DESIGN AND FABRICATION OF THERMOELECTRIC SEAT COOLING SYSTEM

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***Abstract*- Refrigeration is a process of reducing the temperature of an area or substance below the ambient temperature. In General refrigerator works by refrigerant circulating inside them to change liquid into gas, this process is called as evaporation. This system is based on the evaporator, compressor, condenser and expansion device .The refrigerant like Halons, Chlorofluorocarbon (CFC) and Hydro chlorofluorocarbon (HCFC) are used in the refrigeration system. Due to use of these refrigerants global warming and ozone depletion is potentially raised. Because of this ultraviolet radiation enters in earth's atmosphere, the effect of this are skin cancer and eye damage. It also has effect on non-human animals and crops. To avoid this we need an alternative refrigeration system like thermoelectric cooler which is eco-friendly in nature. Many automobile engines have also emitted heat which is also a concern. Thermoelectric seat cooling system is the process of cooling the automobile seat during the summer season. The aim of this work is to cool the bike seat for the comfort of the riders. Due to the over heat in the seat, many medical problems like piles, kidney stone etc., that are affecting the riders. In order to reduce the stress to the riders and to overcome this effect, the concept of thermoelectric refrigeration system is used in automobile seat to control the seat temperature, we use exhaust fan and heat sink inside the seat to reduce the emission of the heat in the seat. This is light in weight, durable and high heat removal rate when compared to vapor compression refrigerator system and other type of refrigeration system.**

***Keyword*- Thermoelectric Refrigerator, Chlorofluorocarbon, Evaporator, Condenser and Global Warming.**

I. INTRODUCTION

A) Heat Sink

A heat sink is a passive heat exchanger that transfers the heat generated by an electronic or a mechanical device to a fluid medium, often air or a liquid coolant, where it is dissipated away from the device, thereby allowing regulation of the device's temperature at optimal levels. In computers, heat sinks are used to cool central processing units or graphics processors. Heat sinks are used with high-power semiconductor devices such as power transistors and optoelectronics such as lasers and light emitting diodes (LEDs), where the heat dissipation ability of the component itself is insufficient to moderate its temperature. A heat sink is usually made out of copper and/or aluminum. Copper is used because it has many desirable properties for thermally efficient and durable heat exchangers. First and foremost, copper is an excellent conductor of heat. This means that copper's high thermal conductivity allows heat to pass through it quickly. Aluminum is used in applications where weight is a big concern.

B) Heat Transfer Principle

In thermodynamics a heat sink is a heat reservoir that can absorb an arbitrary amount of heat without significantly changing temperature. Practical heat sinks for electronic devices must have a temperature higher than the surroundings to transfer heat by convection, radiation, and conduction. The power supplies of electronics are not 100% efficient, so extra heat is produced that may be detrimental to the function of the device. As such, a heat sink is included in the design to disperse heat to improve efficient energy use. To understand the principle of a heat sink, consider Fourier's law of heat conduction. Fourier's law of heat conduction, simplified to a one-dimensional form in the *x*-direction, shows that when there is a temperature gradient in a body, heat will be transferred from the higher temperature region to the lower temperature region. The rate at which heat is transferred by conduction is proportional to the product of the temperature gradient and the cross-sectional area through which heat is transferred.

C) Fins Efficiency

Fin efficiency is one of the parameters which make a higher thermal conductivity material important. A fin of a heat sink may be considered to be a flat plate with heat flowing in one end and being dissipated into the surrounding fluid as it travels to the other. As heat flows through the fin, the combination of the thermal resistance of the heat sink impeding the flow and the heat lost due to convection, the temperature of the fin and, therefore, the heat transfer to the fluid, will decrease from the base to the end of the fin. Fin efficiency is defined as the actual heat transferred by the fin, divided by the heat transfer was the fin to be isothermal (hypothetically the fin having infinite thermal conductivity). Equations 6 and 7 are applicable for straight fins.

