Thermoelectric Power Generation for Train Bogies by Exhaust Heat Energy Losses

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Abstract— In recent years, an increasing concern of environmental problems, in particular global warning and the limitations of energy fuels has resulted in renewed research into new and advanced technologies for generating electrical power. Thermoelectric power generators have emerged as a promising alternative because of its prominent advantages. Thermoelectric power generation offer a potential application in the direct conversion of heat energy that is wasted unnecessarily into electrical power. In this paper, we have presented an energy conversion system in which thermoelectric modules have been attached at the junction of a train engine which will harness the free energy of exhaust and converting into useful power. That energy will be used to drive the internal power requirement of the components of the train.

Key words: Global Warning, Thermoelectric Power Generation, Thermoelectric Modules, Exhaust Energy

I. INTRODUCTION

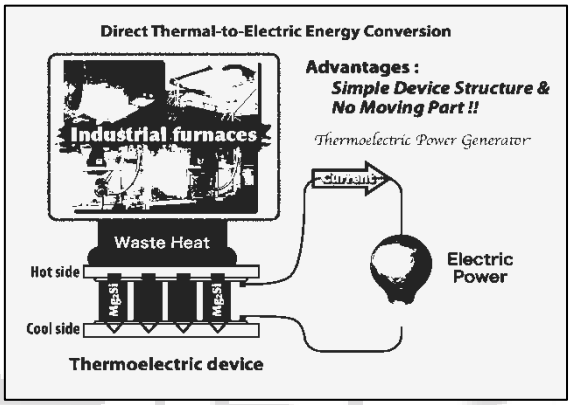
The thermoelectric effect is the direct conversion of temperature differences to electric voltage and vice versa. A thermoelectric device creates a voltage when there is a different temperature on each side. Conversely when a voltage is applied to it, it creates a temperature difference (known as the Peltier effect). At atomic scale (specifically, charge carriers), an applied temperature gradient causes charged carriers in the material, whether they are electrons or electron holes, to diffuse from the hot side to the cold side.

This effect can be used to generate electricity, to measure temperature, to cool objects, or to heat them or cook them. Because the direction of heating and cooling is determined by the sign of the applied voltage, thermoelectric devices make very convenient temperature controllers.

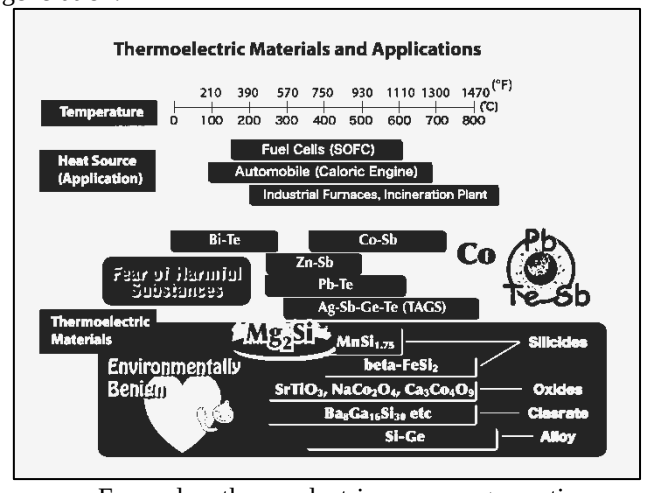
Traditionally, the term thermoelectric effect or thermoelectricity encompasses three separately identified effects, the Seebeck effect, the Peltier effect, and the Thomson effect.

In order to reduce CO_2 emissions to counteract greenhouse effects, the accelerated introduction of renewable energies such as a solar cells and fuel cells based on pure hydrogen sources, seems to be very important to replace the use of fossil fuels. We believe that atomic power generation is not an eternal solution because of radioactive waste and resource abundance. On the other hand, since we cannot abandon the use of fossil fuels immediately, a positive attitude towards the use of waste heat is urgently required to sustain the huge growth in energy consumption on a world scale. We now believe that the industrial reuse of "Waste Heat" and "Waste Si" is definitely required for a sustainable society. In the case of "Waste Heat" from caloric systems, this brings about an increase in CO2 emissions, and consequently to rises in atmospheric temperatures, which is becoming serious. On the other hand, for "Waste Si" from the semiconductor industry, there are problems related to increases in Si waste, and, simultaneously, a lack of Si resources, as we are now beginning to recognize.

