P-N Junction Cooling Helmet using Peltier Effect

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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 the 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 accident occurred 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 helmet. 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. This system consists mainly of a heat sink, aluminium 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.

Keywords: Helmet, Thermo-electric Refrigeration, Heat Sink, Battery, Peltier module

I. INTRODUCTION

Motorcycle helmets are generally believed to greatly reduce injuries and facilities 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 fibre. The helmet has two principal protective components: a thin, outer shell made of acrylonitrile butadiene styrene (ABS) plastic, fibre 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 interior of the helmet can quickly rise to the temperature between 37°C and 38°C. 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 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 T_c of the interconnecting conductor decreases and heat is absorbed from the environment. This heat absorption from the environment (cooling) occurs when electrons passed 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 in transferred through the semiconductor material by electron transport to the other end of the junction TH and liberated as the electrons return to the lower energy level in the p-type material. This phenomenon is called the peltier effect.

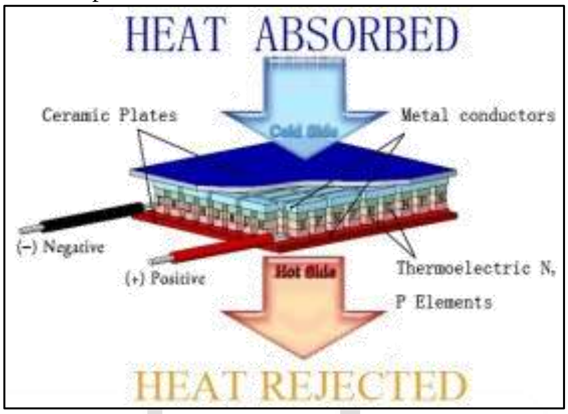

Fig. 1: Conventional arrangement for thermoelectric cooler

II. MATERIAL REQUIREMENT

A. Helmet:

- Helmet weight - 950 gm.
- Helmet material - polycarbonate plastic.

B. Peltier module:

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

C. Heat sink:

- Material - aluminium
- Dimensions - 6cm/8cm/1.5cm

D. Thermal paste:

- Thermal paste type - zinc oxide
- Electrical fan: Dimensions - 6cm/8cm/4cm

E. Batteries:

- Two 6V-5AMPS rechargeable batteries.

Sr No.	Component	No. 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/-

Table 1: Estimation of required Material

III. EXPERIMENTAL SETUP

It is consisting of main components are:
- Thermoelectric module
- Heat sink
- 12V DC battery
- Cooling chamber
- Electric fan as air pump

A. Thermoelectric module

Specifications of thermoelectric 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.

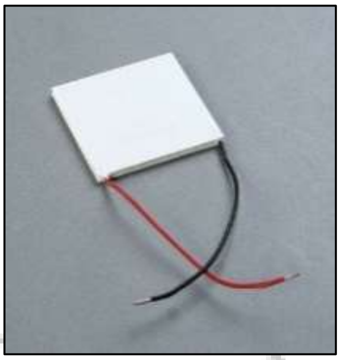

Fig. 2: Peltier module

B. 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.

Fig. 3: Heat sink

C. 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 battery individually for three peltier'. The individual battery gives 5 hours of charging and these batteries are rechargeable.

Fig. 4: Battery

D. Cooling chamber

The cooling chamber acts as a 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.

Fig. 5: Helmet

E. 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: Air pump

IV. OVERVIEW OF NEWLY DESIGNED HELMET

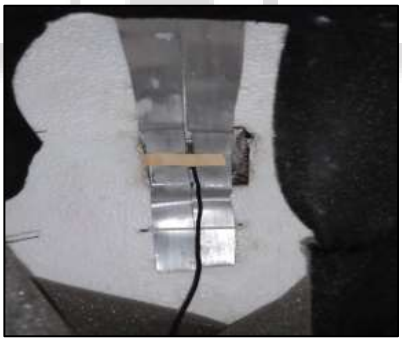

Fig. 7: Peltier module inside the helmet

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 helmet

V. RESULTS

After all the testing is conducted, the tabulated result shows that the helmet is able to deliver a cooling air temperature of 28°C 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.

A. *Test No.1*

Sr. No.	Time (min)	Ambient Temp. in (°C)	Peltier Temperature in (°C)	
			Cold-side Temp	Hot-side Temp
1	5	39	36	42
2	20	39	31	47
3	15	39	26	54

Table 2: Readings of peltier module without heat sink in ideal condition.

