International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 3.45 (SJIF-2015), e-ISSN: 2455-2585
Volume 3, Issue 11, November-2017

DESIGN AND DEVELOPMENT OF COOLING AND HEATING EFFECT IN SHOES USING PELTIER EFFECT

[1]P.DAMODAR, [2]Dr.K.PRAHLADA RAO

1 M.Tech, JNTUA College of Engineering, Ananthapuramu
[2]PRINCIPAL,JNTUCE Mechanical Engineering Dept., JNTUA College of Engineering, Ananthapuramu.

Abstract: ***In this work we are going to design and fabricate a peltier shoe. This shoe is helpful for working in difficult weather conditions. This peltier cell works on the principal of peltier effect, which is a reciprocal of seebeck effect. By this work, we are able to make the comfortable temperature inside the shoe. It helps the people, working in the hot weather conditions like thermal power plants, cement industries etc.***

We are going to place 12V - 9AMPS peltier in each shoe and this peltier will work with the help of DC Current (Battery). The peltier cell consists of 2 surfaces one surface becomes cold and the other becomes hot due to electrons transfer this cold and surfaces are reversed by just reversing the direction of current. Inside the peltiers there will be P-N junction diode like structure, made of two different metals having high difference of electron density. The higher the density difference the higher the performance of peltier cell and vice- versa.

Thus this product will solve many industrial problems for the people working in high temperature conditions and it may introduce to the persons serving for our country without afraid of different temperatures at the border.

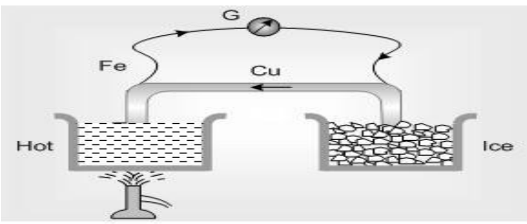
INTRODUCTION

THERMOELECTRIC REFRIGERATION HISTORY

Refrigeration is the process of pumping heat energy out of an insulated chamber 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 1834.

See beck Effect

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



Seebeck effect principle

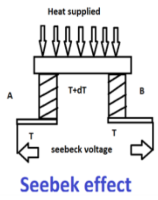
Seebeck Series*:* The magnitude and direction of thermoemf in a thermocouple depends not only on the temperature difference between the hot and cold junctions but also on the nature of metals constituting the thermocouple**.**

(I) Seebeck 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) Thermoelectric current is directly proportional to the distance between the two metals in series. Further the metals in the series forming the thermocouple greater are the thermoemf. Thus, maximum thermoemf is obtained for Sb-Bi thermocouple.

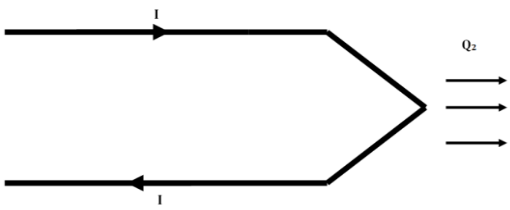
(iii)The current flow at the hot junction of the thermocouple is from the metal occurring later in the series towards that occurring earlier, Thus, in the copper-iron thermocouple the current flows from copper (Cu) to iron (Fe) at the hot junction. This may be remembered easily by the hot coffee.



seebeck effect

HERMOELECTRIC MODULE(PELTIER EFFECT)

The core piece of a thermoelectric cooler 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 works without mobile construction units (pump, compressor) and without cooling fluids. The heat flow can be turned by reversal of the direction of current.



Peltier effect

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 Heat Transfer Methods, Geometry 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 co-efficient 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 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. The second 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. But considering the simplicity to build and insulate rectangle box is considered.

Material

The three different materials for the construction of the outer casing and frame of the device is explored. 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.

After looking at various options keeping the weight, cost and Manufacturing feasibility as the main consideration for selection Fin thickness of 1 mm with profile length of 20 mm is selected.

Thermoelectric Cell

Using Standard correlation available in handbooks the commercial available module with the calculated maximum performance is represented in Table 5.

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		

Model number for TER

Thermoelectric Cooler's Specification Include:
PELTIER EFFECT

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

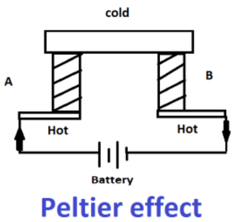
$$Q_p = \pi_{ab}$$

Where,

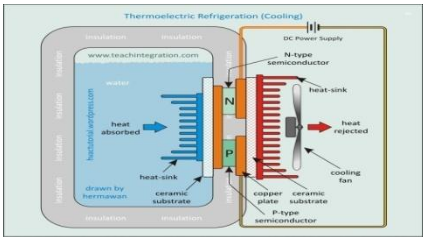
Q_p=heat evolved or absorbed in unit time, (watts)

Π_{ab}=Peltier coefficient.

