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Research Article

Design and Modification of Thermoelectric Tube using Different Materials

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Abstract

By using thermoelectric generators it is possible to develop independent electric energy source in burning and heating systems – in households and industrial heating. With this energy source it is possible to provide with electricity systems appliances, lightening and other consumers. Potential placements for generators are on furnace walls, on flue way walls, on flue pipe walls after furnace. Generators can improve efficiency of combustion, because there is amount of waste heat that leaves through flue pipe in burning process. There are no boundaries for combining elements in system as just the space for their placement. As more elements are linked in chain, as much electric energy is produced. This is one of methods to develop a cogeneration process in domestic boiler house or industrial heating, or burning systems. In research thermoelectric element current, voltage, power and efficiency are defined in different temperature differences.

Keywords: *Thermoelectric Tube, Thermoelectric Generator, Seebeck Effect, Peltier Effect, Lead Teluride, Aluminium*

1. Introduction

The exhaust gases released from the automobiles have very high temperature. They are released to the outside atmosphere without making any use of it. When we apply heat to the thermoelectric tube, electricity is produced which can be used to run other electronic equipments on automobile Such as digital speedometer, GPS, charge battery, etc. Themoelectric tube has a high figure of merit (Efficiency) than regular thermoelectric module, thus making it more efficient.

The seebeck effect is used in the thermoelectric tube. As the heat flows from hot side to cold side, free charge carriers – electrons or holes – in the material are also driven to the cold end. The resulting voltage is proportional to the temperature difference via the Seebeck coefficient. The thermoelectric tube will generate DC electricity as long as there is a temperature difference across the module. The more electricity will be generated when the temperature difference across the tube increases, and the efficiency of converting heat energy into electric energy will also increase.

2. Seebeck Effect

Thermoelectric generators (TEG) are devices that convert temperature differences into usable electricity. TEGs are made from thermoelectric modules which are solid-state integrated circuits that employ three established thermoelectric effects known as the Peltier, Seebeck and Thomson effects. TEGs require heat as an energy source and can generate power as long as there is a heat source such as gas or oil flame, stove, camp fire, industrial machinery, and furnace.

Devices that scavenge energy from the ambient surrounding environment have become a popular topic for research. For some applications, energy scavenging eliminates the need for batteries or increase the time between battery replacements. One ambient energy source found in our environment is a temperature change (thermoelectric-Seebeck) effect. This form of ambient energy is found in buildings, machines, bridges, staircases, furnaces, indoor and outdoor temperature differences, and the human body. The use of TEGs based on thermoelectric effects (or Seebeck, Peltier, Thomson effect) is made possible by direct conversion of temperature differences to electrical power. The Seebeck effect occurs when a temperature difference exists between two dissimilar electrical conductors or semiconductors, producing a voltage across two materials.

Thermal gradients in the environment are directly converted to electrical energy through the Seebeck (thermoelectric) effect as reported by Disalvo and Rowe. Temperature changes between opposite segments of a conducting material result in heat flow and consequently charge flow since mobile, high-

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energy carriers diffuse from high to low concentration regions. Thermopiles consisting of n- and p-type materials electrically joined at the high-temperature junction are therefore constructed, allowing heat flow to carry the dominant charge carriers of each material to the low temperature end, establishing a voltage difference across the base electrodes in the process. The generated voltage and power is relative to the temperature differential and the Seebeck coefficient of the thermoelectric materials. Big thermal gradients are essential to produce practical voltage and power levels. However, temperature differences greater than 10°C are rare in a micro-system, so consequently such systems generate low voltage and power levels. Moreover, naturally occurring temperature variations can also provide a means by which energy can be scavenged from the environment with high temperature. Stordeur and Stark have demonstrated a thermoelectric micro-device which is capable of converting 15 μW/cm3 from 10 °C temperature gradients [10]. While this is promising and, with the improvement of thermoelectric generators, could eventually result in more than 15 μW/cm3, situations in which there is a static 10 °C temperature difference within 1 cm3 are very rare. This, however, assumes no losses in the conversion of power to electricity.

There are a variety of thermoelectric generators available in the market, and there are industrial applications of TEGs. The efficiency of thermocouples has been under research by both academic institutions and private sectors to increase output power of thermoelectric generators.

According to the Bierschenk and Townsend, a compact, thermal energy harvester can power temperature and vibration sensors that monitor motors anywhere inside the plant, alerting managers of excessive motor wear and allowing them to perform preventative maintenance to avoid factory downtime. This task lessens the regular maintenance schedules and costly unnecessary repairs. Basically, a solid-to-air miniature harvester consisting of a thermoelectric device positioned between an aluminum interface plate and small, finned natural convection heat sink sustains requirements. One of the latest designs of thermoelectric energy harvester was the TEG designed and introduced in the available technologies web site of Pacific Northwest National Laboratory. This new thermoelectric generator is equipped for conversion of environmental (ambient) thermal energy into electric power for a variety of applications that necessitate low power source use. This thermoelectric energy harvester includes an assembly of very small and thin thermocouples in a unique configuration that can exploit very small (>2°C) temperature variations that occur naturally in the environment of the application such as ground to air, water to air, or skin to air interfaces. The body of the TEG consists of reliable and stable components that provide maintenance free, continuous power for the lifetime of the application claimed by the manufacturer. Depending on the temperature range, a TEG's electrical output can be changed from a few microwatts to hundreds of milliwatts and more by modifying the design.

