Fabrication of Cooling Jacket For Motorcycle

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Abstract- *Due to metabolic heat generation from our body, we are very uncomfortable both in cold and hot weather, especially when we work hard and while travelling. In cold weather we wear warm jacket to have more comfort. But, we can't have much comfort when we use jacket. Unlike cold weather, in hot weather we don't have such an alternative solution for comfort. If there is a jacket cooler, then it will be comfort both in cold and hot weather. A thermoelectric cooling prototype jacket has been fabricated. An innovative evaporative type heat sink has been designed and fabricated. A control switch used to regulate the flow of current through the circuit. Thus to control the heat capacity of the module has been prepared. The performance of the prototype jacket was evaluated by analytical and numerical methods.*

It works on the principle of peltier effect. The thermoelectric cell takes advantage of this effect with a thermopile--essentially a stack of different pieces of metal attached together. One end of the thermopile gets very hot and the other end gets cold. It utilizes a DC current, when the electrons pass from higher electron density material to lower electron density material, one junction of the metal becomes heated and the other is cooled. In this project we utilize the power of a motorcycle battery to charge the jacket.

I. INTRODUCTION

Conventional cooling systems such as those used in refrigerators utilize a compressor and a working fluid to transfer heat Heat energy is absorbed and released as the working Fluid undergoes compression and expansion and changes phase from vapor to liquid to and back, respectively Semiconductor thermoelectric cells (also known as peltier coolers) offer many advantages over conventional refrigeration

They are totally solid state devices, with no moving parts and this makes them reliable, rugged, and quiet They use no ozone depleting chlorofluorocarbons, potentially offering a more environmentally responsible alternative to refrigeration systems which are conventional They are extremely compact, much more than compressor based systems Precise temperature control ($< \pm 0\ 1$ °C) can be acquired with Peltier cells However, their efficiency is low compared to natural conventional refrigerator

Thus, they are used in these applications, where their unique advantages outweigh their low efficiency Although some large scale applications have been considered (on submarines and surface vessels), Peltier cells are generally used in applications where small size is needed and the cooling demands are not too great, such as for cooling electronic components

COMPARISON OF THERMOELECTRIC CELL REFRIGERATION AND OTHER METHODS OF REFRIGERATION

Thermoelectric Refrigeration System

Cooling is achieved electronically using the "Peltier effect" The heat is pumped with electrical energy Thermoelectric cooling provides an alternative solution to the common compressor and absorber cooler Thermoelectric coolers are used especially if small cooling power is needed (up to 100 W)

Vapour Compression Refrigeration System:

Cooling is achieved by vaporizing a refrigerant (such as Freon) inside the refrigerator heat is absorbed by the refrigerant through the principle of the "latent heat of vaporization" and released outside the refrigerator where the vapour is condensed and compressed into a liquid again This uses mechanical energy

Vapour Absorption Refrigeration System:

Cooling is achieved by vaporizing a refrigerant inside the refrigerator by boiling it out of a water ammonia solution with a heat source (electric or propane) This uses the principle of "latent heat of vaporization" The vapour is condensed and reabsorbed by the ammonia solution outside the refrigerator Uses heat energy

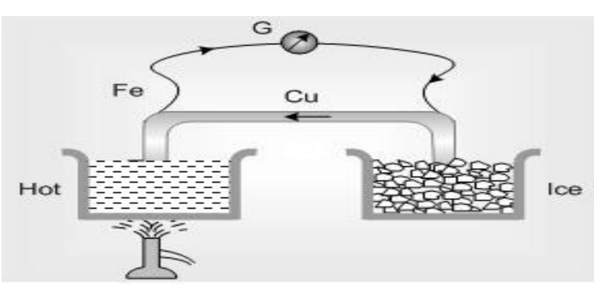
THERMOELECTRIC REFRIGERATION

Refrigeration is the process of pumping heat energy out of an insulated chamber in order to reduce the temperature of the chamber below that of the surrounding air Thermoelectric refrigeration uses a principle called the "PELTIER" effect to pump heat electronically The Peltier effect is named after a French scientist who discovered it in 1834BIn 1834 Jean Peltier noted that when an electrical current is applied across the junction of two dissimilar metals, heat is removed from one of the metals and transferred to the other

This is the basis of thermoelectric refrigeration Thermoelectric modules are constructed from a series of tiny metal cubes of dissimilar exotic metals which are physically bonded together and connected electrically When electrical current passes through the cube junctions, heat is transferred from one metal to the other Solid state thermoelectric modules are capable of transferring large quantities of heat when connected to a heat absorbing device on one side and a heat dissipating device on the other The Koolatron's internal aluminum cold plate fins absorb heat from the contents, (food and beverages), and the thermoelectric modules transfer it to heat dissipating fins under the control panel Here, a small fan helps to disperse the heat into the air The system is totally environmentally friendly and contains no hazardous gases, nor pipes nor coils and no compressor
The only moving part is the small 12volt fan Thermoelectric modules are too expensive for normal domestic and commercial applications which run only on regular household current They are ideally suited to recreational applications because they are lightweight, compact, and insensitive to motion or tilting, have no moving parts, and can operate directly from 12-volt batteries

SEEBECK EFFECT

Definition: When the two junctions of a thermocouple are maintained at different temperatures, then a current starts flowing through the loop known as thermo electric current The potential difference between the junctions is called thermo electric emf which is of the order of a few microvolts per degree temperature difference (µV/°C)



SEEBECK EFFECT

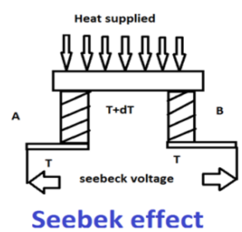
See beck effect*:* The magnitude and direction of thermo emf in a thermocouple depends not only on the temperature difference between the hot and cold junctions but also on the nature of metals constituting the thermocouple

(i) See beck arranged different metals in the decreasing order of their electron density Few metals forming the series are as below

Sb, Fe, Cd, Zn, Ag, Au, Cr, Sn, Pb, Hg, Mn, Cu, Pt, Co, Ni, Bi

(ii) Thermo electric emf is directly proportional to the distance between the two metals in series Farther the metals in the series forming the **thermocouple** greater are the thermo emf Thus maximum thermo emf is obtained for **Sb-Bi** thermo couple

(iii) The current flow at the hot junction of the thermocouple is from the metal occurring later in the series towards that occurring earlier, Thus, in the copper iron thermocouple the current flows from copper (Cu) to iron (Fe) at the hot junction This may be remembered easily by the hot coffee



SEEBECK EFFECT

- For small temperatures difference between two junctions of materials A and B the open circuit voltage developed is proportional to the temperature difference and is given by
- $\Delta V=\alpha_{ab}\Delta T$

THERMOELECTRIC MODULE

The core piece of a thermoelectric suit is the thermoelectric module A thermoelectric module is an electrical module, which produces a temperature difference with current flow The emergence of the temperature difference is based on the Peltier effect designated after Jean Peltier The thermoelectric module is a heat pump and has the same function as a refrigerator It gets along however without mechanically mobile construction units (compressor, refrigerant pump,) and without cooling fluids The heat flow can be turned by reversal of the direction of current