I=direct current in amperes.



peltier effect



Thermoelectric cooling

COMMERCIALPELTIER DEVICES

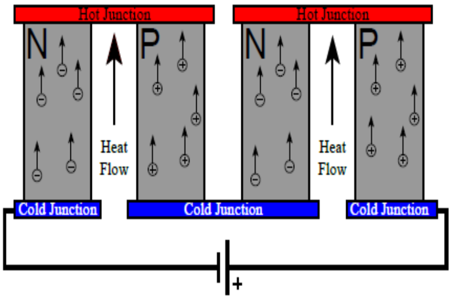
A single Peltier element can be used to produce electrical power (via the Seebeck effect) or to pump heat (via the Peltier effect). In either application the power output of a single Peltier element is generally not sufficient for elastic situations. To increase their power, commercial Peltier devices are composed of many n-type and p-type semiconductor Peltier elements. The individual elements are connected in series using metallic junctions. Because of this, the junctions between the semiconductors do not form a potential barrier, as they would do in a p-n diode and charge carriers move freely in both directions. In a Peltier device, the individual elements are arranged so that the n- and p-type heat move in the same direction.

Complete Peltier device architecture. It consists of two electrically insulating ceramic plates sandwiching a series of p-n 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

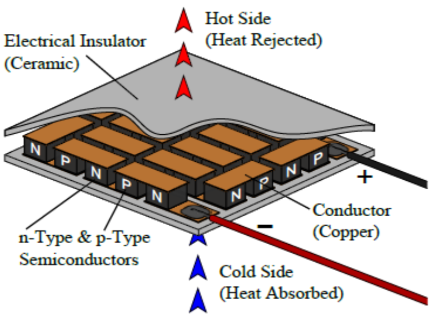
Though primarily used as heat pumps, Peltier devices nonetheless generate a thermovoltage (V_{th}) when subjected to a temperature gradient(ΔT). An electrical current(I) will ow if the Peltier device is connected to a load resistor(R_{load}). In this case, the Peltier device converts heat energy to electricalenergy quantified by the dissipated power, $P = IV_{load}$, where Vload is the voltage drop across the load resistor.In the laboratory, P can be determined by measuring I and V_{load}.

The Peltier device is not an ideal voltage source therefore its internal resistance(RI) must be included in the analyses of power data. Further more, RI istypically on the order of a few tens of Ohms. Therefore, the resistance of the ammeter (Ra) cannot be ignored.



Electrical power production

A series of alternating n- and p-type semiconductor elements, whichpump heat from bottom to top when a voltage is applied.

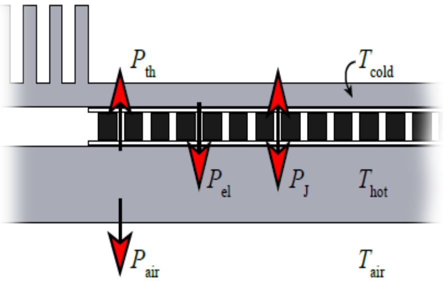


Heating in Peltier module

The design of a commercial Peltier device. Sandwiched between two ceramic insulators, alternating n- and p-type 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 Pelt = 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 electricalpower dissipated in the Peltier device (i.e., the Joule heat) is P_j= RI2,where R is the resistance of the Peltier device. $P_j$flows into both sides of the Peltier device. Finally, heat Pair flows from the hot side to the surrounding environment.



Thermal conductance

Heat ows in the Peltier device. Current(I) owing through the Peltier device pumps heat P_{el} = ΔI and generates the temperature gradient, $\Delta T = T_{\text{hot}} - T_{\text{cold}}$. In the opposite direction as P_{el}, heat u_x P_{th} conducts through the Peltier device from hot to cold. Joule heat, P_j, ows into bothsides of the Peltier device. Heat Pair conducts from the heat block to the surrounding air at temperature pair.Several simplifications and approximations can be made to reducethe complexity of these heat flows during measurements. The first simplification is to perform the experiments in the open-circuit regime where I = 0.Therefore P_{el} = P_i = 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 P_{th}affects the heat content of the hot block because T_{cold} is constant. The heat stored in the heat block is Q_{hot} = mcT_{hot}, where m = 0.22 kg is the mass of the heat block, and c = 897 J/ (kg K) is the heatCapacity of aluminum.
The rate equation for the heat ow is

$$P_{th} = \Delta Q_{hot} = mc\, \Delta T_{hot} = \square \Delta T_{hot}$$

Starting from a temperature T_{hot} (t = t_0) = T_0, the hot block cools
According to

