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THE MOELECTRIC PORTABLE AIR CONDITIONING SYSTEM

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ABSTRACT

The present air conditioning system produces cooling effect by refrigerant like ammonia and ferrous etc. using this we get maximum output but one of the major disadvantage is it releases harmful gases and causes global warming. The problem can be overcome by using the thermo electric module (Peltier effect) there by protecting the environment. This air condition system can be used dual purpose like cooler in summer as well as Heater in winter. Because it won't emit harmful & toxic gases like hydrogen &chlorofluorocarbons. The current scenario is to implement the advance design structure in thermo electric air conditioning system. This setup is used to find the different temperature level and different ambient temperature. To increase the efficiency of Peltier effect and to reduce the size of present air conditioning system to make eco-friendly air condition.

INTRODUCTION

In thermoelectric materials, electrical energy can be directly converted into thermal energy and thermal energy into electrical energy. Direct conversion between electrical and thermal energy is possible because of two important thermoelectric effects: the Seebeck effect and the Peltier effect. The Seebeck effect refers to the existence of an electric potential across a thermoelectric material subject to a temperature gradient. The Peltier effect refers to the absorption of heat into one end of a thermoelectric material and the release of heat from the opposite end due to a current flow through the material.

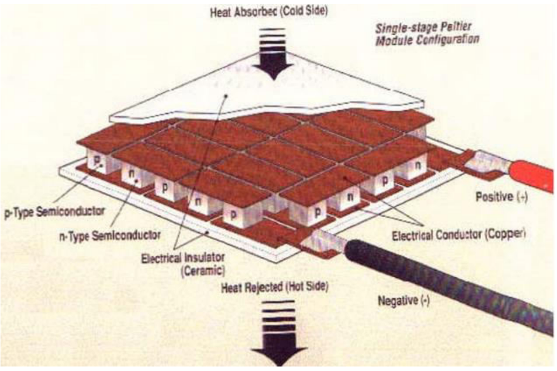


Figure 1: Peltier model diagram

Thermoelectric cooling, commonly referred to as cooling technology using thermoelectric coolers (TECs), has advantages of high reliability, no mechanical moving parts, compact in size and light in weight, and no working fluid. In addition, it possesses advantage that it can be powered by direct current (DC) electric sources, when a voltage or DC current is applied to two dissimilar conductors, a circuit can be created that allows for continuous heat transport between the conductor’s junctions this is the principle of thermoelectric air-condition. Air conditioning is a process of removing heat from a room or other applications. Many ways of producing a cooling effect by like vapour compression and vapour absorption air condition. These air conditioners are producing cooling effect by using refrigerants like Freon and ammonia etc. It gives maximum output but, one of the disadvantage is producing harmful gases to the atmosphere. The harmful gases are chlorofluorocarbon and some other gases are present.

INTRODUCTION TO THERMOELECTRICS

The use of thermoelectric (TE) devices is not new; Seebeck and Peltier devices were developed in the 1800s but did not see application in industry until the late 1950s. Initially the materials used were very inefficient and required substantial amounts of power to perform their tasks. In the 1950s, the development of semiconductors led to practical TE devices, which consumed less power and had superior performance. Presently, devices are 2 being used in military, aerospace, scientific, medical, electronics and most recently, in automotive applications. Through varying configurations, a TE device is able to provide: heating, cooling and electricity. Throughout the first 40 years of commercial introduction, few improvements were made to TE devices. Recent advancements in materials, manufacturing and heat transfer effectiveness introduce new opportunities for TE devices.

As with most innovative ideas, thermoelectric began with application in the military and aerospace industries. These industries took advantage of TEs as generators and cooling devices. Most space missions by NASA incorporated thermoelectric generators to provide electric power to their rockets or satellites. The longest running is still in use today after 35 years of service. The military has also employed TE devices as generators due to their ability to provide power silently in stealth operations.

