# Helmet Cooling using Peltier Module

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**Abstract –** *Human life is so precious and valuable, that it should not be compromised under any cost. The concern over the safety of Motorcyclist drivers has pushed for the invention of this equipment that can save lives. According to Statistics from the Insurance Institute for Highway Safety (2010), it is mentioned that nearly 70% of mortality in road accidents occur due to head injury. It is not that people are very negligent about their lives on road, but that they experience dozens of discomforts by wearing helmets. The most common discomfort is that, heavy sweat occurs due to excessive heat formation.*

*This project deals with the development of cooling system for biker's helmet using thermoelectric technology using peltier module. The system consists mainly of a heat sink, aluminum passageway and Peltier coil. The prototype is fabricated and mounted onto biker's head. Experiments are conducted on the prototype to analyze the performance of the cooling system during different intervals of time.*

***Key Words***: Helmet, Thermo-electric Refrigeration, Heat Sink, Battery, Peltier module.

## 1. INTRODUCTION

Motorcycle helmets are generally believed to greatly reduce injuries and fatalities in motorcycle accidents. Thus, many countries have laws requiring acceptable helmets to be worn by motorcycle riders. Safety is a primary feature of a motorcycle helmet. Modern helmets are fabricated from plastics, often reinforced with Kevlar and carbon fiber. The helmet has two principal protective components: a thin, outer shell made of acrylonitrile butadiene styrene (ABS) plastic, fiber glass or Kevlar and a soft, thick, inner liner about one-inch thickness usually made of expanded polystyrene foam or expanded polypropylene foam. The foam liner is very similar to that used in refrigerators as thermal insulation. The hard outer shell prevents puncture of the helmet by sharp pointed object and provides the framework to hold the inner liner. The inner foam liner is to absorb the crush during an impact. The one-inch thickness of insulation liner lining the interior of the helmet restricts and virtually eliminates the heat exchange with the outside wall of the most efficient part of the body. This creates an uncomfortable and dangerous hot environment to the head of the wearer. The interior of the helmet can quickly rise to the temperature between 37 ⍰ and 38 ⍰. When this occurs, the physiological and psychological effects on the rider are very real and potentially dangerous due to a deadening of the senses and a decrease in ability to concentrate. It is observed that head cooling is the most efficient of any other part of the body because it has the highest skin temperature as well as large constant-volume blood flow. Head cooling has been perceived as an essential necessity to provide overall thermal comfort to the rider.

Thermoelectric refrigeration is achieved when a direct current is passed through one or more pairs of n- and p-type semiconductor materials. Fig. 1 is a diagram of a single pair consisting of n- and p-type semiconductor materials. In the cooling mode, direct current passes from the n- to p-type semiconductor material. The temperature Tc of the inter connecting conductor decreases and heat is absorbed from the environment. This heat absorption from the environment (cooling) occurs when electrons pass from a low energy level in the p-type material through the interconnecting conductor to a higher energy level in the n-type material. The absorbed heat is transferred through the semiconductor materials by electron transport to the other end of the junction $T_H$ and liberated as the electrons return to a lower energy level in the p-type material. This phenomenon is called the Peltier effect.

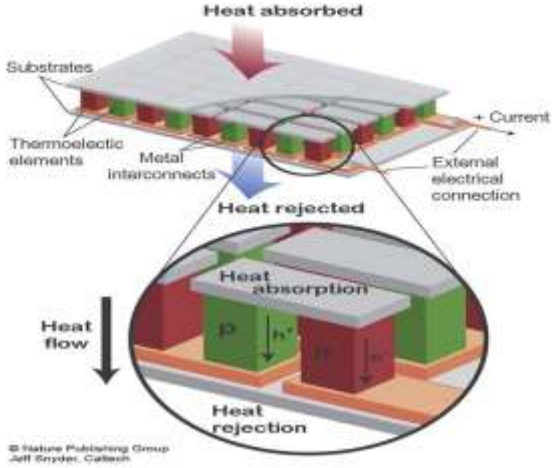

**Fig. 1** Conventional arrangement for thermoelectric cooler

### 1.1 Material requirement

- **Helmet:**

Helmet weight 950gm.