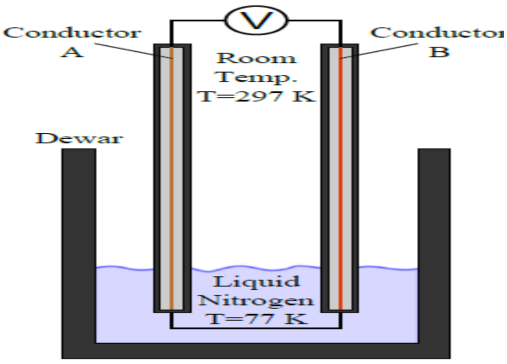
$$\dot{T}_{\text{hot}}(t) = \frac{\kappa}{mc}\left(T_0 - T_{\text{hot}}(t)\right)$$

LABOURATORY PROCEDURE

MEASUREMENTS WITH THETHERMOCOUPLE

Three metallic conductors are supplied in the lab: 1) phosphor-bronze, 2) copper and3) 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, a 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 2.7 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 thermovoltages 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.

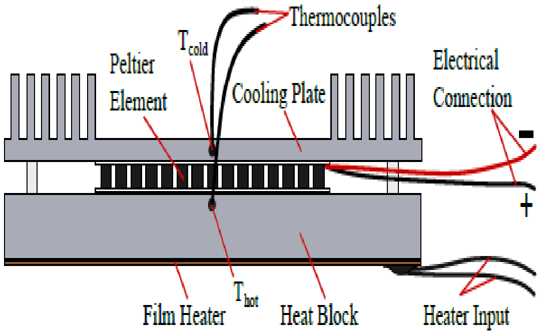


Thermocouple measurement

The two conductors, A and B, are enclosed inside two stainlesssteel tubes. They are connected together at one end and submerged in LN2Dewar 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" reservoirs an aluminum block covered with thermal insulation. The \cold" reservoirs 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.



Peltier effect measurement

A schematic of the Peltier laboratory setup. The Peltier deviceis 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 dualchannel thermometer probes (thermocouples) are inserted into two holes for measuring the temperature deference $\Delta T = T_{\text{hot}} - T_{\text{cold}}$. The electricalconnections of the Peltier device are used to apply and measure voltage and current.

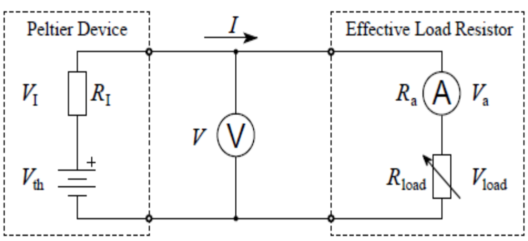
WARM UP PROCEDURE

Before you start, get everything ready to record time-dependent 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 measure ΔT with the two thermocouples embedded in the Al masses. Digital multimeters are available to measure electrical properties. The thermometer and the multimeters have a hold feature for pausing the measurements. This canhelp 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.

CONSTANTTEMPERATURE MEASUREMENTS

1. While waiting for the temperatures to stabilize measure all the resistor values (Rload) in the circuit box and measure the resistance of the ammeter (Ra).
2. Make sure the volt-meter 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 $R_{load} = 0$ i.e., only use R_a.
6. Measure $V = V_{th}$ at $I = 0$ i.e. V when $R_{load} = 1$.
7. Measure ΔT again to see if there was a temperature drift.



Peltier device with effective load resistor

The circuit diagram for a Peltier device when connected to anelectrical load. In addition to the internal resistance of the Peltier device (RI) the setup includes a variable load resistance, Rload, and the resistance of the ammeter (R_a). The temperature gradient generates the internal thermo-voltage, Vth. Voltages VI, Va, and V_{load} are created across resistances, RI, Ra 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 electiveload resistance($R_a + R_{load}$).

COOL-DOWN PROCEDURE

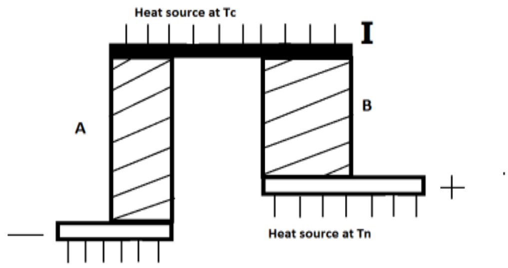
While the system cools down you will measure the thermal conductance.