The electronics and automotive industries will be analyzed in this review; both offer new opportunities for TE devices. The electronics industry is now applying TE modules as active cooling devices for computer CPUs and other heat generating devices such as laser diodes and infrared cameras. TE devices are also being introduced into mass market consumer products, such as small refrigerators and freezers. The automotive industry began using TE devices in temperature regulating seats during the late 1990s. These have since seen substantial growth, and are currently being installed in over 1,000,000 cars annually. Research continues to be conducted to determine the technological viability of TEs to perform as the vehicle’s heating, ventilation and air conditioning (HVAC) system. There is a big effort underway to use the devices for generating electricity through 3 extraction of waste heat from the exhaust. Such systems are being developed to improve fuel economy while reducing vehicle emissions.

EXPERIMENTAL OVERVIEW

When current is supplied to a thermoelectric cooler, heat will be absorbed and rejected at the cold and the hot sides, respectively, which results in a difference in the junctions’ temperatures. To maintain this temperature gradient, heat has to be rejected from the hot side. Otherwise, the two sides will reach thermal equilibrium leading to a rise in the temperature of the cold junction. To do that, heat sinks with forced conviction process using fans or blowers for air and pumps for liquid water configurations are recommended, depending on the system application. For the cold side, heat is absorbed from the air driven by fans to achieve cooling air with low temperatures. Through reversing the direction of the supplied current, heat dissipation at the hot side can also be used to produce heating by using forced air convection and heat sinks. In this case, the cold side should be as warm as possible to maximize the efficiency of heating on the hot side; this can be handled by applying forced convection at the cold side so that heat is absorbed from the ambient air to the cold heat sink to keep it warm. The volume flow rate at the two heat sinks can be easily varied by manipulating the input power to the fans, and the cooling/heating power can bechanged depending on the demand by changing the input current to the thermoelectric cooler. The critical parameters when operating a thermoelectric cooler are the input current or voltage through the power supply and the cold and hot junction temperatures, which can be measured using thermocouples.

EXPERIMENTAL SETUP

To assess the validity of this optimum design results, an experiment had to be conducted based on the optimum design input parameters. From the optimum design of the heat sinks, two commercial heat sinks with close geometry to the optimum values were selected to be used in the experimental work. The thermoelectric cooler also was chosen based on the optimum parameters results, and due to availability limitations, a similar module with close geometry was selected instead. The test stand accommodates two 40 ×40 heat sinks at the cold and the hot sides and a 40 × 40 *mm* TEC1-12706 thermoelectric module from TETECHNOLOGY, INC company.

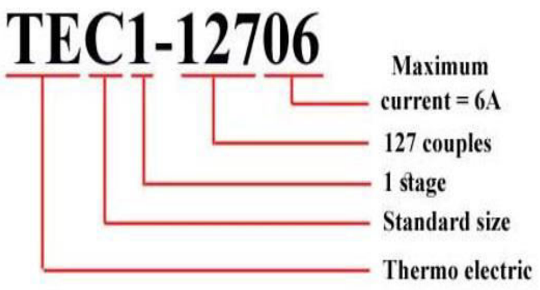


Figure 2: TECI-12706

Indicates a schematic drawing of the test stand with air flow direction while Figure 3.6 shows a photograph of the test stand with removed isolation pads. These pads are extremely important to reduce the errors associated with heat convection and radiation losses from the system. As mentioned earlier, one of the convenient features of thermoelectric coolers is that they can provide coldness and hotness depending on the direction of the applied voltage. Therefore, exactly same experimental setup was employed to investigate the performance of the heating mode. The only difference is that the polarity of the applied voltage was switched so that the thermoelectric device produces heat at the main heat sink (cold heat sink in the previous setup). In such case, the same volume flow rates were maintained at the two sides of the thermoelectric system.