DESIGN OF THERMOELECTRIC COMPONENTS

The design progressed through a series of steps These steps were identification of the problem, analyze problem, brainstorm ideas, decide upon a design selection, and implement design Redesign if necessary The main design considerations were Geometry, Heat Transfer Methods and Materials

HEAT TRANSFER METHODS

There are several methods which can be employed to facilitate the transfer of heat from the surface of the thermoelectric to the surrounding These methods are described in the following three sections Natural convection, Liquid cooled, Forced convection when the coefficient of thermal transfer (*K*) was investigated, the *K* for natural convection was approximately 25 W/mK This value compared to 100W/mK for forced convection Clearly the size of the heat sink for a natural convection apparatus would need to be 4 times that for a forced convection set-up

GEOMETRY

Two main geometries were considered for the device the First choice for cooler geometry was a cylinder The advantage found with this shape is that it has the largest volume to surface area ratio of the two designs considered This is a good property when the objective is to minimize heat loss and the second was a rectangle The advantage of rectangle is its simplicity to build and insulate

A door can easily be attached to one of the sides Finally any insulation, thermoelectric modules or heat sinks are easily fastened to the sides So by considering the simplicity to build and insulate rectangle box is considered

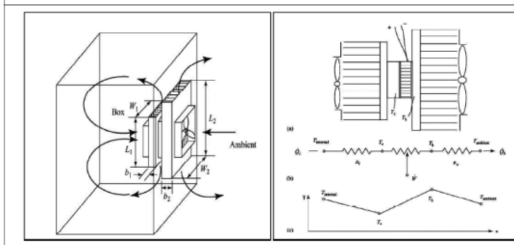
MATERIAL

We explored three different materials for the construction of the outer casing and frame of the device These were aluminum, stainless steel and Hips High impact polystyrene is desirable as it has a low thermal conductivity Building the device out of would make it very light, portable while maintaining rigidity is readily available and reasonably priced, is easy to cut and drill The outer casing and container would be made by first making a positive mold and applying a cloth coated with resin

HEAT SINK DESIGN

In order to visualize the energy flow in the entire system, a thermal circuit is constructed, which is schematically shown in Figure *Rc* and *Rh* and are the overall thermal resistances for the internal heat sink and external heat sink, respectively The components of the air cooler are an internal heat sink, a thermoelectric module, and an external heat sink as shown in Figure 2 is the amount of heat transported at the internal heat sink, which is actually the design requirement (45 Watts)

Figure 2: Air Flow of a Thermoelectric Air Cooler



HEAT SINK DESIGN

FIGURE Considering the dimension available at the machine area and various options keeping the weight, cost and manufacturing feasibility as the main consideration for selection for mounting of heat sink both at hot and cold side area Fin thickness of 1mm with profile length of 20 mm is selected Tables 3 and 4 represent the summary result for hot side and cold side fin respectively

THERMOELECTRIC CELL

Using Standard correlation available in handbooks the commercial available module with the calculated maximum performance is represented in Table below

Table 5: Model Number for TER

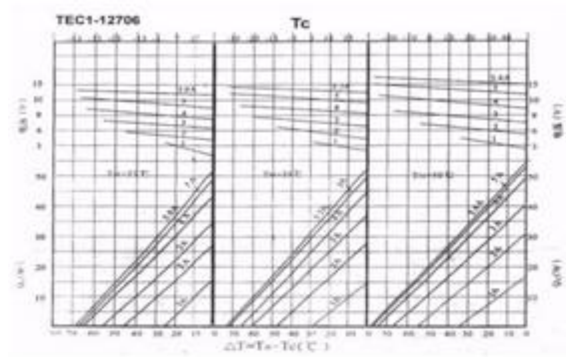
Module: Model TEC1-127-06L			
Q_{max}	51.4 Watts	Dimensions	
I_{max}	6 Amp	Width	40 mm
V_{max}	15.4 V	Length	40 mm
T_{max}	67 °C	Thickness	3.8 mm
Number of Thermocouple	127		

Thermoelectric Cooler's Specification Include

Part Number	Data obtained at hot plate temperature Th=27°C.				DimensionAxBxHmm
	Imax (amps)	DTmax(°C)	Vmax (Volts)	Qmax (watts)	
TEC101703	3.3	69	1.90	3.90	15x15x4.8
TEC1-03103			3.50	7.20	20x20x4.8
TEC1-07103			8.60	16.40	30x30x4.8
TEC1-12703			15.0	29.30	40x40x4.8
TEC1-01704	3.9	69	2.00	4.00	15x15x4.7
TEC1-03104			3.66	7.30	20x20x4.7
TEC1-07104			8.40	16.70	30x30x4.7
TEC1-12704			15.00	33.40	40x40x4.7
TEC1-01705	5.0	68	2.00	5.60	15x15x4.3
TEC1-03105			3.66	10.30	20x20x4.3
TEC1-07105			8.40	23.70	30x30x4.3
TEC1-12705			15.00	42.50	40x40x4.3
TEC1-01706	6.0	68	2.00	6.90	15x15x4.0
TEC1-03106			3.66	12.50	20x20x4.0
TEC1-07106			8.40	28.70	30x30x4.0
TEC1-12706			15.00	51.40	40x40x4.0
TEC1-03108	8.5	68	3.75	16.80	20x20x3.3
TEC1-07108			8.60	38.50	30x30x3.3
TEC1-12708			15	68.09	40x40x3.3
TEC1-127085			15	68.09	50x50x4.7
TEC1-12710S	10	68	15.80	85.0	40x40x3
TEC1-12710	10	68	15.80	85.0	50x50x4.8
TEC1-07114	14	68	8.40	65.90	44x44x4.6
TEC1-12714			15.80	118	50x50x4.6
TEC1-12718	18.5	68	15.8	156	50x50x4.1
TEC1-12726	26	65	15.8	220	50x50x3.6
TEC1-03140	39	65	3.63	80.0	55x55x5.8

Where

- I – Input Amps to the TEC (in Amps)
- Imax – Input Amps that produce the maximum DT [DTmax] (in Amps)
- Qc – Amount of heat that can be absorbed at the cold side face of the TEC (in watts)
- Qmax – Maximum amount of heat that can be absorbed at the cold side This occurs at
- I = Imax and when DT = 0 (in Watts)
- Th – Temperature of the hot side face of the TEC (in °C)
- Tc – Temperature of the cold side face of the TEC (in °C)
- DT – Difference in temperature between the hot side (Th) and the cold side (Tc)
- dT = Th-Tc (in °C)
- DTmax – Maximum difference in temperature a TEC can achieve between the hot side (Th) and the cold side (Tc)
- This occurs at I = Imax and when Qc = 0 (in °C) Vmax – Voltage at I = Imax (in Volts) **F**



PELTIER GRAPH

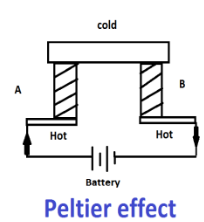
II LITERATURE REVIEW

THERMO ELECTRIC OPERATING PRINCIPLE:

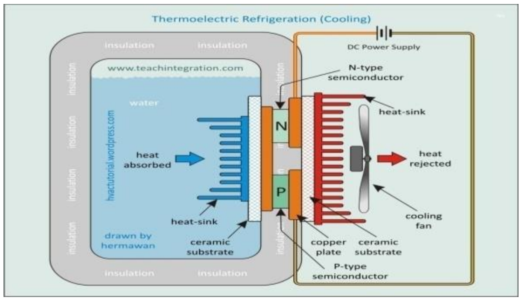
Thermoelectric coolers operate by the Peltier effect (which also goes by the more general name thermoelectric effect) The device has two sides, and when DC current flows through the device, it brings heat from one side to the other, so that one side gets cooler while the other gets hotter The "hot" side is attached to a heat sink so that it remains at ambient temperature, while the cool side goes below room temperature In some applications, multiple coolers can be cascaded together for lower temperature

In 1834, Jean Peltier discovered that when a direct current is passed through a junction of two dissimilar metals, the junction became either hot or cold The same circuit can be considered as made up of material A and B into which a battery is introduced to provide a direct current I At the junction between the two dissimilar metals, the heat evolved or absorbed in unit time proportional to the current and is given by

$Q_p = \pi_{ab} I$
Q_p=heat evolved or absorbed in unit time, (watts)
Π_{ab}=peltier coefficient
I=direct current in amperes



PELTIER EFFECT



- In 1838,Emil Lenz clearly showed the importance of both Peltier's and Seebeck's discovery by placing a drop of water on a junction of two dissimilar metals and passing a direct current through the circuit when the current flowed in one direction ,the water froze When the flow of current reversed, the ice melted However, Lenz, like his predecessors failed to realize the significance of his findings of and the knowledge remained dormant for over 100 years, mainly due to unavailability of materials which could produce wide temperature differences
  Before discussing the principles of thermoelectric refrigeration, it is necessary to see the required properties of the materials which meet the following conditions:
- The thermo-electric material must be excellent conductor of electricity to minimize resistance losses
- The thermo electric material must be a very poor conductor of heat because the heat must be absorbed at one end, and rejected at the other
- The thermo electric material must have high thermo-electric power This means it must have a high rate of change in voltage with temperature that means [dE/dT] must be high
- A good thermo-electric material should have a higher electrical conductivity, low thermal conductivity, and a high Seebeck coefficient
- After the discovery of transistor which required semi conductors, the development of thermo electric refrigerator took the practical shape because the semiconductor was the proper material for thermoelectric refrigeration

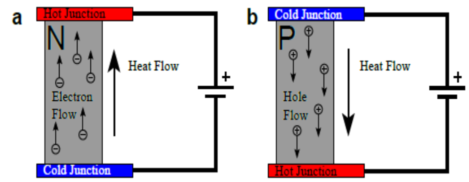
THE PELTIER DEVICE:

Peltier devices are named so because, typically, they are used as a heat pump based on the Peltier effect In this case, a constant current, I_{el}, is driven through the Peltier device, and the Peltier effect generates a temperature Difference

$$\Delta T \propto P_{\mathrm{el}} = \Pi I_{\mathrm{el}}.$$

N- AND P-TYPE PELTIER ELEMENTS:

When a semiconductor is used as a thermoelectric material, its majority charge carriers (electrons or holes) determine the electrical behavior For example, when nand ptype semiconductors are biased in the same direction their charge carriers flow in opposite directions As a result, nand ptype Peltier elements create opposite temperature gradients



N AND P PELTIER ELEMENTS

n-type versus p-type Peltier elements

a) An ntype semiconductor is biased externally creating an electrical current The negative carriers (electrons) carry heat from bottom to top via the Peltier effect b) The positive carriers (holes) within a ptype semiconductor {biased in the same direction as (a) pump heat in the opposite direction, that is, from top to bottom

COMMERCIAL PELLETIER DEVICES:

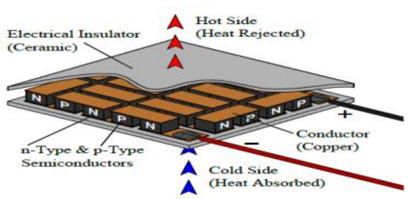
A single Pelletier element can be used to produce electrical power (via the Seebeck effect) or to pump heat (via the Peltier effect) In either application, the power output of a single Peltier element is generally not sufficient for realistic situations To increase their power, commercial Peltier devices are composed of many n-type and p type semiconductor Peltier elements

The individual elements are connected in series using metallic junctions As a result of this, the junctions between the semiconductors do not form a barrier potential, as they would do in a pn diode, and charge carriers ow freely in both directions In a Peltier device, the individual elements are arranged so that the n- and p-type heat ow in the same direction

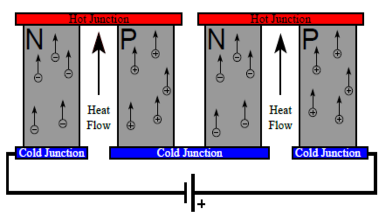
Complete Peltier device architecture It consists of two electrically insulating ceramic plates sandwiching a series of p pairs joined by copper This design provides a large surface area improving heat pumping for cooling and heating applications Waste heat absorption and electrical power production (via the Seebeck effect) also benefit from the increased surface area

ELECTRICAL POWER PRODUCTION:

Though primarily used as heat pumps, Peltier devices nonetheless generate a thermovoltage, Vth, when subjected to a temperature gradient, ΔT An electrical current, I will flow if the Peltier device is connected to a load resistor, Rload In this case, the Peltier device converts heat energy to electrical energy quantified by the dissipated power, P = IVload, where Vload is the voltage drop across the load resistor In the laboratory, P can be determined by measuring I and Vload The Peltier device is not an ideal voltage source; therefore, its internal resistance, RI, must be included in the analyses of power data Furthermore, RI is typically on the order of a few tens of Ohms Therefore, the resistance of the ammeter, Ra, cannot be ignored



A series of alternating n and ptype semiconductor elements, which pump heat from bottom to top when a voltage is applied

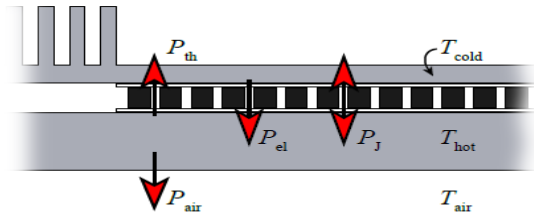


ELETRICAL POWER PRODUCTION

Thecommon design of a commercial Peltier device is placed between two ceramic insulating mterials, alternating n and Ptype semiconductors elements are arranged across a plain and are connected in series electrically with copper junctions When current is supplied to the Peltier device, heat is pumped from one surface to the other

Thermal conductance:

When current, I, ows through the Peltier device, heat ow Pel = ΔI generates a temperature deference, ΔT In response, heat conducts from the hot to the cold side of the Peltier device given by Pth = □ΔT The electrical power dissipated in the Peltier device (that is, the Joule heat) is PJ = RI2, where R is the resistance of the Peltier device Pj flows into both sides of the Peltier device Finally, heat Pair flows from the hot side to the surrounding environment