1. Return the system to the open-circuit condition 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 battery and start recording T_{cold}, T_{hot}, and V_{th} as the system cools down. This can take more than 30 min.

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 i.e. analyze your raw data and present it in an informative way. State and justify your assumptions. In addition to that address following points(which will help you to analyze your data).

PELTIER DEVICE ANALYSIS



Peltier device analysis

1. Heat absorption and heat rejection occur only at the junctions.
2. Thermal conductivity and electrical resistance are constant 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.

α_{ab}=Relative seebeck coefficient for material A and B

Heat source at T_c

I= current in amps

R=Total electricresistance 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=temperatureof $_{hot}$ 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

1. 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% preferable 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).

2.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.

EXPERIMENTAL SETUP

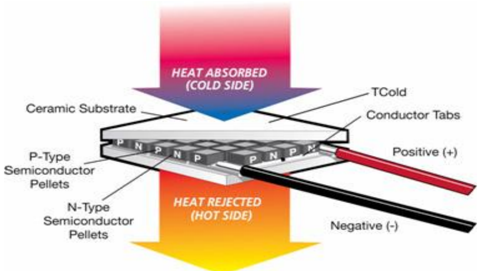
COMPONENTS OF REFRIGERATOR SHOES

1. Peltier Cells
2. Design of copper Box
3. Batteries
4. Radiators
5. Blowers
6. Thermometer
7. Heat Sink

PELTIER CELLS

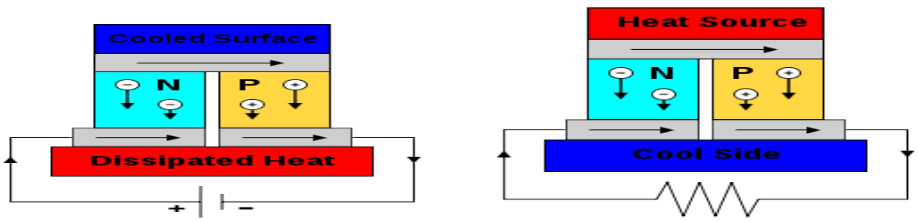
Thermoelectric Refrigeration jacket is entirely depending on Peltier cell. So,the refrigeration jacket process we attain more efficient to arrange twoPeltier in our project. The First Peltier required 238 Watts and 15 Amps, secondPeltier requires 138 Watts and 9 Amps.The Peltierexhibit semiconductor properties as follows for clear identification.

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 thermoemf (Peltier) is dependent on the number of charge carriers. The smaller the number of carriers the large is Peltier voltage. In semi-conductors, 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 semi-conductor is about 200μ-volts/°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.



Peltier Cell

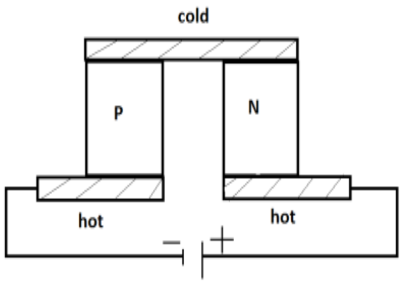
Semi-conductor materials generally exhibit very large thermo-electric emf.As compared to the metals, both N-type and P-type semi-conductors can be used. N type semi-conductor is one where current carriers are mostly electrons. If such a semi-conductor is sandwiched between two metal strip and connected to D.C. voltage source as shown in fig the junction where the current enters becomes hotter and another junction gets cooled.



Peltier working

Current conduction can also take place due to the flow of positive charges (holes) as in P-type semi-conductor as shown in fig.In this case, the effect is opposite to that observed in N-type semi-conductor.

Coupling N-type and P-type semi-conductors 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 the hot end be dissipated continuously.



Peltier line diagram

DESIGN OF COPPER BOX

Aluminum is also a popular metal used in sheet metal due to its flexibility, wide range of options, cost effectiveness and other properties. The four most common coppergrades available as sheet metal are 1100-H14, and 6061-c6

Grade 1100-H14 is commercially pure copper, highly chemical and weather resistant. It is ductile enough for deep drawing and weld able, but has low strength. It is commonly used in chemical processing equipment, light reflectors, and jewelry.

Grade 3023-C14 is stronger than 1100, while maintaining the same formability and low cost. It is corrosion resistant and weld able. It is often used in stampings, spun and drawnparts, mail boxes, cabinets, tanks, and fan blades.

Grade 5052-H32 is much stronger than 3003 while still maintaining good formability. It maintains high corrosion resistance and weld ability. Common applications include electronic chassis, tanks and pressure vessels.