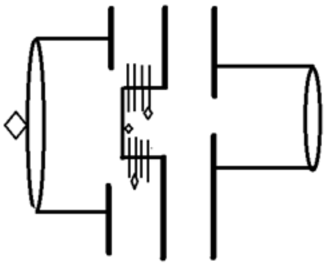


Figure 3: 2D Schematic of the experimental setup

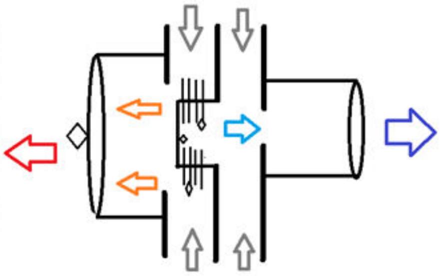


Figure 4: 2D Schematic of the experimental setup with flow of air

As seen in Figure two aluminum blocks with dimensions (40 × 40 ×19.1 $mm3$) are clamped between the heat sinks with two thermocouple inserts (with a diameter of 2 mm and depth of 20 mm) in each block. Two parallel K-type thermocouples are inserted into the center of the aluminum blocks where the average hot and cold temperatures occur. These aluminum blocks had two purposes. This first one was to measure the junction temperature occurring at the surfaces of the thermoelectric module through a linear method of extrapolation. The second purpose was to measure the heat flux accruing at the junction of the thermoelectric module. In order to efficiently blow the cold and the hot air, it is essential to design proper air ducts. The housing air ducts for both sides were fabricated using plastic sheets to minimize the heat leak along the air ducts.

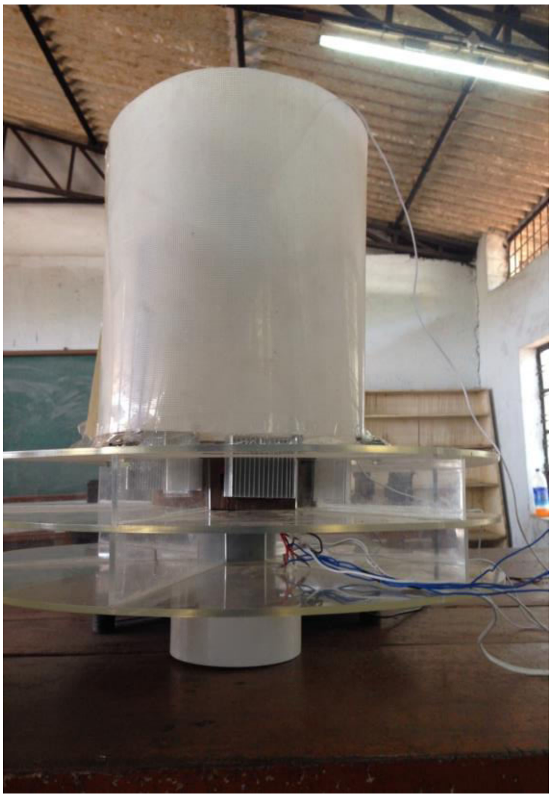


Figure 5: Photograph of the experimental setup

Now, in order to obtain the junction temperature, let's consider the conduction heat transfer diagram shown in Figure 3.7. Assuming perfect insulation and perfect contact between the interfaces of the aluminium blocks and the thermoelectric module surfaces and one-dimensional uniform heat fluxes at the cold and the hot junctions.

Where, Th and Tc are the temperatures at hot and cold side of the module respectively. Qc max is the cooling capacity at cold side of the module when ΔT = 0. ΔTmax is the maximum possible temperature difference between the cold and hot side of the module when Qc = 0. Imax is the maximum input current at Qc= 0. Vmax is maximum DC voltage at Qc=0.

In the below equations, αm, Km, Rm are the device Seebeck voltage, device thermal conductance and device electrical resistance under the assumption of all identical couple and the unidirectional heat flow.

$$\alpha m = Vmax/\ Th$$

$$Rm = Th\ - \Delta TmaxTh * Vmax/\ Imax$$

$$Km=(Th - \Delta Tmax)/\ 02\Delta Tmax*(VmaxxImax)/\ Th$$

$$Qc = (\alpha mxTcxI) – (I2*Rm)/\ 2 - KmTh\ - Tc$$

$$W = \alpha mxIh\ - TI2Rm$$

Theoretical COP

$$\boldsymbol{COP} = Qc/W$$

CALCULATIONS

By applying the above formulas we can find the COP of the module.

Eg 1:As we know that voltage applied is Vmax=10.5 and current is I=6.

