Fabrication of New Thermoelectric Block Floor for Power generator

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Abstract. This was the study and designing of the thermoelectric block floor for power generator that are normally used for footpaths, traffic islands, and gardening together with solar radiation heat. Physically, this thermoelectric block is an octagonal block with a size of 19.8 x 19.8 x 6 cm. The block was composed of two layers. The upper layer received the solar radiation and produced the thermoelectric module heat by synthesizing thermoelectric materials and creating 4 thermoelectric modules from Bi2Te3 for one composition set where an aluminum sheet was used for cooling. Additionally, the lower layer was exposed to the ground with low temperature to produce the usable electric power. The efficiency of this electric power was tested with the solar radiation heat of the thermoelectric block floor and by the Thai Industrial Standards (TIS) 827-2531: Interlocking Concrete Paving Blocks. After installing the thermoelectric block floor at the Faculty of Industrial Technology, Sakon Nakhon Rajabhat University, it was found that the block was usable as defined by TIS 827-2531: Interlocking Concrete Paving Blocks; meanwhile, the test on the electric power of the thermoelectric block floor indicated that the maximum electric potential difference was 73.91 mV where the temperature difference was 6.2 K measured from the surface of the block. In addition, the maximum electric power was 88.25 mV where the solar radiation was 1124.5 W m-2. Notably, this electric power of the thermoelectric block floor was directly variable following the solar radiation value. However, if used for power generator or as an alternative energy for engineering activities, the thermoelectric block should be properly designed and developed to produce higher level of electric power and more of them should be created for both series circuit and parallel circuit.

1. Introduction
Global warming is internationally critical problem with a severe impact on the global climate change. One major cause of this problem is the human’s consumption of the fossil fuel such as coal, oil, or natural for energy production that releases a lot of Carbon Dioxide, a cause of the greenhouse effect toward the earth’s atmosphere [1].
Despite the current hydroelectricity production as a renewable energy source, there is only a few of that energy source as well as the water resource for electricity production; the water is still in shortage. For this reason, there is an effort to look for new sources of energy which is cost-saving and cannot be completely consumed. Actually, some of those energy sources have been already used in some foreign counties such as the tide, wave (sea), or oceanic heat. Still, there is some limits concerning the development of solar energy, wind power, and geothermal energy since it requires a very high cost, a large area for an installation, a long period of construction, or there are insufficient amount of those energy in some countries.

As a consequence, it becomes even more necessary to invent a new method for electricity production to replace an old form of energy that seems to be surely in shortage in the future. In this regard, thermoelectric is one characteristics of a substance that can be applicably developed as an alternative energy. This is currently a highlight amongst many researchers.

In term of the use of Seebeck effect[3-6], a thermoelectric material can be modified as a thermoelectricity generator so it is possible to turn the electric power from a waste or an excessive heat from a man’s routine e.g. the heat from the electric pot, a human body heat, as well as other natural heats such as solar heat, hot spring’s heat, the heat from soil or the global warming, and use it to build a thermoelectric device as a thermoelectricity generator. Eventually, we can build and design several models of thermoelectric device from Material P and N.

Currently, the block floor installation is a waste of land use with the thermal power so there is a concept of turning a simple block floor that are broadly used and seen along the footpaths, traffic islands, and gardening into the smart block floor that automatically generates an energy by using the thermoelectric device. This energy generator is based on the temperature deference between the two layers. Namely, the upper layer receives and generates the heat from sunlight whereas the lower layer faces with the ground where the temperature is lower and used to generate a usable electric current. Particularly, this thermoelectric block floor does not consume energy so it will not cause any toxic substances. This smart block floor also makes no noise since none of its parts is movable. The device has a long lifespan and each part can be removed from one another and put back together. The device’s maintenance is also very simple because there is no liquid used. Moreover, this block floor requires no space for installation as needed for other energy generator devices. Therefore, this thermoelectric block floor could be a good option for generating the power for the streetlight in the night time and it also indicates a leading line along street. More importantly, this material can be an alternative and renewal energy that leads to security and sustainability of a nation.