Helmet material polycarbonate plastic

- **Peltier module**:

Thermoelectric cooling module, which is a semiconductor based electronic component that functions like a small heat sink

- **Heat sink:**

Material – aluminum

Dimensions – 6cm / 8cm / 1.5cm

- **Thermal paste:**

Thermal paste type – zinc oxide

Electrical fan:

Dimensions – 6cm / 8cm / 4cm

- **Batteries:**

Two 6V - 5AMPS rechargeable batteries

**Table1:** Material requirement

| S.NO | Component | Number of units | Cost per unit | Total cost |
|---|---|---|---|---|
| 1. | Helmet | 1 | 1050/- | 1050/- |
| 2. | Peltier | 1 | 300/- | 300/- |
| 3. | Heat sink | 1 | 250/- | 250/- |
| 4. | Thermal paste | 1 | 250/- | 250/- |
| 5. | Electric fan | 1 | 150/- | 150/- |
| 6. | Batteries | 2 | 350/- | 700/- |

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## 1.2 Experimental Setup

The experimental setup consisting of main components are

I. Thermoelectric module

II. Heat sink

III. 12 volts DC battery

IV. Cooling Chamber

V. Electric fan as air pump

### I. Thermoelectric module:

Specifications of Thermo Electric Module:

A thermoelectric cooling (TEC) module is a semiconductor-based electronic component that functions as a small heat pump. When DC power is applied to a TEC, heat gets transferred from one side of the module to the other.

There are 127 couples in single module; 40mm x 40mm x 3.8mm size.

Current passing across the junction of the semiconductors causing a temperature difference. The side with the cooling plate absorbs heat which is then moved to the other side of the device where the heat sink is. TECs (Thermoelectric cooler) are typically connected side by side and sandwiched between two ceramic plates. The cooling ability of the total unit is then proportional to the number of Thermoelectric cooler in it. When two conductors are placed in electric contact, electrons flow out of the one in which the electrons are less bound, into the one where the electrons are more bound. The reason for this is a difference in the so-called Fermi level. Between the two conductors Fermi level represents the demarcation in energy within the conduction band of a metal, between the energy levels occupied by electrons and those that are unoccupied.

When two conductors with different Fermi levels make contact, electrons flow from the conductor with the higher level, until the change in electrostatic potential brings the two Fermi levels to the same value. (This electrostatic potential is called the contact potential.). Current passing across the junction results in either a forward or reverse bias, resulting in a temperature gradient. If the temperature of the hotter junction (heat sink) is kept low by removing the generated heat, the temperature of the cold plate can be cooled by tens of degrees.

**Fig.2** Peltier modules

### II. Heat Sink:

The rectangular fin type heat sink is most suitable to be used on the prototype helmet. The effective operation of the cooling system would depend on the ability of the external sink to remove heat energy.

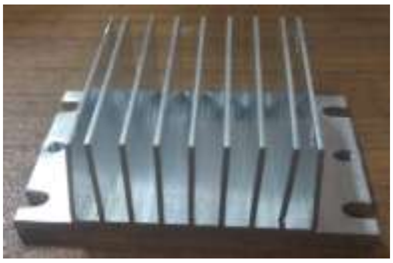

**Fig3.** Heat sink

**III. Batteries:**

Specifications of Batteries:

- 12 volts DC rechargeable batteries
- 5 amps battery capacity

In order to cope with the relatively high power needed by the components in the helmets, two 12V lithium polymer rechargeable batteries are used. The entire power source is supplied through these batteries individually for three Peltier's. The individual battery gives 5 hours of charging and these batteries are rechargeable.