The value of 11294.9 Mtoe (million tonnes oil equivalent represents the total amount of primary energy consumption of the world last year. (BP statistical review of world energy 2009) Of this huge primary energy consumption, please consider that about 70 % of the installed primary energy is discarded as heat, resulting in increases in CO2 emissions and atmospheric temperature rises. By using a direct thermal-to-electric energy conversion technique, we would like to reuse this discarded heat energy in order to reduce CO2 emissions as soon as possible.



This figure is a schematic illustration of the thermal-to-electric energy conversion; the so-called thermoelectric device. One side of the thermoelectric device is heated by waste heat from such as industrial furnaces and automobile engines. The temperature difference between the hot-side and the cool -side can be used to generate electrical power. This is the mechanism for thermoelectric power generation. The device structure is very simple and there are no moving parts, as compared with other competitive power generators such as gas turbines and the Stirling engine. These are remarkable advantages for thermoelectric power generation.



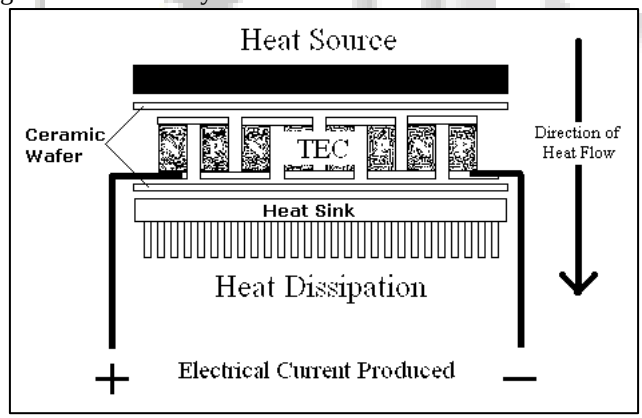
Formerly, thermoelectric power generation was performed using Pb-Te, but, as you know, these days

regulations such as ROHS and REACH in the EU prohibit the development of Pb-Te thermoelectric devices. From this point of view, we have been trying to fabricate environmentally benign thermoelectric materials from Mg2Si. The constituent elements of Mg and Si are abundant and are non-toxic. Additionally, Mg2Si itself and its by-products are not included in the scope of regulations covering harmful substances.

The expected value for the conversion efficiency of Mg2Si is 9.5 % for each "element" where an "element" consists of a device structure equipped with an electrode, a thermal contact and associated electronics. Compared with other materials, Mg2Si exhibits comparable or slightly higher energy conversion efficiency. Since Mg2Si is a very light material, if we refer to the value of efficiency divided by material density, the index that we obtain exhibits much higher values. In a comparison of relative abundance, material cost, and the need for environmentally hazardous substances, Mg2Si is exemplary. Its constituent elements Si and Mg are readily available, it has sufficient energy conversion efficiency, and its non-toxic nature means it can be discarded safely after its lifetime.

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. It is the Seebeck effect that is responsible for electrical power generation. Their construction consists of pairs of p-type and n-type semiconductor materials forming a thermocouple. These thermocouples are then connected electrically forming an array of multiple thermocouples (thermopile). They are then sandwiched between two thin ceramic wafers.

When heat and cold are applied, the device then generates electricity.