$$\eta_f = \frac{\tanh(mL_c)}{mL_c}$$

$$mL_c = \sqrt{\frac{2h_f}{kt_f}}L_f$$

D) Peltier Device

When a current is made to flow through a junction between two conductors, A and B, heat may be generated or removed at the junction. The Peltier heat generated at the junction per unit time, Q depends on the current I and also the peltier coefficients of the 2 materials. The total heat generated is not determined by the Peltier effect alone, as it may also be influenced by Joule heating and thermal gradient effects. The Peltier coefficients represent how much heat is carried per unit charge. Since charge current must be continuous across a junction, the associated heat flow will be different when the peltier coefficients of the materials are different. The Peltier effect can be considered as the back-action counterpart to the Seebeck effect (analogous to the back-emf in magnetic induction) if a simple thermoelectric circuit is closed then the Seebeck effect will drive a current, which in turn (via the Peltier effect) will always transfer heat from the hot to the cold junction. The close relationship between Peltier and Seebeck effects can be seen in the direct connection between their coefficients: A typical Peltier heat pump device involves multiple junctions in series, through which a current is driven. Some of the junctions lose heat due to the Peltier effect, while others gain heat. Thermoelectric heat pumps exploit this phenomenon, as do thermoelectric cooling devices found in refrigerators.

II MATERIALS & METHODOLOGY

A) Design

Initially we made an imaginary layout of our idea and then started with 2D - design using standard AUTO CAD 2010 and later developed into 3D - modeling using SOLIDWORKS 2010. SOLIDWORKS 2010 software is used for 3D drafting. It is computer aided design software helps to perform 2D and 3D modeling easily. The each and every part of the component can be designed separately and assembled together, it is the easiest way to identify the errors and helps to simulate easily.

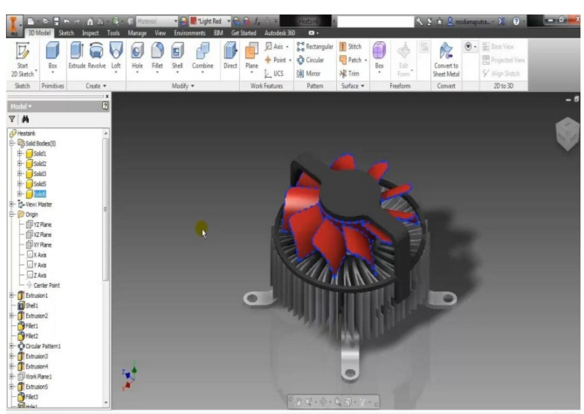

Fig.1 Heat Sink with fan

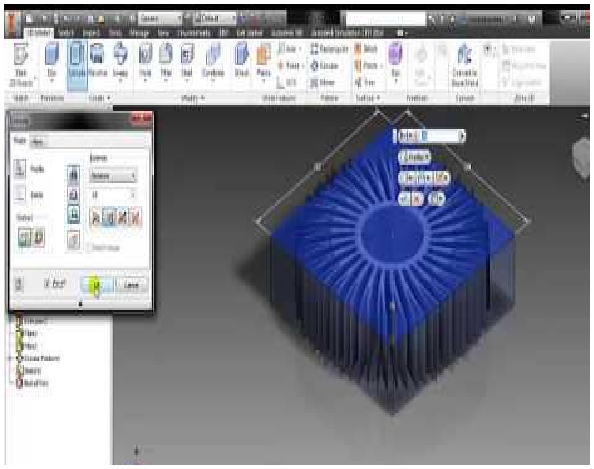

Fig.2 Cooling effect is seen on top of the Heat Sink

B) Construction

We have assembled the device and mounted it into an automobile seat. The peltier is attached to the heat sinks and fan accordingly as per the figures given below. This peltier and heat sink is then attached to the aluminum plate. This entire arrangement is mounted into the automobile seat. We have used a thermostat for the controlling of temperature gradient. Then a speed controller is connected so as to control the fan speed for more cooling effect. Then a digital thermometer with a sensor is used to check the temperature gradient. The connections are then given out through the plastic mould and fixed onto it. The wirings are then connected to the battery of the automobile and is given a switch control for on and off as per the passenger requirements.