**Fig 4.**Battery

**IV. Cooling chamber**

The chamber is built with a built-in internal fan thermoelectric cooler for cooling purpose. It acts as medium of heat transfer where outside air will be cooled and then directly transferred into the helmet. The chamber is built to provide enough space for air to be cooled and pumped-in using small electric fan. The fan will be installed on the open space of the chamber thus extracted cooled air from the chamber, right into the helmet

**Fig 5.** Helmet

**V. Electric fan as an air pump**

The use of the fan is very important in this design. The fan works as the pump for transferring cooled air from the cooling chamber into the helmet.

**Fig 6.** Electrical fan

## 2. OVERVIEW OF NEWLY DESIGNED HELMET

**Fig 7.** Peltier module inside the helmet

**Fig 8.** Top view of helmet with battery connection

**Fig 9.** Side view of helmet with heat sink and electrical fan

**Fig 10.** Front view of the helmet

## 3. RESULTS

After all the testing is conducted, the tabulated result shows that the helmet is able to deliver a cooling air temperature of 28▯ in static condition. This result is obtained by running the helmet for 5 minutes period of time at different velocities of air flow over the heat sink (supposedly get during traveling). The results from field testing of the helmet show great improvements if the helmet is worn during travel. Additional mass flow rate of air from moving air is able to increase the performance of the helmet considerably. The experiment is conducted at 15, 20 and 40kmph and it is get to know that the minimum speed of the vehicle should be maintained in order to get a considerable cooling effect is more than 20kmph.

### Test No: 1

**Table2.** Readings of Peltier module Without Heat sink in ideal condition

| S.NO | Time (min) | Ambient temperature in (˚C) | Peltier temperature in (˚C) | |
|---|---|---|---|---|
| | | | Cold side temperature | Hot side temperature |
| 1. | 5 | 39 | 36 | 42 |
| 2. | 20 | 39 | 31 | 47 |
| 3. | 15 | 39 | 26 | 54 |

### Test No: 2

**Table3.** Readings with Heat sink (velocity of air flow over the sink is 15Kmph)

| S.NO | Time (min) | Ambient temperature in (˚C) | Peltier temperature in (˚C) | |
|---|---|---|---|---|
| | | | Cold side temperature | Hot side temperature |
| 1. | 1:30pm | 37 | 37 | 37 |
| 2. | 1:35pm | 37 | 30.9 | 37.5 |
| 3. | 1:40pm | 37 | 31.6 | 37.2 |
| 4. | 1:45pm | 37 | 31.7 | 37.1 |
| 5. | 1:50pm | 37 | 31.9 | 37.1 |
| 6. | 1:55pm | 37 | 31.8 | 37.2 |

### Test No:3

**Table4:** Readings with Heat sink (velocity of air flow over the sink is 20Kmph)

| S.NO | Time (min) | Ambient temperature in (˚C) | Peltier temperature in (˚C) | |
|---|---|---|---|---|
| | | | Cold side temperature | Hot side temperature |
| 1. | 2:00pm | 37 | 37 | 37 |
| 2. | 2:05pm | 37 | 29.5 | 41 |
| 3. | 2:10pm | 37 | 26.8 | 38.2 |
| 4. | 2:15pm | 37 | 26.4 | 37.8 |
| 5. | 2:20pm | 37 | 26.02 | 38.1 |
| 6. | 2:25pm | 37 | 26.02 | 37.5 |

### Test No 4.

**Table 5:** Readings with Heat sink (velocity of air flow over the sink is 40Kmph)

| S.NO | Time (min) | Ambient temperature in (˚C) | Peltier temperature in (˚C) | |
|---|---|---|---|---|
| | | | Cold side temperature | Hot side temperature |
| 1. | 2:10pm | 38 | 38 | 38 |
| 2. | 2:15pm | 38 | 29 | 42 |
| 3. | 2:20pm | 38 | 27.2 | 41.4 |
| 4. | 2:25pm | 38 | 25.3 | 44.4 |
| 5. | 2:30pm | 38 | 24.1 | 44.3 |
| 6. | 2:35pm | 38 | 23.2 | 44.6 |