Grade 6061-T6 is a common heat-treated structural copper alloy. It is weld able, corrosion resistant, and stronger than 5052, but not as formable. It loses some of its strength when welded. It is used in modern aircraft structures.

The Inner box is made and prepared with a dimension of (13HX14.50W X13.50L). The inner box surroundings are fill up and seal with foaming chemical and thermocoal sheet.

Copper Box

In this project, lead acid rechargeable battery and lithium ion battery can be used. According to our availability lead acid battery is used because it is very suitable to the capacity of Peltier modular. Battery capacity is 6 volts 4.5 amps.

RADIATORS

Radiators are heat exchangers used to transfer thermal energy from one medium to another for the purpose of Cooling and heating. The majority of radiators are constructed to function in automobiles, buildings, and electronics. The radiator is always a source of heat to its environment, although this may be for either the purpose of heating this environment, or for cooling the fluid or coolant supplied to it, as for engine.

Radiator

BLOWERS

1. Heat Rejection
2. Cool Distribution

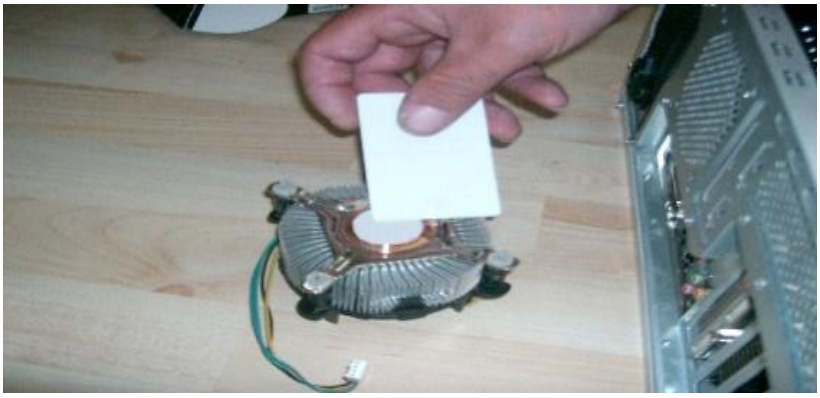
In heat rejection process the blowers are arranging and fixed with the radiators in outer side the phenomenon of Peltier effect of one side heat is rejected into the atmosphere this rejection occurred in outside of refrigeration.

In cool distribution process the blowers are also arranged and fixed with radiators in the inner side the Peltier cooling of one side of cooling is distributed inner side in this process.

Fig Blower

HEATSINK

Thermal grease (also called thermal gel, thermal compound, thermal paste, heat paste, heat sink paste, thermal interface material, or heat sink compound) is a viscous fluid substance, originally with properties akin to grease, which increases the thermal conductivity of a thermal interface by filling microscopic air-gaps present due to the imperfectly flat and smooth surfaces of the components; the compound has far greater thermal conductivity than air (but far less than metal). In electronics, it is often used to aid a component's thermal dissipation via a heat sink.



Heat sink

COPPER TUBES

Copper tubingis most often used for supply of hot and cold tap water, and as refrigerant line in HVAC systems. There are two basic types of copper tubing, soft copper and rigid copper. Copper tubing is joined using flare connection, compression connection, or solder. Copper offers a high level of corrosive resistive, but is becoming very costly.

REFRIFERATION SHOE COMPONENTS ASSEMBLY

STEP 1:
Fixing of copper tubes inside of the shoe by switching with the thread tightly and then fix the plastic pipes with the gum to the copper tube edges

STEP 2:
Fix the copper box to the shoe by using aluminum plates. Manufactured copper box consists of two Peltier's which is connected in series and water to extract heat. It also acts as a reservoir..

Step 3
Fixing of heat sink to the shoe at backside. Heat sink is used to extract more heat to the atmosphere

Step 4
Now separate all the positive terminal wire and negative terminal wire from the al the components. Merge all the positive terminal wires and negative terminal wires separately. Afterwards connect switch to the wires then our project is ready for operating.

EXPERIMENTATION
A pair of P-Type and N-Type semiconductor thermoelement forming thermocouples which are connected electrically in series and thermally in parallel is known as thermoelectric module.

In N-Type semiconductor extra valence electrons are added. These electrons are repelled by the negative pole of the power supply and attracted by positive pole. Heat flow is takes place in direction of electron flow. In P-type semiconductors which are missing the fourth valence electron, creates "Broken Bonds" (Holes) that are free to move. These "holes" are repelled by positive pole of power supply. Heat flow takes places in direction of hole flow.