THERMAL CONDUCTANCE

Heat owns in the Peltier device Current, I, owing through the Peltier device pumps heat Pel = ΔI and generates the temperature gradient,

$$\Delta T = T_{\text{hot}} - T_{\text{cold}}$$

In the opposite direction as Pel, heat ux Pth conducts through the Peltier device from hot to cold Joule heat, PJ, owns into both sides of the Peltier device Heat Pair conducts from the heat block to the surrounding air at temperature Tair A number of simplifications and approximations can be made to reduce the complexity of these heat flows during measurements

The first simplification is to perform the experiments in the opencircuit regime where I = 0 Therefore Pel = PJ = 0 The approximations are to assume that $T_{\text{cold}} \approx T_{\text{air}}$ and that $P_{\text{air}} \approx 0.$ These assumptions are filled when ΔT is small and when the heat block is thermally insulated In this situation, only Pth affects the heat content of the hot block because Tcold is constant The heat stored in the heat block is Qhot = mcThot, where m = 0:22 kg is the mass of the heat block, and c = 897 J= (kg K) is the heat Capacity of aluminum The rate equation for the heat flow is

Pth = ΔQhot = mc ΔThot = □ΔThot

Starting from a temperature Thot (t = t0) = T0, the hot block cools according to

$$\dot{T}_{\text{hot}}(t) = \frac{\kappa}{mc}\left(T_0 - T_{\text{hot}}(t)\right)$$

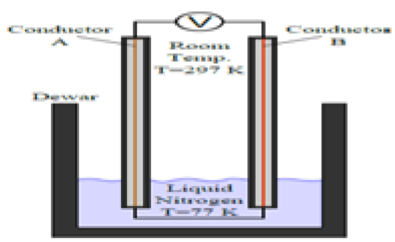
Laboratory procedure:

Measurements with the thermocouples

Three metallic conductors are supplied in the lab: 1) phosphorbronze, 2) copper, and 3) constantan Each conductor is contained inside a stainless steel tube with BNC connections at both ends The Seebeck coefficients for these materials are not very large Therefore, liquid nitrogen (LN2) Dewar is supplied to provide a large temperature difference between LN2 at TLN ' 77K and room temperature (TRT ' 297 K) The supplied thermometer can be used to monitor the room temperature ends of the tubes, but TLN does not need to be measured See Fig 7 for a schematic of the measurement

Thermocouple measurement procedure:

1 Measure and record the room temperature resistance of each conductor individually
2 Combine the conductors together in pairs and measure the three thermo voltages using the LN2 Dewar
3 Determine the three effective Seebeck coefficients:
(a) SC-Cu for constantan and copper
(b) SPB-Cu for phosphor-bronze and copper
(c) SC-PB for constantan and phosphor-bronze

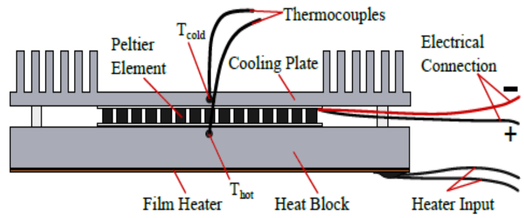


MEASURMENT OF THERMOCOUPLES

The two conductors, A and B, are enclosed inside two stainless steel tubes They are connected together at one end and submerged in LN2 Dewar to cool them to TLN ' 77 K The other ends remain at room temperature (TRT ' 297 K), and the voltage difference between the conductors is measured with a voltmeter

Measurements with the Peltier device:

The Peltier setup in the lab consists of a commercial Peltier device placed between two aluminum heat reservoirs as shown in Fig 8 The \hot" reservoir is an aluminum block covered with thermal insulation The \cold" reservoir is an aluminum block machined with cooling _ns A fan can be placed on the cold reservoir to improve its cooling power This is recommended because it helps stabilize the temperature gradient



MEASURMENT WITH PELTIER DEVICE

A schematic diagram of the Peltier laboratory setup The Peltier device is mounted between two aluminum masses The bottom heat block can be heated with the film heater by applying a current to the heater inputs The cooling plate on top can be cooled with the fan (not shown) The dual channel thermometer probes (thermocouples) are inserted into two holes for measuring the temperature deference

$$\Delta T = T_{\text{hot}} - T_{\text{cold}}$$

The electrical connections of the Peltier device are used to apply and measure voltae and current

Warm-up procedure:

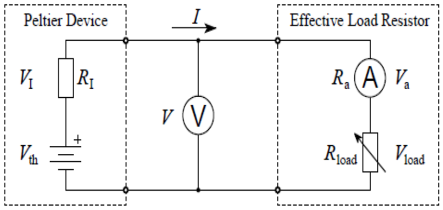
Before you start, get everything ready to record timedependent data Ideally you will record T_{cold}, T_{hot}, and V_{th} simultaneously This is done best by heating slowly so that values do not change rapidly You will measurewith the two thermocouples embedded in the Al masses Digital multi meters are available to measure electrical properties The thermometer and the multi meters have a hold" feature for pausing the measurements This can help when recording time-dependent data

1. Connect the thermometer probes and a voltmeter to the electrical connections of the Peltier device
2. Place the fan on the cold block and turn it on
3. Apply 12V to the heater film About 1A of current will flow
4. Measure T_{cold}, T_{hot}, and V_{th} as the system heats up
5. It can take 30 min before the temperatures stabilize

Constant temperature measurements:

1. While waiting for the temperatures to stabilize, measure all the resistor values, Rload, in the circuit box and measure, Ra, the resistance of the ammeter
2. Make sure the voltmeter spans both the load resistor and the ammeter
3. Once the temperatures have stabilized, record ΔT
4. Measure V and I as a function of all R_{load} values
5. Measure V and I when R_{load} = 0, that is, only use Ra

6. Measure $V = V_{th}$ at $I = 0$, that is, V when Rload = 1
7. Measure ΔT again to see if there was a temperature drift



CONSTANT TEMPERATURE MEASUREMENT

The circuit diagram for a Peltier device when connected to an electrical load In addition to the internal resistance of the Peltier device, R_I, the setup includes a variable load resistance, R_{load}, and the resistance of the ammeter Ra The temperature gradient generates the internal thermo voltage, V_{th} Voltages V_I, V_a, and V_{load} are created across resistances, RI, R_a, and R_{load}, respectively An ammeter is used to measure the current, I A voltmeter is used to measure the voltage drop, V , across the total elective load resistance, Ra + R_{load}

Cool-down procedure:

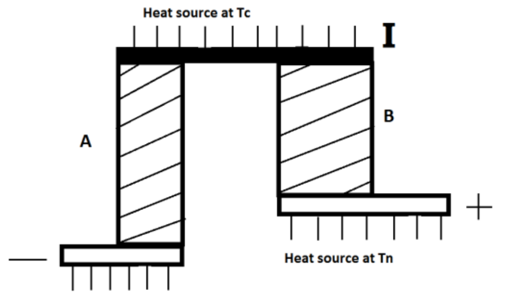
While the system cools down, you will measure the thermal conductance