2. Experimental

2.1 Thermoelectric module fabrication
The n– Bi₂Te₃ and p– Sb₂Te₃ were synthesized by ball mill and hot press method [12]. The starting materials were mixed by planetary ball mill for 2 h at 350 rpm in atmosphere. The mixed powders of n and p materials were loaded into graphite die in dimeter 20 mm after then hot pressing 1 MPa, heating at 1073 K (n) and 923 K (p) for 1 h in Ar atmosphere. The pellets were cut in size of 4×4×4 mm³ for thermoelectric leg. Cu plate and alumina were used for electrode and substrate, respectively. The thermoelectric module was fabricated using 17 couples of p-n by melting solder method.

2.2 Thermoelectric Block Floor fabrication
The thermoelectric block floor was built as an octagonal block in size of 198 × 198 ×60 mm³, and 4 kg of weights. The surface for compression force of this thermoelectric block floor is 860 kN as defined by TIS 827-2531: In details, the design of the thermoelectric block floor with an automatic power generating system consisted of the following parts in Figure 1. The top layer (CaCO₃) has 20 mm of thickness for receive the heat from sunlight. The middle layer used for supporting 4 thermoelectric modules. The bottom of thermoelectric module used the aluminum sheets for heat rejected. 4. The lowest layer (CaCO₃) was 30 mm of thickness.
Practically, the thermoelectric block floors were installed at the faculty of industrial technology, Sakon Nakhon Rajabhat University, and the installation procedure was described in Figure 2.

![Diagram of thermoelectric block floor for power generator](image)

**Figure 1.** thermoelectric block floor for power generator

**Figure 2.** Thermoelectric Block Floors Installation

3. Results and discussion

3.1 The open circuit voltage
According to the thermoelectric module of n-$\text{Bi}_2\text{Te}_3$ and p-$\text{Sb}_2\text{Te}_3$ with 17 pairs connecting with series circuit. The open circuit voltage was illustrated in Figure 3. It was found that the electrical voltage was increases with temperature increasing and a maximum reached 0.91 V at a different temperature of 373 K.

3.2 The temperature of thermoelectric block floor
The temperature of thermoelectric block floor were measured 4 points including $T_1$ = temperature inside thermoelectric block floor, $T_2$ = temperature on the upper layer of a thermoelectric block floor, $T_3$ = environmental temperature and $T_4$ = temperature on the lower layer of a thermoelectric block.

The maximum temperature was observed in $T_2$ Figure 4 about 319 K at 12 O’clock and the lowest temperature was found in $T_3$ about 305 K at 13.00 O’clock. $T_1$, $T_2$ and $T_3$ show increased with time until 12.00 O’clock and after that slightly decreasing. The temperature of $T_4$ shows a few changes because this point is lowest position and connecting with the ground. So that, thermoelectric block floor can create different temperature between on the top and bottom side. The maximum different temperature between $T_2$ and $T_3$ is 12.4 K at 12.30 O’clock.
3.3 Electrical voltage of thermoelectric block floor

The electrical voltage of thermoelectric block floor was measured from 09.00 A.M. to 17.00 P.M. It was found that, the electrical voltage was increased with different temperature from 09.00 A.M. to 12.00 A.M. after that both electrical voltage and different temperature decreased. The maximum output voltage was found at 11.30 A.M. of 88.25 mV for 6.3 K of different temperature.
Figure 5. The relationship between electrical voltage, different temperature and time

Figure 6. The Solar Radiation of Thermoelectric Block Floor at 09.00 A.M. to 17.00 P.M.

Figure 6 shows the solar radiation comparing with the time. The solar radiation shows the maximum value of 1124.5 W m\(^{-2}\) at 11.30 A.M.

4. Conclusion
In this study, thermoelectric block floor was built as an octagonal block in size of 198 × 198 × 60 mm\(^3\). The surface for compression force of thermoelectric block floor is 860 kN as defined by TIS 827-2531: Interlocking Concrete Paving Blocks. The Bi\(_2\)Te\(_3\) and Sb\(_2\)Te\(_3\) thermoelectric materials were synthesized by hot press method. The thermoelectric module was fabricated by melting solder method. The thermoelectric module was measured from 25 – 75 K of different temperature and shows maximum voltage about 0.91 V at different temperature of 75 K. The thermoelectric block floor was installed at
the Faculty of Industrial Technology, Sakon Nakhon Rajabhat University. The maximum electric voltage was obtained about 73.91 mV at different temperature of 6.2 K.

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