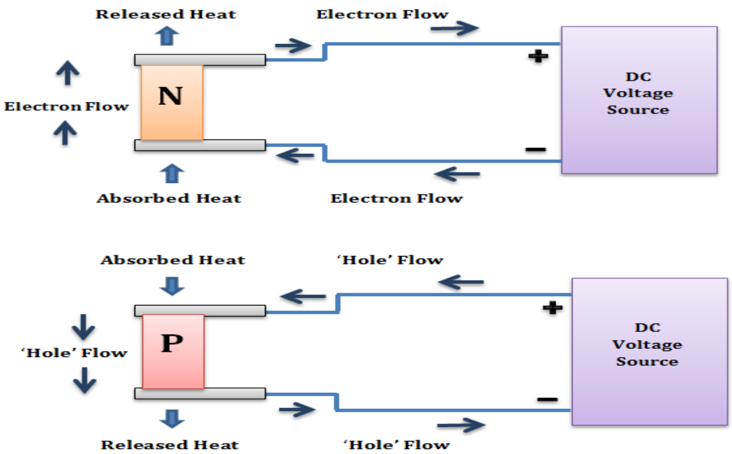


Fig Heat Flow in Thermoelectric Module

The amount of heat flow in above case is less, to increase heat flow arrange P and N Type pellet in couple and form a junction between them with copper tab. Free end of N and P Type pellets connects to the positive voltage potential and negative side of voltage respectively. Electrons are continuously flow from negative pole of supply to positive pole of voltage supply, through N and P type semiconductors

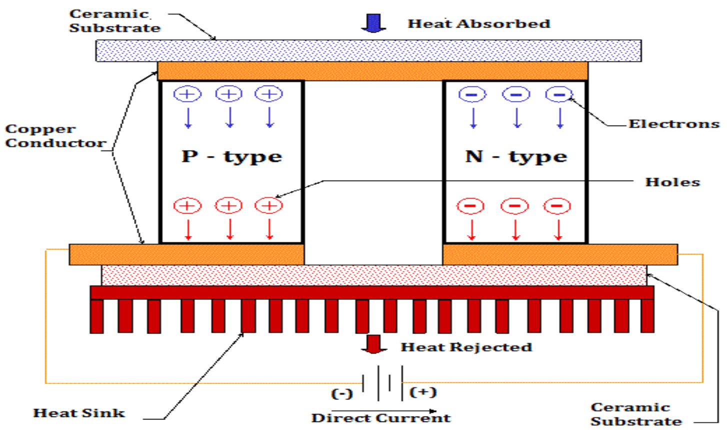
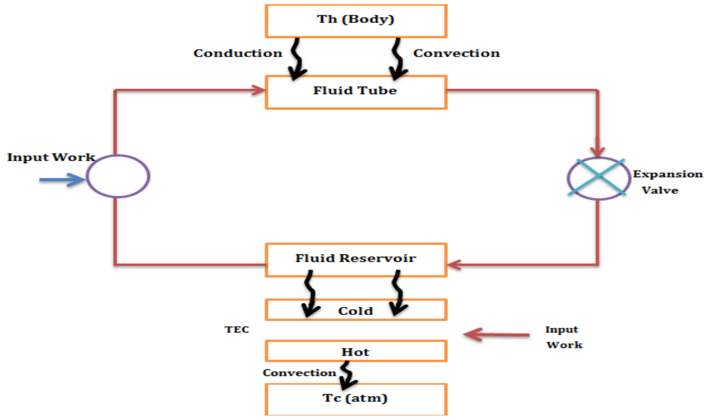


Fig Thermoelectric module principle

In above series circuit configuration keeps all the heat moving in the same direction through the pellets. When a positive DC voltage is applied to as shown in figure.6 electrons flow from the P-Type to the N-Type semiconductor. The temperature of cold side decreases as electron absorbs heat, untilled equilibrium reached.

The purpose of this Jacket is to provide cooling mechanism. The thermoelectric cooler is used to chill water in reservoir. Figure shows liquid jacket design. In Refrigerated jacket, line tube absorbs heat from human body. The liquid in lined tube is passed through expansion valve, where temperature and pressure of liquid reduces. This liquid is then transfer to fluid reservoir. Thermoelectric cooler is used to absorb heat from liquid stored in reservoir and transfer to atmosphere, due to which temperature of liquid stored in reservoir decreases and vice versa. This liquid is pumped and transfer through jacket line tube. This cycle is repeated.