TABLE I DIMENSIONS FOR FABRICATION

S.No	Equipments
1	Bike Seat
2	Battery
3	Heat Sink
4	Exhaust Fan
5	Peltier Plate
6	Aluminum Plate

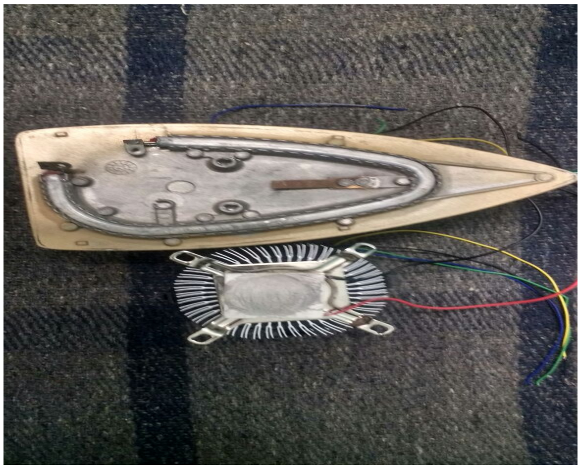

Fig.3 Aluminum place and heat sink

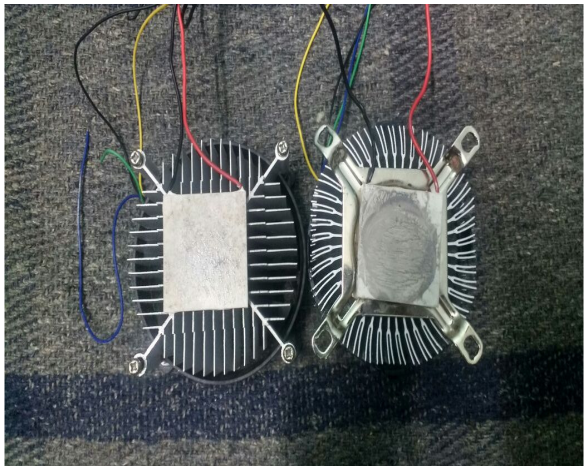

Fig.4 Peltier attached to heat sinks and fan

III EXPERIMENTAL SETUP

A) Working

As a practical matter, it is only possible to reach either heat pumping capacity in watts, or to obtain the maximum temperature differential in degrees. In other words, the DTmax is the maximum temperature difference between the hot and cold sides of the module when optimal power is applied and there is no heat load (Q=0). As a thermal load Q is added, the difference in temperature between the two surfaces will decrease until the heat pumping capacity or Qmax value is achieved and there is no net cooling (DT=0). Since your application will likely require net cooling of an object with a thermal mass, the actual heat pumped, or Q, will be less than Qmax and the actual difference in temperature will be less than the DTmax. Curves may be produced to show the relationship between power applied to a module and net cooling. From our module specifications page you may see the curves for our most popular modules by clicking on the appropriate part number. After learning what power is required for an appropriate module to reach the desired level of cooling and heat pumping capacity, it is necessary to focus on the assembly required, specifically heat-sink selection, in order to allow the module to maintain the desired results. The actual cold-side temperature, with a given level of cooling (or DT) on the module, is derived by subtracting the temperature of the cold-side Tc from the temperature of the hot-side Th.