B. *Test No.2*

Sr. No.	Clock Time (min)	Ambient Temp. in (°C)	Peltier Temperature in (°C)	
			Cold-side Temp	Hot-side Temp
1	1:30 pm	37	37	37
2	1:35 pm	37	30.9	37.5
3	1:40 pm	37	31.6	37.2
4	1:45 pm	37	31.7	37.1
5	1:50 pm	37	31.9	37.1
6	1:55 pm	37	31.8	37.2

Table 3: Readings with heat sink (velocity of air flow over the sink is 15Kmph)

C. *Test No.3*

Sr. No.	Clock Time (min)	Ambient Temp. in (°C)	Peltier Temperature in (°C)	
			Cold-side Temp	Hot-side Temp
1	2:00 pm	37	37	37
2	2:05 pm	37	29.5	41
3	2:10 pm	37	26.8	38.2
4	2:15 pm	37	26.4	37.8
5	2:20 pm	37	26.02	38.1
6	2:25 pm	37	26.02	37.5

Table 4: Readings with heat sink (velocity of air flow over the sink is 20Kmph)

D. *Test No.4*

Sr. No.	Clock Time (min)	Ambient Temp. in (°C)	Peltier Temperature in (°C)	
			Cold-side Temp	Hot-side Temp
1	2:10 pm	38	38	38
2	2:15 pm	38	29	42
3	2:20 pm	38	27.2	41.4
4	2:25 pm	38	25.3	44.4
5	2:30 pm	38	24.1	44.3
6	2:35 pm	38	23.2	44.6

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

Following charts show the graphical comparison of the results obtained.

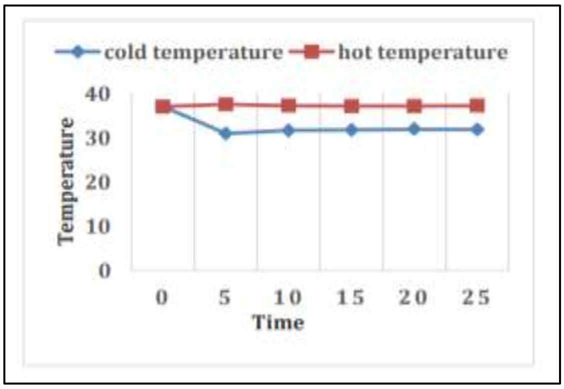

Fig. 11: Temperature Vs Time Chart (Air Velocity 15Kmph)

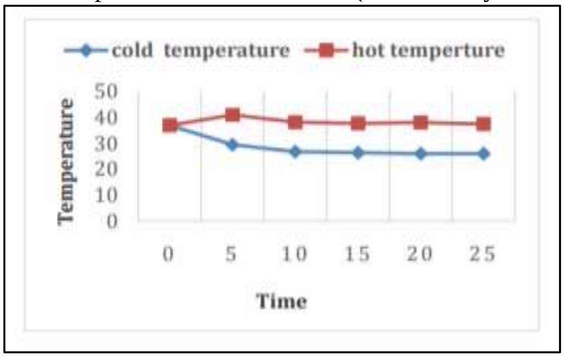

Fig. 12: Temperature Vs Time chart (Air velocity 20Kmph)

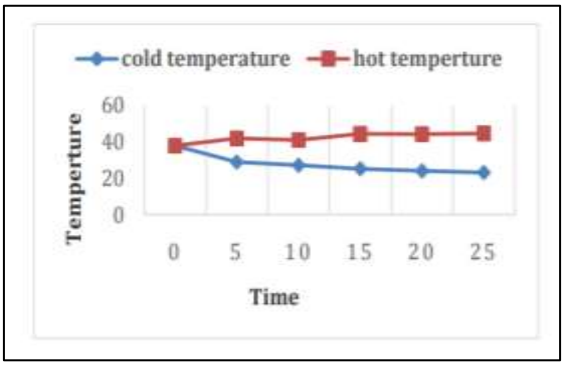

Fig. 13: Temperature Vs Time chart (Air velocity 40Kmph)

VI. 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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REFERENCES

[1] Carpenter, B., 1987. Heads, Helmets and Heat. Road Rider Magazine.
[2] Tan, F.L. and S.C. Fok, 2006. Cooling of helmet with phase change material. Journal of Applied Thermal Engineering, 26: 2067-2072.
[3] Buist, R.J. and G.D. Streitwieser, 1988. The Thermoelectrically cooled helmet. Proceedings of the 17th International Thermoelectric Conference, Arlington, TX, USA, pp: 88-94.
[4] Johnson, D.A. and J. Bierschenk, 2005. Latest developments in thermoelectrically enhanced heat sinks. Electronics Cooling. http://www.electronicscooling.com. Retrieved March 8, 2009
[5] Airaksinen, M., Tuomaala, P., Holopainen, R., Modeling Human Thermal Comfort, Presented at CLIMA 2007 – Wellbeing Indoors, Helsinki, Finland, 2007.
[6] Hsu, Y. L., Tai, C. Y., Chen, T. C., Improving Thermal Properties of Industrial Safety Helmets, Journal of Industrial Ergonomics, 26 (1999), 1, pp. 109-117.
[7] Hachimi - Idrissi, S., et al., Mild Hypothermia Induced by a Helmet Device: a Clinical
[8] Clark, R. P., Toy, N., Forced Convection around the Human Head, Journal of Applied Physiology, 244 (1975), 2, pp. 295-302.
[9] Holland, E. J., et al., Helmet Design to Facilitate Thermo neutrality during Forest Harvesting, Ergonomics, 45 (2002), 10, pp. 699-716.
[10] Fresh Air System Technology: Airflow cooled helmet, http://www.fastraceproducts.com