Flow chart of jacket

Shoe Interface and a cooling module are main parts of the liquid cooling Jacket. Jacket Interface is consisting of conductive fabric Jacket tubing and an insulating fabric. Water in Jacket line tube is cooled by cooling module using thermoelectric cooler, which absorb heat from liquid and transfer to atmosphere and vice versa.

Shoe Interface

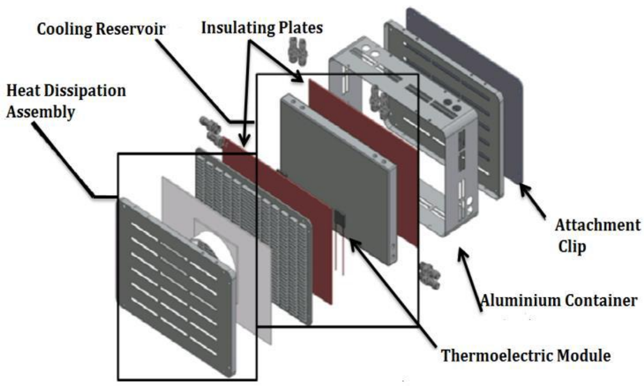
The main function of Jacket interface is to provide the high thermal efficiency and comfort to user. Shoe Interface is consisting of internal layer, tubing and external layer.

Internal layer is first subcomponent of jacket interface which must keep tight and comfortable to fit the user. The tubing was sewn on internal layer. The second sub component of vest interface is tubing, which is thermally conductive to circulate cool water throughout cooling vest. The tubing invests extracts heat from body and transferred to fluid moving through it. External layer is final subcomponent of vest interface use to provide insulation to device. External layer is use to increase thermal efficiency.

Cooling and heating Module:

The heat dissipation assembly and the cooling reservoir are the main sub components of

cooling module. Cooling module is used to cool the water store in reservoir. Cooling module is attached to thermal vest by an attachment clip.



Expanded View of Cooling Module

The cooling reservoir is used for extracting heat from the circulating water to and from the body jacket interface. The circulated water from jacket is circulated though reservoir acts as heat exchanger. To increase the efficiency of system thermoelectric module is surrounded with insulting material.

In heat dissipation assembly, atmospheric air and working fluid is used to dissipate heat from cooling reservoir to atmosphere. Atmospheric air is drawn by fan to cool heat exchanger and water is circulated through heat dissipation assembly to cool heat exchanger. If reverse polarity is given to the dc battery heating of the jacket happens and process is same as the cooling effect.

PELTIER EFFICIENCY

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.

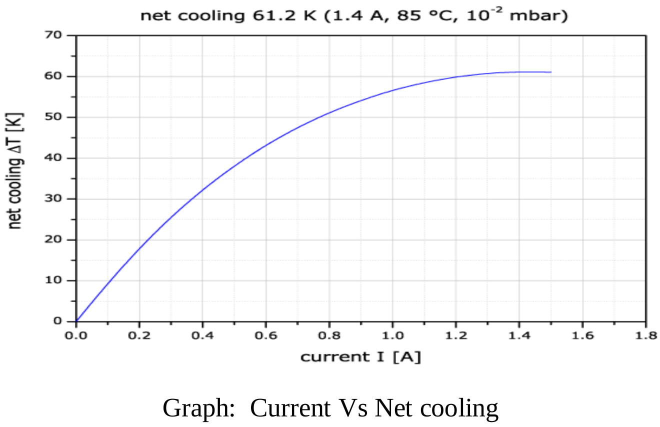
OPERATING TEMPERATURE RANGE

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 (IPEX)

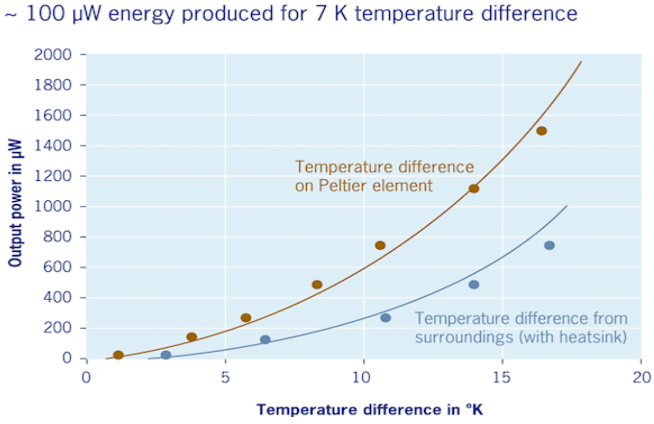
The reachable ingress protection depends on the fans. They are exposed to the environment. Fans are available with ingress protection IP67. The thermoelectric modules can be sealed. The cooling units can be developed in such a way that no water or humidity enter the cooling unit. Standard cooling units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

RELIABILITY

Thermoelectric cooling units are considered, construction based, as very reliable. With in appropriate 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 everycase. 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 Failure) 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: Current Vs Net cooling



Graph: Temperature difference Vs Output power

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. Despite 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 several 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.