Th=305.8K Tc=302.5K

$\alpha m = Vmax/\ Th$

=10.5/305.8 =0.034

$Rm = Th\ - \Delta TmaxTh * Vmax/\ Imax$

=1.71

$Km\ =\ (Th\ \ -\ \ \Delta Tmax)/\ \ 02\Delta Tmax*(axxImax)/\ Th$

=5.328

COP = Qc/W

=14.436/37.674 =0.383

Eg:2 As we know that voltage applied is Vmax=10.5 and current is I=6.

Th=315.8K Tc=305.8K

$\alpha m = Vmax/\ Th$

=0.033

$Rm = Th\ - \Delta TmaxTh * Vmax/\ Imax$

=1.66

$Km\ =\ (Th\ \ -\ \ \Delta Tmax)/\ \ 02\Delta Tmax*(ax\square Imax)/\ Th$

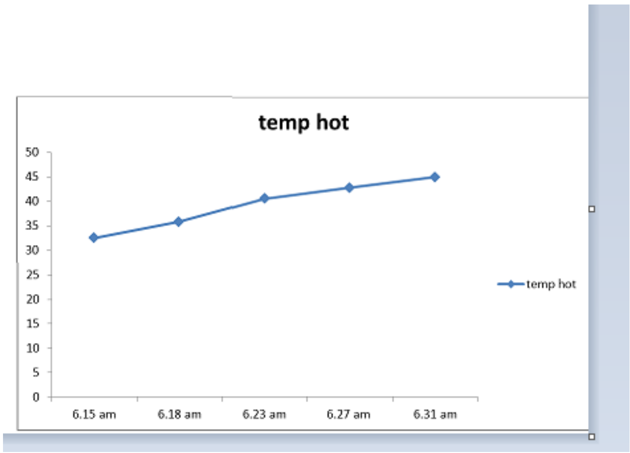
=1.844

COP = Qc/W=29.261/118.34 =0.247

RESULTS AND ANALYSIS

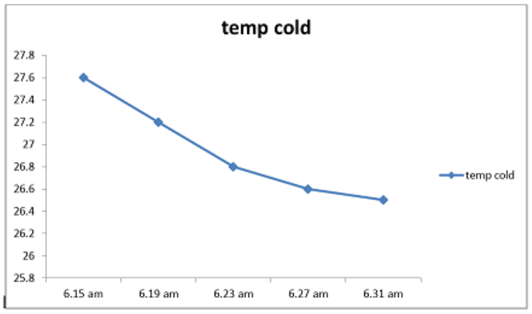
Different types of graph are drawn with respect to the results noted while testing the apparatus.

Graph between hot temperature Vs time



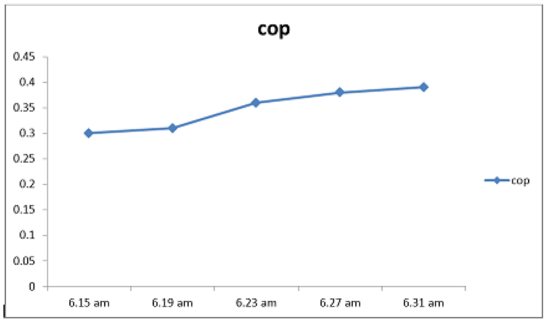
From the above graph we can know that time is directly proportional to temperature at hot side. As the time of applied current goes on increases the temperature on the hot side also increases because of flow of electrons from one side to other side which makes the hot side hotter. Heat rejection from hot side must be as soon as possible otherwise there will be heat transfer from hot side to clod side.

Graph between cold temperatures vs time



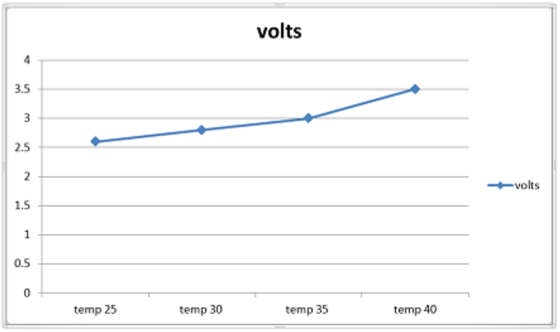
From the above graph we can know that time is indirectly proportional to temperature at cold side. As the time of applied current goes on increases the temperature on the cold side also decrease because of flow of electrons from one side to other side which makes the cold side much colder. It is difficult to maintain this temperature because of heat transfer from hot side to cold side.