1. Return the system to the open-circuit condition used during the warm- up procedure That is, disconnect the ammeter and use only the volt- meter
2. Get ready to measure time-dependent data
3. Disconnect the heater and start recording T_{cold}, T_{hot}, and V_{th} as the system cools down This can take more than 20 minutes

Data analysis:

In your lab report you should discuss your results as well as observations that you deem relevant Your data should be presented in an appropriate manner {that is, analyze your raw data and present it in an informative way State and justify your assumptions In addition, address following points (which will help you to analyze your data)

Peltier device data analysis:



PELTIER DEVICE DATA ANALYSIS

1. Heat absorption and heat rejection occur only at the junctions
2. Thermal conductivity and electrical resistance are coZstant over the range of temperature under consideration
3. Thomson coefficient is negligible

Net refrigerating effect at the junction is given by
$Q_1=\alpha_{ab}T_c-1/2\ I^2R-U(T_h-T_c)$
Where Q_1=Net refrigeration effect at the cold junction
$P\alpha_{ab}$=Relative seebeck coefficient for material A and B
Heat source at T_c
I= current in amps
R=Total electric resistance of the circuit in ohms
$=L_a/A_a\sigma_a + L_b/A_b\sigma_b$
U=Total thermal conductance of branches in parallel
$=A_aK_a /L_a + A_b K_b /L_b$
T_c and T_h= temperature of hot and cold junctions respectively in Kelvin
σ =Electrical conductivity and
K=Thermal conductivity
A_a and A_b=constant cross-section areas of two branches
L_a and L_b= Lengths of two branches
Φ=Refrigerating effect/Power- input

CHARACTERISTIC VALUES OF A PELTIER COOLER

Power supply

- **Voltage**

Basically the cooling capacity depends on the current The cooling units are usually built for using at constant dc voltage e g 12V, 24V We advise you to reduce the maximum ripple to 10%, preferably to 5% for an optimal operation If the voltage rises over the nominal value, the increase of the cooling performance is small or even declines and the efficiency drops intense

If the voltage is reduced, the maximum temperature difference cannot be achieved any more The cooling power reduces in equal measure, but the COP rises The use of adjustable DC supplies makes a rough adjustment for the temperature possible If an exact temperature is required, a controller must be used

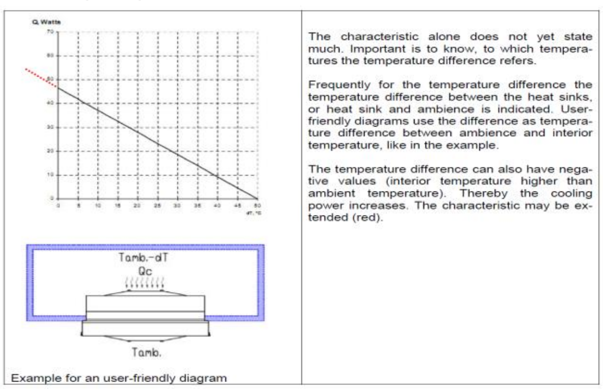
Please note that the fans have always to be operated with rated voltage By reversal of the polarity one heats instead of cools So the cooling unit can be used as air conditioner Please note that the polarity of the fans may not be inverted (=> separate supply)

- **Current**

The initial current is larger than the current in continuous operation Consider this for the dimension of the power supply With increasing temperature difference at the cooling unit the current decreases

Relation between temperature difference and cooling power

Data such as 300W cooling unit, maximal cooling power 250W, operating cooling power 180W say little about the efficiency of a cooling unit The cooling performance depends on the temperature difference Please see in the following diagram

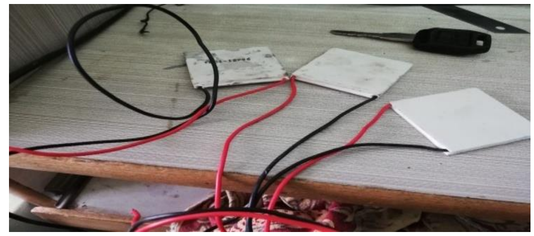


III COMPONENTS USED FOR COOLING

1. Peltier Cells
2. Radiators
3. Designing of copper box
4. Battery
5. Thermometer
6. Water pumps

Peltier Cells:

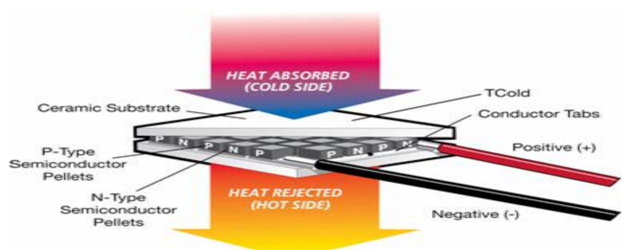
The project is entirely depends on peltier effect So, The cooling process we attain more by arranging arrange 2 peltier in our project The two peltiers works on 12V and 6 amps each peltier exhibit semiconductor properties



PELTIER CELL

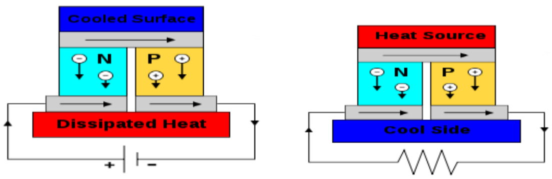
If a piece of solid is heated at one end, the charge carried (electron in metals) will leave this region and move to the cooler part The density of the electrons at the cooler end increases and an equilibrium condition is reached as the negatively charged region opposes a further flow of electrons from the hot end Thus, a potential is developed across the two ends of the material

The magnitude of this thermo emf, (Seebeck) is dependent on the number of charge carriers The smaller the number of carriers, the large is Seebeck voltage In semiconductors, the number of charge carriers is very much smaller (about 10^4 to $10^{18}/cm^3$) compared to that in metal (about $10^{22}/cm^3$) The Seebeck coefficient of a semiconductor is about 200µvolts/°c while that of metal is only of the order of a few micro volts The current is considered as the flow of negatively charged particles (electrons) The conventional direction of current flow is usually taken opposite to the flow of electrons



CONVECTIONAL DIRECTION OF CURRENT FLOW

Semconductor materials generally exhibit very large thermoelectric e m f As compared to the metals, Both Ntype and Ptype semiconductors can be used N type semiconductor is one where current carriers are mostly electrons If such a semiconductor is sandwiched between two metal strip and connected to D C voltage source as shown in fig(a) the junction where the current enters becomes hotter and other junction gets cooler



PELTIER CELL DIODE FLOW

Current conduction can also take place due to the flow of positive charges (holes) as in Ptype semiconductor as shown in fig In this case, the effect is opposite to that observed in Ntype semiconductor Coupling Ntype and Ptype semiconductors as shown in fig will produce maximum cooling effect The temperature the cold end can be lowered below the room temperature if the heat liberated at hot end be dissipated continuously