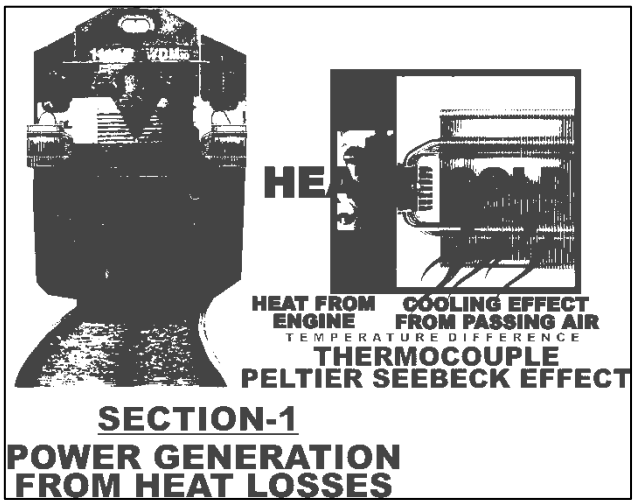
These thermocouples are then connected electrically in series and/or parallel forming an array of multiple thermocouples (thermopile). When heat and cold are applied this device then generates electricity. Almost any heat source can be used to generate electricity, such as solar heat, ocean heat, geothermal heat, even body heat! In addition the efficiency of any device or machine that generates heat as a by-product can be drastically improved by recovering the energy lost as heat.

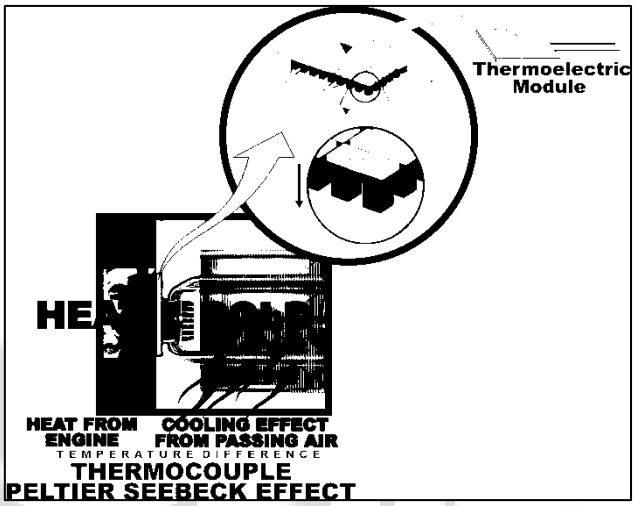
Most importantly,

We divided our project in two sections

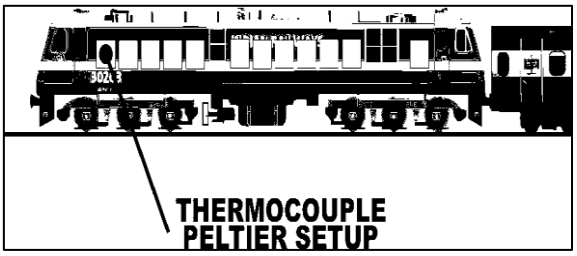
1) Power generation from heat losses
2) Emergency brake applied in case of fire.

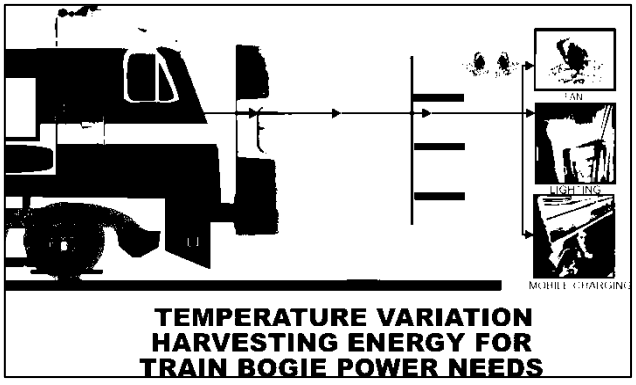
A. Section-1





B. How Train Engine Looks Like





HARVESTING ENERGY USE FOR LIGHT, COOLING (FAN ONLY) AND MOBILE, LAPTOP CHARGING

SECTION-2

EMERGENCY BRAKE APPLIED IN CASE OF FIRE

In this way, we can, with the help of thermoelectric modules we can try and run internal mechanisms of a train.

II. CONCLUSION

Electricity is no longer a luxury; it has become a necessity in our everyday lives. Thermoelectric generation can easily power up the whole country based on usage. We have already seen the advantages of a thermoelectric generator that how it can easily power the inside of a train bogie by the use of Seebeck effect and Peltier effect and convert into useful power. With the help of thermoelectric modules, we can easily power up fan, lights and even charging points of train. Similarly, in homes, too we can see its potential.

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