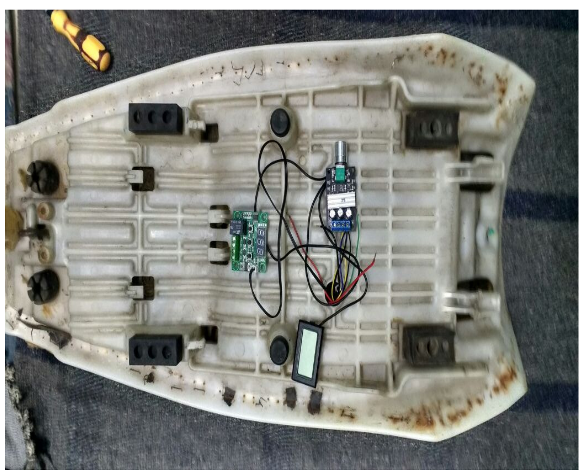

Fig.5 Speed controller, thermostat and digital thermometer are given connections as per requirements to the battery

It's sometimes desirable, to direct the cold-side airflow away from our air conditioners. For example, you might like to move cooled air some distance within an enclosure, improve temperature uniformity, spot cool or force cooled air through a duct. This is easy to do on our air conditioners by flipping over the cold side fan. For enhanced performance a fan shroud can be added that creates a space between the heat-sink and fan where a slight vacuum is formed, enhance turbulence, and heat transfer. Liquid heat-sinks generally have the lowest thermal resistance but are often the most complicated; when plumbing and cooling the liquid is involved.

For many single module applications however, there are a variety of liquid-to-air 'radiators' readily available, that offer an excellent solution for thermoelectric "spot cooling." This method exhausts to ambient the heat from both the item cooled and the TEC. The Corsair Hydro Series, designed for CPU cooling, are economical ($130 and less), compact, and completely self-contained. We have found that with slight modifications to the stock installation hardware provided, mounting to appropriately machined plates is relatively uncomplicated. We also recommend using higher speed fans than are provided, if possible, to enhance cooling through the radiator. When installing TE modules in an assembly, it's most common to compress, or "clamp" them between a forced convection heat-sink on the hot-side and something to be cooled. The object cooled can be a block of metal creating a cold plate, another forced convection heat-sink making an air conditioner, or a liquid heat-sink forming a liquid-to-air exchanger. Liquid-to-Liquid exchangers can also be made, and are similarly installed.

IV RESULTS AND DISCUSSION

In comparison: Conventional Refrigeration because thermoelectric cooling is a form of solid-state refrigeration, it has the advantage of being compact and durable. A thermoelectric cooler uses no moving parts (except for some fans), and employs no fluids, eliminating the need for bulky piping and mechanical compressors used in vapor-cycle cooling systems.

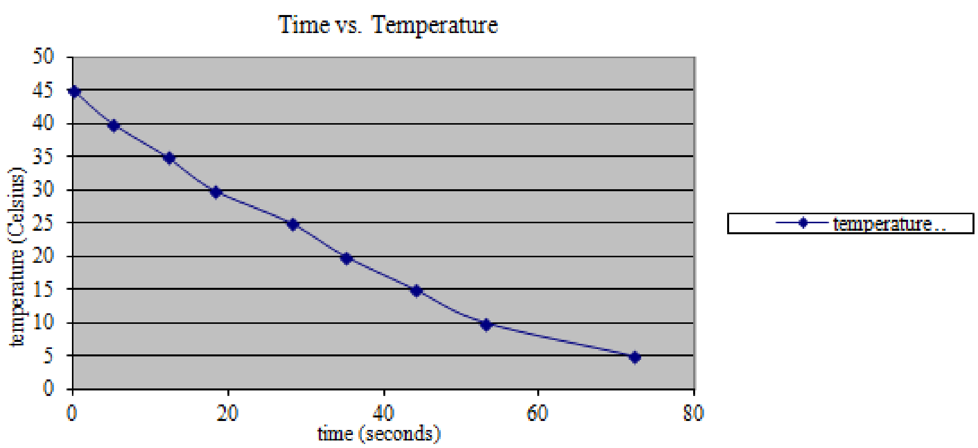

Fig.6 Time vs Temperature for the Cooling Effect for the Automobile Seat

A) Calculations

All calculations used in the project ,related to cooling load , selection of heat sinks, selection of fans, pressure drop calculations, surface area needed to cool the air etc. are mentioned below,

Cooling load-Qc the amount heat load to be absorbed by the cold junction has to be calculated before the selection of TECs.