RADIATORS:

Radiators are simple heat exchangers which distribute the heat by natural air circulation (very little heat is transferred through radiation despite the name) 80 or so years ago most radiators were made from cast iron now they are mostly made from pressed steel; a few are made from aluminum

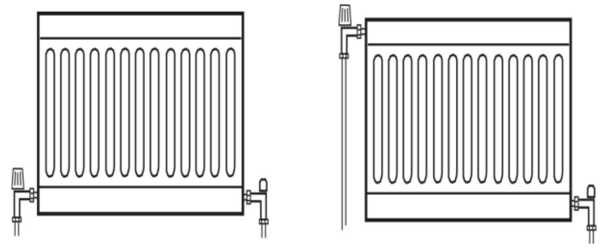
Manufacturers all produce data sheets showing the output of their radiators and many software companies (and radiator manufacturers) produce simple software so you can calculate radiator size Normally manufacturers' data sheets will quote radiator output when there is a temperature difference (water to air) of 50 °C Where the temperature differs from this correcting factors are necessary to determine actual output and therefore size So, for instance, if a radiator is required which will run at a lower temperature than normal, its size must be increased to compensate Radiators can be single panel or double panel and with, or without, fins (right) Doubling up the radiators and adding fins increases output without increasing the amount of space taken up by the radiator

RADIATOR

One pipe and two pipe systems:

Many of the earlier pumped systems used what is known as a onepipe system water flows from radiator to radiator and then back to the boiler However, as the water flows into each radiator, heat is drawn from it and therefore the water, which reenters the flow pipe, is slightly cooler Indeed, towards the end of the run the radiators are significantly cooler This can be overcome to a certain extent by progressively increasing the size of the radiators this is expensive and looks rather odd

In a two pipe system there are two pipe circuits, one a flow pipe and the other a return: each radiator is connected to both The water, which leaves the radiator, flows into a return pipe, which goes back to the boiler The same process occurs in all the other radiators Therefore, all of the radiators receive water at more or less the same temperature



TYPES OF RADIATORS

PRadiators need to be balanced to make sure they are all roughly at the same temperature (before any control is exercised via thermostatic radiator valves) There is a problem, otherwise, of radiators near to the boiler getting quite hot and radiators further away staying cool To avoid this, the outlet of each radiator is fitted with a 'lock shield valve' which needs to be adjusted when the system is first installed Balancing the rods evens out the flow of water through each radiator so that when the central heating system is working normally, the temperature drop across each radiator is about 12°C Balancing procedure is beyond the scope of this article but it usually involves checking the incoming and outgoing water temperature at each radiator

Adjustments can be made by tightening or loosening the lock shield valve this controls the water flowing through the radiator Once the radiators have been balanced, no further adjustment should be required until the boiler is renewed or radiators are changed

Radiator sizing

The heat output of the radiators should be carefully calculated Radiators should, where possible, be sited under windows to counteract cold downdraughts and to give a more comfortable environment in the room Radiators should be installed close to P the floor, preferably 100&150mm above finished floor level Wide, low radiators will be more effective at heating the room evenly than tall, narrow ones Enclosures around radiators reduce the heat output but might be required to prevent vulnerable people getting burnt

The heat loss calculation is normally done on a room by room basis to work out radiator sizes For each room the heat loss through each construction element is established The heat loss is the 'area x 'U' value x temperature difference inside and outside' (standard values are normally used see table) In addition allowance has to be made for heating the air due to air changes Note that in some rooms there will be a flow of heat INTO the room When the heat loss has been calculated a correction factor is normally applied when sizing the radiator

For example, if a condensing boiler is being used and the radiators are running fairly cool (to ensure the water in the return pipe will condense in the boiler) the correction factor may be as high as 50% In this case the radiator will have to have an output of nearly1200watts Adding together the total heat loss (in all the rooms) helps size the boiler

Design of copper box

Copper alloys are prime candidates for high heat flux applications in fusion energy systems High heat flux is a major challenge for various fusion devices because of the extremely high energy density required in controlled thermonuclear fusion The removal of a large amount of heat generated in the plasma through the first wall structure imposes a major constraint on the component design life

Materials with high conductivity are needed to assist heat transfer to the Coolant and to reduce the thermal stress for pulsed mode of operation A number of issues must be considered in the selection of materials for high heat flux applications in fusion reactors While high conductivity is the key property for such applications, high strength and radiation resistance are also essential for the effective performance of materials in a high heat flux, high irradiation environment In addition, fatigue behavior is a major concern for many high heat flux applications because of planned or inadvertent changes in the thermal loading Pure copper has high thermal conductivity but rather low strength, and therefore its application as heat sinks is limited

The strength of copper can be improved by various strengthening mechanisms Among them, precipitation hardening and dispersion strengthening are the two most viable mechanisms for improving the strength of copper while retaining its high electrical and thermal conductivities A number of precipitation hardened (PH) and dispersion strengthened (DS) copper alloys are commercially available, and have been evaluated for fusion applications, for example, PH CuCrZr, CuNiBe, CuNiSi

DESIGN OF COPPER BOX

Physical Properties of copper

Copper, atomic number 29 with an atomic weight of 63 54, exhibits a face entered cubic crystal structure Copper is a transitional element and, being a noble metal, it has inherent properties similar to those of silver and gold Its excellent conductivity, malleability, corrosion resistance and bio functionality stem from copper's elemental origins

Copper has a high solubility for other elements such as nickel, zinc, tin and aluminum This solid solution alpha (α) phase is responsible for the high ductility exhibited by copper alloys Alloying additions beyond the solubility limit result in the beta (β) phase, which exhibits a body centered cubic (bcc) structure This β phase has high temperature stability, and alloys that exhibit an α+β structure have excellent hot forming capability The density of copper is 0 321 lb/in² (8 89 g/cc), and its melting point is 1981°F (1083°C) All of these properties and characteristics are significantly modified when copper is alloyed

Electrical & Thermal Conductivity: Conductivity is the primary characteristic that distinguishes copper from other metals The electrical conductivity of materials is measured against that of a standard bar of "pure" copper that in 1913 was assigned a value of 100% IACS (International Annealed Copper Standard) Since that time, improved processing techniques and higher purity ingots have resulted in commercial copper with electrical conductivity values slightly above 100% IACS

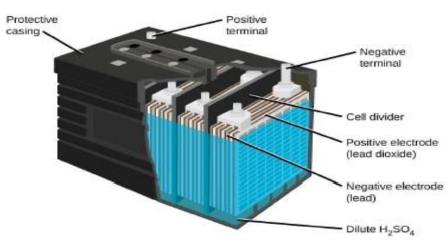
The thermal and mechanical processing variations used to produce commercial alloys can cause profound changes in their conductivity, and frequently the alloys with the highest strengths have the lowest conductivity The IACS values are usually published as minimum values for annealed tempers Tempered (cold worked) products may have a value 1 to 5 percentage points below the annealed value