Figure: PELTIER SHOES

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 equipment’s.

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 thermoelectric refrigeration is the independence of C.O.P on the size of thermoelectric 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 thermoelectric 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.

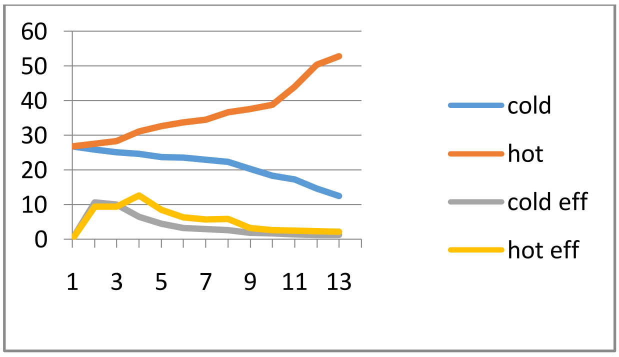
RESULTS AND DISCUSSIONS

RESULTS

A prototype of Refrigerator shoes fitted with two number of Peltier modules(TEC 1-12706) is fabricated to study the cooling effect and heating effect. The prototype is tested for its cooling performance and heating performance at different surrounding temperatures. The experimental results in the form of cold side and hot side temperatures are presented at different time intervals. The experiment results are shown in the table below provided. The time for obtaining human comfort temperature varies for mentioned two different temperatures.

RESULT TABLE FOR TEMPERATURE OF COLD SIDE AND HOT SIDE OF COOLING SHOES

Table 8.1 Result table at temperature 29.7^{0}c



Graph Graph between time, temperature and efficiency at 29.7^{0}c

DISCUSSION

The number of trials is taken to provide proper cooling to the person who wears the cooling shoes. The testing is conducted and the tabulated results shows that the cooling Shoes can deliver a cooling and heating air temperature of 19.7^0 c and 41.6^{0}c in static condition these results are obtained in the period of 10 minutes at surrounding temperature 29.7^{0}c. The experimental results shown in above tables clearly indicate that providing Peltiers in the shoes provides the comfort conditions for the motorcyclist. The Peltier efficiency were also calculated for both cooling and heating performance.

CONCLUSION

Thermoelectric (Peltier) cooling cum heating shoes is an innovative idea to keep the human body in a comfort conditions at different climatic zones. shoes totally works on the principal of Peltier effect. When it is tested in an atmospheric temperature of 30.2^{0}c gives a comfortable temperature of 20^{0}c within 10 minutes which makes the human body to feel comfort at high temperature conditions.

At the same time when in a cold climate by just reversing the connections a high temperature is attained inside the shoes which makes the human feel warm. So, Shoes is very helpful at different climate conditions.

shoes is mostly applicable for the soldiers, patients who have to maintain their body temperature in a comfort region. It is also helpful for the labors who are working in the hot conditions like thermal power plants, constructions, coal mines etc.

REFERENCES

[1]**Ajay kotwal., "Thermoelectric cooler use in cooling vest"**(volume:3, Issue:5) 2015.

[2] **Taylor, R.A., Solbrekken, G., comprehensive system-level optimization of thermoelectric devices for electronic cooling applications, Components and Packaging technologies**, IEEE Transactions on (volume:31, Issue:1).

[3**]https://en.wikipedia.org/wiki/Thermoelectric**cooling basics.

[4**]Dr. Paul Park,** "water cooling vest".

[5]**Godfrey S., "An Introducing to Thermoelectric Cooler**" Electronic Cooling, vol.2, No3.

[6]**Rowe D.M., 1995, CRC** handbook of Thermoelectric.

[7]**Huang B.J. and Duang C.L., 2000,** "A design method of thermoelectric cooler" International Journal of Refrigeration.

[8] Andrew B. Kustas, Austin L. Jurgensmeyer, Desiree D. Williams, Brian D. Dickman, Thomas H. Bradley, John D. Williams. **"High Efficiency Thermoelectric Cooler for use in Firefighter Applications".**

[9]Yuecheng Chi, Yee Chon Chin, Daniel Demoski, Ronald Kroll, Andrew Chin Hock Low. "**Water Cooling Vest" 2008**.