### 3.1 Temperature VS Time Chart (Air Velocity 15Kmph):

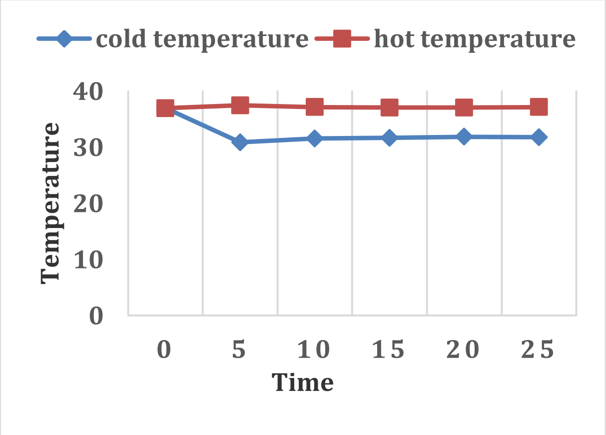

**Chart-1:** Temp vs Time graph when the velocity of air flow over the sink is 15Kmph

### 3.2 Temperature VS Time Chart: Air Velocity 20Kmph)

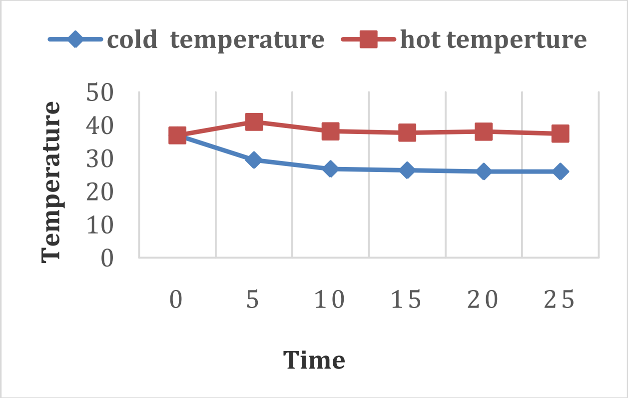

**Chart-2:** Temp vs Time graph when the velocity of air flow over the sink is 20 Kmph

### 3.3 Temperature VS Time Chart: Air Velocity 40kmph)

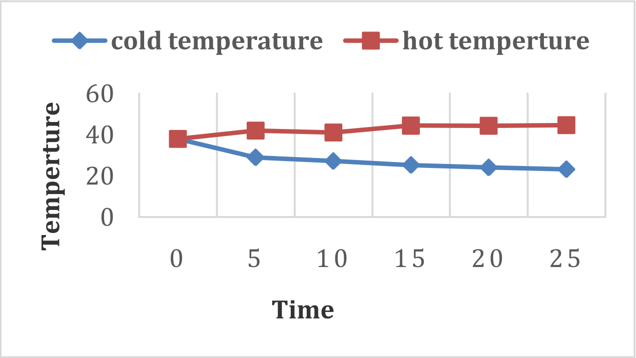

**Chart-3:** Temp vs Time graph when the velocity of air flow over the sink is 40 Kmph

## 4. CONCLUSION

The prototyping of a cooling system based on thermoelectricity for a motorcyclist helmet has been done at different conditions. The targeted cooling performance is achieved and future improvements will be carried out to enhance the better cooling performance of the design. This will include the use of a higher power thermoelectric module in the future design to improve its performance. However, a problem of higher demand from the power source needs to be successfully addressed first. Furthermore, a problem of noise created by the internal fan should be addressed thoroughly and installation of a low-noise fan should be prioritized. Using better heat sink i.e other than aluminum heat sink for better and efficient heat dissipation. Future improvements can also do by considering the aerodynamic effect on the helmet

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