Alloys of higher electrical resistivity (R) will waste more energy, since heat generated due to an electric current (I) is proportional to I2 times the resistance The heat generated will increase the temperature of the component, with potentially adverse consequences Higher thermal conductivity alloys allow the designer to dissipate some of that heat, minimizing any temperature rise Within alloy families, thermal conductivity tends to be related to electrical conductivity; *i e* , alloys of higher electrical conductivity will tend to have higher thermal conductivity

This rule of thumb is convenient since thermal conductivity is rather difficult to measure, while electrical conductivity, or its inverse, electrical resistivity, is easy to measure The nearly linear relationship between thermal and electrical conductivity at 68°F (20°C) for selected copper alloys

BATTERY:

Definition: devices that transform chemical energy into electricity Every battery has two terminals: the positive cathode (+) and the negative anode (There are two types of batteries they are primary and secondary cells



BATTERY

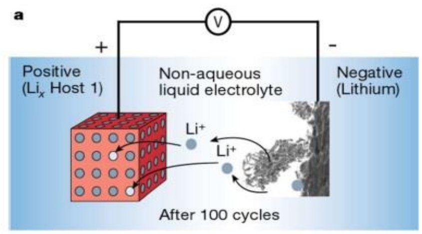
Primary and Secondary Batteries:

Primary batteries are disposable because their electrochemical reaction cannot be reversed Secondary batteries are rechargeable, because their electrochemical reaction can be reversed by applying a certain voltage to the battery in the opposite direction of the discharge

TYPES OF BATTERIES

Standard modern batteries:

- **Zinc Carbon:** used in all inexpensive AA, C and D dry cell batteries The electrodes are zinc and carbon, with an acidic paste between them that serves as the electrolyte (Disposable)
- **Alkaline:** used in common Duracell and Energizer batteries, the electrodes are zinc and manganese-oxide, with an alkaline electrolyte (disposable)
- **Lead-Acid:** used in cars, the electrodes are lead and lead oxide, with an acidic electrolyte (rechargeable)
- **Nickel-cadmium:** (NiCd) rechargeable, “memory effect” Nickel-metal hydride: (NiMH) rechargeable, “memory effect” (less susceptible than NiCd)
- **Lithium-Ion:** (Li-Ion) rechargeable, no “memory effect”, high energy density, power rate, cycle life, costly



TECHNICAL TERMS:

- **Energy Density:** Total amount of energy that can be stored per unit mass or volume How long will your laptop run before it must be recharged
- **Power Density:** Maximum rate of energy discharge per unit mass or volume Low power
- **Safety:** At high temperatures, certain battery components will breakdown and can undergo exothermic reactions
- **Life:** Stability of energy density and power density with repeated cycling is needed for the long life required in many applications
- **Cost:** Must compete with other energy storage technologies

BATTERY USED IN PROJECT (12v)

THERMOMETER:

A thermometer is a device that measures temperature or a temperature gradient using a variety of different principles A thermometer has two important elements: the temperature sensor (e g the bulb on a mercuryiglass thermometer) in which some physical change occurs with temperature, plus some means of converting this physical change into a numerical value (e g the visible scale that is marked on a mercury-in-glass thermometer)

DIGITAL THERMOMETER

Types of thermometers:

1 contact-type thermometers
- platinum resistance thermometer
- liquid-in-glass thermometer
- thermocouple

2 Radiation thermometers

WATER PUMP:

In This project we are using two water pumps

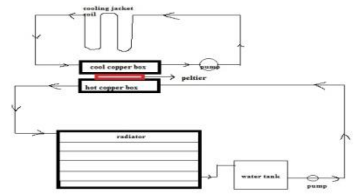
- The first water pump is used to pump water from radiator to tank and
- The second is used to circulate the entire jacket to copper box

WATER PUMP

- Water pump is used to pump the water in two boxes for cooling and heating
- One of the copper box is attach to the cool side of the copper box and another one is attached to the heating sie at water tank

IV. EXPERIMENTAL SETUP & ANALYSIS

BLOCK DIAGRAM OF EXPERIMENTAL SETUP:



CONNECTIONS ON HOT SIDE:

On the hot side of the peltier cell, a copper box is placed to receive the heat from the hot junctions of peltier The water is used as a coolant to the hot side The water absorbs the heat from conduction and convection process It carries the heat away from hot box to radiator, where it gets cooled and it is collected in water tank It again re circulates

p The fins provided to the radiator, increases the rate of heat transfer The rate of Heat transfer from hot water to surroundings, when riding a bike The rate of cooling of Hot water increases the rate of cooling on cold side

CONNECTIONS OF COLD SIDE

On the cold side of the peltier, an insulated copper box is placed it receives the cooling from the cold side if the peltier and transfer it to the flowing water The water is circulated around the body for the riders and kept the body cool and protect the rider from de-hyradation

The rate of cooling depends upon the rate of cooling on the hot side of the peltier and the atmospheric temperature The rate of heat dissipation increases on hot side increases the rate of cooling We can obtain 15 to 20^0c within 20 minutes

Thermoelectric cooling is not very efficient It is often only about 10 percent efficient, compared to normal refrigeration, which is in the 40 to 60 percent range Normal refrigeration isn't practical for a cooler, since it is heavy, bulky and overpowered But the thermoelectric cooler doesn't have to do that much

The refrigerator is insulated, so not much heat leaks in It is also quite small, so it takes much less energy to cool than a refrigerator

The efficiency of a thermoelectric cooling unit is indicated as the COP (Coefficient of Performance) It is defined as follows

$$COP = \frac{Q_c}{P_{el}}$$ Q_c: cooling power P_{el}: electrical power

The COP depends on the temperature difference The higher the temperature difference the smaller is the COP

OPERATING TEMPERATURE RANGE:

p The operating temperature range of a cooling unit is determined by the thermoelectric modules and the fans There are thermoelectric modules for operating temperatures up to 200°C At low temperatures the cooling power decreases strongly due to the material

INGRESS PROTECTION (IPX):

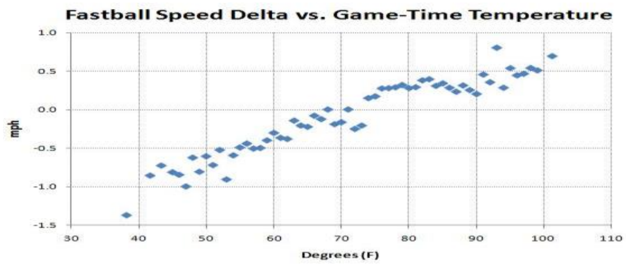
The reachable ingress protection depends on the fans They are exposed to the environment Fans are available with ingress protection IP67 The thermoelectric modules can be sealed The cooling units can be developed in such a way that no water or humidity enters the cooling unit Standard cooling units meet IP54

RELIABILITY

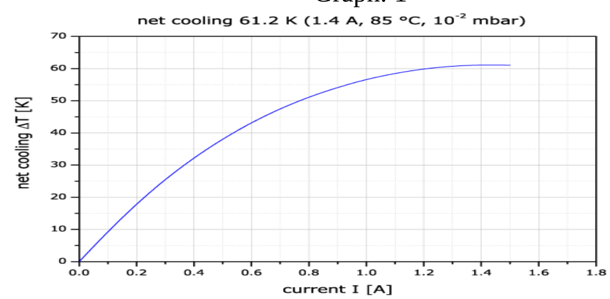
Thermoelectric cooling units are considered, construction based, as very reliable With inappropriate treatment the following errors can occur:

- Overheating of the thermoelectric module because of insufficient heat dissipation (heat sink, fan) on the hot side or too high voltage
- Quick or large changes of temperature on the hot and/or cold side One may not exceed the maximum operating temperature, defined in the specifications, in every case An excess of the maximum temperature leads to a decrease of cooling power or even to a loss The temperature range can be extended by the choice of suitable thermoelectric modules

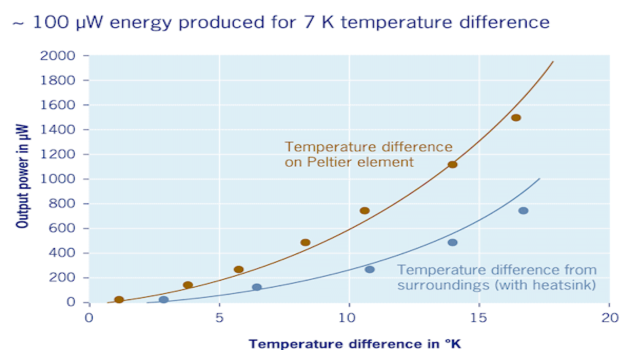
If a cooling unit is used in the cycling mode, (heating / cooling), special thermoelectric modules should be used They withstand temperature depending mechanical stress in the cycling mode Compared to standard thermoelectric modules they withstand more cycles under same conditions The MTBF (Mean Time between Failures) for thermoelectric modules of Kryotherm is 200'000 hours at ambient temperature The life cycle of the fans is shorter and thus crucial Thermoelectric cooling is not very efficient It is often only about 10 percent efficient, compared to normal refrigeration, which is in the 40 to 60 percent range Normal refrigeration isn't practical for a cooler, since it is heavy, bulky and overpowered But the thermoelectric cooler doesn't have to do that much The refrigerator is insulated, so not much heat leaks in It is also quite small, so it takes much less energy to cool than a refrigerator



Graph: 1



Graph: 2



Graph-3

Applications:

- In a typical small domestic refrigerator, a cooling power of about 50 watts is required In principle, this can be provided by a single thermocouple However a very large current (1000amps) is required at a very low D C voltage (0 1 V) In order to limit this current to a reasonable value, it is necessary to increase the number of couples This will also step up the applied D C voltage to a few volts which can be easily obtained A typical form of construction of a practical thermoelectric refrigerator is shown below In spite of certain practical difficulties, such as availability of high current, low voltage D C current source, peltier refrigerators are gaining prominence and are now widely used in several western countries These refrigerators in very compact form on a moving trolley are used in some international airlines to provide cold drinks and hot snacks as it can be used for heating and cooling also just by changing the terminal knob of the refrigerators

- Peltier cooling can also be made use of in air-conditioning of rooms where large cooling capacities are required but the temperature differences need not be so large The cooling unit can form part of one of the walls and heat appearing at the outside face of the unit can be radiated to the surrounding air by means of suitable fins The great advantage of this system is that it can be used for heating the room in winter merely by reversing the direction of current Such a heating is more effective than would be the case if the current is passed through ordinary resistance heater wires because in this case , the system acts as a heat pump
- Apart from these domestic applications, thermoelectric cooling can be effectively used in a number of scientific and applications To name a few, the applications include constant low temperature bath and chambers, cooled baffles for oil diffusion pump in vacuum systems, dew point hygrometer for determining absolute humidity, photomultiplier cooler, cooling the biological tissues for facilitation of slicing thin sections, serum coolers for preservation of blood plasma and serums and many others

ADVANTAGES:

1. Simple and less number of parts is required
2. Thermo-electric units are much more flexible than conventional units
3. It can take overload simply by increasing power input
4. These units being static are more reliable than rotating or reciprocating equipments
5. These units are noiseless and there are no moving parts
6. Control is easy as it is done merely by adjusting the current supply
7. Very compact in size and suitable for low capacity
8. It can operate in any position
9. Infinite life is expected
10. The weight per unit refrigeration is considerably lower than conventional refrigeration systems
11. No leakage problem
12. Just by reversing the polarity results in an inter change of heating and cooling process
13. An important advantage of thermo electric refrigeration is the independence of C O P on the size of thermo electric refrigerator and this makes it particularly attractive to use Peltier cooling when cooling capacity is required is high
14. Peltier cooling can also be used in air conditioning rooms where large cooling is required but the temperature difference is small The large cooling unit can form a part of the inside walls and the outside face of the unit can be exposed to the surrounding air by means of suitable films

- A great advantage of such thermo electric conditioning system is that, it can be used for heating the room in winter merely by reversing the direction of current Such as heating is more effective than would be the case if current is passed through ordinary resistance heater wires because in this case ,the system acts as a heat pump

- **Solid state design**

  1. No moving parts
  2. Integrated chip design
  3. No hazardous gases
  4. Silent operation

- **Compact and lightweight**

  1. Low profile
  2. Sizes to match your component footprint
  3. No bulky compressor units
  4. Perfect for bench top applications

- **High reliability**

  1. 100,000 hours + MTBF

- **Precise temperature stability**

  1. Tolerances of better than +/- 0 1°C
  2. Accurate and reproducible ramp and dwell times

- **Cooling/heating mode options**

  1. Fully reversible with switch in polarity
  2. Supports rapid temperature cycling

- **Localized Cooling**

  1. Spot cooling for components or medical applications
  2. Perfect for temperature calibration in precision detection systems

- **Rapid response times**
  1. Instantaneous temperature change
  2. Reduced power consumption
- **Low DC voltage designs**
- **Dehumidification**
  1. Efficient condensation of atmospheric water vapor

V CONCLUSION AND FUTURE SCOPE

The objective of the project is to achieve the cooling for the rider when riding in hot weather as well as we can acquire heating effect while cooling in cool weather A peltier Cooling system is has been designed and developed to provide active cooling with help of single stage 12 V TE module to provide adequate cooling First the cooling load calculations for this peltier component considered under study were presented Simulation tests in laboratory have validated the theoretical design parameters and established the feasibility of providing cooling with single stage thermoelectric cooler was tested in the environmental chamber

As peltier cell not available in open market, which we can retain cooling at case of power outage due to high current carrying capacity The retention time achieved was 52 min with the designed module in this project In order to achieve the higher retention time, another alternative was incorporate This consists the additional heater on heat sink The highest retention time achieved was 57 minutes S

Future Scope

With recent development taking place in field of thermoelectric and nano science different thermoelectric material with figure of merit ZT more than one with high temperature difference to be explored this will further help to reduce the temperature, current below and can also perform better at higher ambient conditions To improve the power retention in this thermoelectric cooler sandwich heater needs to be explored with quick switching mechanism from thermoelectric cell off state of heater to on state, so that temperature drop in thermoelectric cell can be reduced

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