Applications of this energy harvesting design are diverse, including automotive performance monitoring, homeland and military security surveillance, biomedicine, and wilderness and agricultural management. It is also documented that the thermoelectric energy harvester may be appropriate for many other stand-alone, low-power applications depending on the nature of the application. In addition to PNNL's patent pending thermoelectric generator, Applied Digital Solutions Corporation has developed and presented a thermoelectric generator as a commercial product. This thermoelectric generator is capable of producing 40⍰w of power from 5 ⍰C temperature variations using a device that is 0.5 cm2 in area and a few millimeters thick. This device generates about 1V output voltage, which can be enough for low power electronic applications. Moreover, the thermal-expansion actuated piezoelectric generator has also been proposed as a method to convert power from ambient temperature gradients to electricity by Thomas, Clark and Clark [13]. As an example, Figure 1 shows a picture of a Seebeck effect TEG

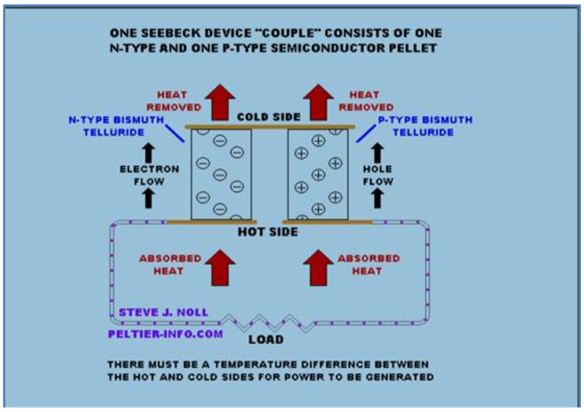


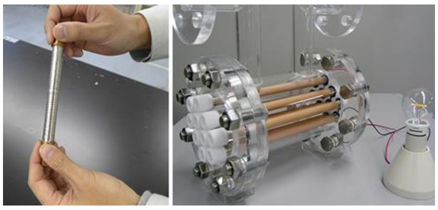
Fig.1 Seebeck Effect

3. Materials and Methods

Thermoelectric Tube

Up till now, only Panasonic has developed a thermoelectric tube which has the efficiency or the FIGURE OF MERIT more than that of the thermoelectric module. Thus making it more efficient and maybe cost efficient. Thermoelectric tube is made up of p- type and n-type semiconductor material placed on a tube like structure. The tube is made up of any metal which has high thermal conductivity. The semiconductor materials used must have low thermal conductivity and high electrical conductivity. Panasonic has used the semiconductor material as Bi_2Te_3 (Bismuth telluride) and the metal as Nickel. The thermoelectric tube that Panasonic has developed is as shown in fig below.

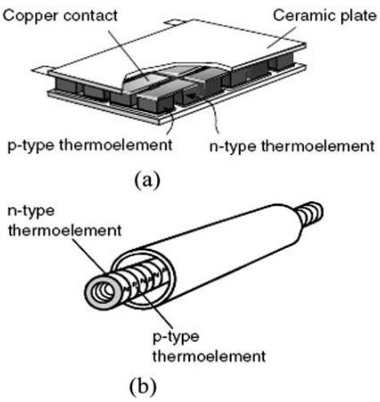
when several tubes are used, they can create much more electricity. The figure of merit of thermoelectric tube is in the range of 1.6- 2 which is much more than thermoelectric module.

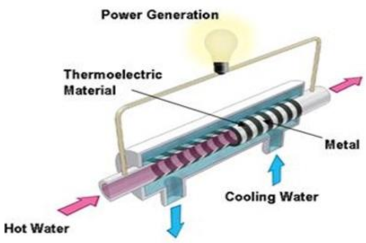


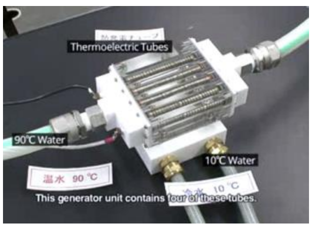
The temperature range of some of the p-type and n-type semiconductors is as shown below.

The rough sketch of thermoelectric tube is given below:

The temperature of the hot water can be around 90 C and that of the cold water can be 10 C.
As the temperature difference increases, the current also increases.







4. Results, conclusion, Current & Future Developments

Recently, an increasing concern of environmental issues of emissions, in particular global warming and the constraints on energy sources has resulted in extensive research into innovative technologies of generating electrical power and thermoelectric power generation has emerged as a promising alternative green technology. In addition, vast quantities of waste heat are discharged into the earth's environment much of it at temperatures which are too low(i.e. low-grade thermal energy) to recover using conventional electrical power generators. Thermoelectric power generation offers a promising technology in the direct conversion of waste-heat energy, into electrical power. In this paper, a background on the basic concepts of thermoelectric power generation is presented and recent patents of thermoelectric power generation with their important and relevant applications to waste-heat energy are reviewed and discussed. Currently, waste heat powered thermoelectric generators are utilized in a number of useful applications due to their distinct advantages. These applications can be categorized as micro- and macro-scale applications depending on the potential amount of heat waste energy available for direct conversion into electrical power using thermoelectric generators. Micro-scale applications included those involved in powering electronic devices, such as microchips. Since the scale at which these devices can be fabricated from thermoelectric materials and applied depends on the scale of the miniature technology available. Therefore, it is expected that future developments of these applications tend to move towards nano technology. The macro-scale waste heat applications included: domestic automobiles, industrial and solid waste. Currently, enormous amounts of waste heat are discharged from industry, such as manufacturing plants and power utilities. Therefore, most of the recent research activities on applications of thermoelectric power generation have been directed towards utilisation of industrial waste heat. Future developments in this area might focus onto finding more suitable thermoelectric materials that could handle higher temperatures from various industrial heat sources at a feasible cost with acceptable performance. Another future direction is to develop more novel thermoelectric module geometries and configurations. The developments of more thermoelectric module configurations by developing novel flexible thermoelectric materials will make them more effective and attractive in applications where sources of waste heat have Arbitrary shapes.

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