Graph between copVs time



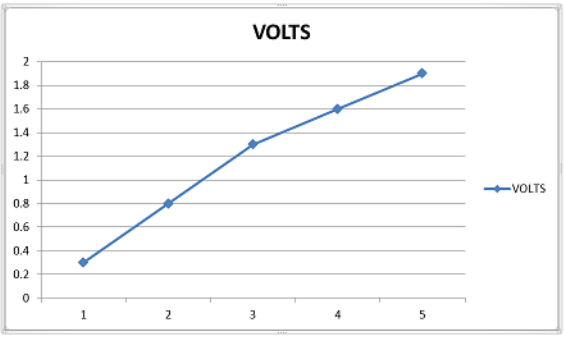
From the above graph we can know that time is directly proportional to cop. As the time of applied current goes on increases the cop of the peltier model also increases because of flow of electrons from one side to other side which makes the hot side hotter, cold side colder which increase the temperature difference between the two sides.

Graph between hot temperature Vs volts



Input voltage at a given value of input current and module hot side temperature is lowest where the temperature difference is equal to zero and highest when the temperature difference is at its maximum point. Clearly there is a linear relationship between Vin and Th at various input current. The interesting phenomenon however is that as the input current decreases so does the input voltage decreases at any given module hot side temperature.

Graph between VOLTS VERSUS INPUT CURRENT



Clearly as can be expected, there is a linear relationship between input voltages and input current. As the input current increases so does the input voltage. The interesting thing however is that as the temperature difference decreases, so also is the input voltage decreasing for a given temperature difference.

CONCLUSION

An ion beam deposition technique was successfully applied to create n and p-type superlattice films with thermoelectric non-dimensional figures of merit, Zt, of 8 and 25, respectively (measured at 650K). The n and p-type super lattices were made from un-doped Si/ Si C and B4C/B9C. The Si C, B4C, and B9C.targets were prepared by spreading powders over stainless steel trays that were then placed under the ion beam. The Si target was comprised of 6” polished silicon wafers. Hence the materials of the films were easily obtainable and low cost alternatives to conventional thermoelectric materials. The ion beam-formed super lattices performed comparatively to super lattices formed using magnetron deposition processes that were reported in the literature. In addition, the rate of super lattice growth with the ion beam system was found to be ~2x faster than magnetron system, which will help reduce the cost of forming TE modules based on these materials. Thin film processing parameters that were investigated included ion energy, pre-etching condition, layer thickness, layer number, and deposition temperature. The pre-etching of the silicon substrate substantially improved the super lattice resistivity and made the most significant difference in Zt compared to the other processing parameters. Decreasing the ion energy increased the Zt by a factor of two, and this affect was attributed to sharper boundaries being formed between adjacent layers. Deposition temperature was found to strongly affect film adhesion to the silicon substrate below 300°C, however, deposition temperatures above 400°C resulted in well adhered films. It has been shown that theoretical improvements to Zt should continue to increase as the layer thickness decreases. Our tests confirmed that thinner layer superlattices performed better; however, studies were only conducted with layer thickness ranging from 20 nm to 5 nm.

FUTURE SCOPE

SUGGESTIONS FOR FUTURE WORK

Two main goals are identified for advancing this work. First, to achieve a better understanding of how to maximize Zt, a better test apparatus needs to be setup to study materials as they are produced within the vacuum system. In this way, Zt as a function of various process parameters can be determined. Second, the manufacturability of modules comprised of many p-n couples needs to be addressed. For thin film super lattice materials to be a viable option for TEG applications, a low cost efficient manufacturing process must be designed.

APPLICATIONS

a) Refrigeration
b) Energy Generation and Its Enhancements

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