Qc = m Cp ΔT (m = *p*. Q)
p = 1.164 kg/m3 (At 30°C)
Q = VxA
A = WxH =0.080m x0.030m =0.0024m2
V = 2.5m/s
Q = 2.5x0.0024 =0.006m3/s
m = 1.364 kg/m3x0.006m3/s =0.0069kg/s
Cp = 1007J/KgK (At 30°C)
ΔT = 45-15 =30°C
Qc = 1007x30x0.0069 =2308.449W ≈208W

Qh was calculated by adding the electrical power input and the cooling load.

Pe =18V x 13amp=234W
Qh =208W+234W =442K
COP = Qc/Pe = 208/234=0.888

This was not the actual COP of the system. It can be higher, as the power input designed is higher than the calculated Qc. A higher power input for TECs were selected in the project. The system was designed with a higher power input. Therefore the actual COP can even higher. Thermal Resistance of the hot side Heat Sink Hot side heat sink has to be selected based on its Thermal resistance. The thermal resistance of the hot side heat sink is calculated below.

Qh = (Th-T∞)/ Rt
Qh = 442W (Qc + Pe)
T∞ = 32.5°C
Th = 36.2°C
Rt = (36.2-32.5)/442= 0.0083 K/W

Power of blower fan: The power of the fan will be equal to the product of total pressure drop (pt) and volume flow rate. The total pressure drop will be the sum of pressure drop in cold side heat sink channel (rectangular channel) and the circular duct. To calculate the pressure drop using Darcy Law, the equation is as follows:

The pressure drop = 0.5*(fL/D)* p * v2
Pressure drop in the circular duct (pc):-
For the circular duct, Darcy friction factor is value is taken as 0.03 for

f = 0.03
L= 0.14
D =8.4
r = 0.042
p = 1.164 kg/m3
Q = V A
V = Q/A
Q = 0.0068
A = Π*r2 = 3.14*0.0422 = 0.005538 m2
v = 0.83098 m/s
pc = 0.5 * fL/D * p * v2 = 0.5 *((0.03*0.14)3/0.084)* 1.164*0.830982
pc = 0.01711 N/m2

The calculations are computed below.

Qc =m Cp ΔT
QC = hA* ΔT A = Qc/ (hΔT) h = 100 w/m2 k
ΔT = T* - Tc T* = (T1 + T2)/2 T* = (45oC + 10°C)/2
T* = 17.5°C
Tc = 15°C
ΔT = 17.5°C - 15°C
ΔT = 2.5°C
A = 208/ (100*2.54)
A = 0.832 m2

The velocity of hot side, the velocity of cold side, and the applied voltage is varied and different sets of readings are taken. The results of various combinations are plotted.

V CONCLUSION

In current application, a thermoelectric cold plate cools radio equipment mounted in a fighter jet wingtip. The exacting size and weight requirements, as well as the extreme g forces in this unusual environment, rule out the use of conventional refrigeration. Thermoelectric devices also have the advantage of being able to maintain a much narrower temperature range than conventional refrigeration. They can maintain a target temperature to within ±1° or better, while conventional refrigeration varies over several degrees. Unfortunately, modules tend to be expensive, limiting their use in applications that call for more than 1 kW/h of cooling power. Owing to their small size, if nothing else, there are also limits to the maximum temperature differential that can be achieved between one side of a thermoelectric module and the other. However, in applications requiring a higher ΔT, modules can be cascaded by stacking one module on top of another. When one module's cold side is another's hot side, some unusually cold temperatures can be achieved. The main objective of applying a thermo seat cooling device to the seats of automobiles is achieved satisfactorily. The desired outcome of reducing stress and improving the driving experience and comfort is achieved.

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