absorbed/emitted heat of an N-couple

$$Q_{PH/PC} = SIT_{H/C} \quad (3)$$

where is S is the Seebeck coefficient and $T_{H/C}$ is the temperature of the hot or cold side.

When a temperature gradient is imposed on a conductor under an open-circuit condition, the creation of an electrical potential difference between the hot and cool sides of the conductor is called the Seebeck effect. The generated Seebeck voltage, called the electromotive force (EMF), in a TE is expressed as