Experimental Study on Generation of Cooling Inside the Motorcyclist Helmet by Using Peltier Module

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Abstract-**Safety and comfort are the two major issues to be consider for two wheelers. For safety purpose bike rider must wear helmet. Most of the deaths happen in accidents due to head injuries. A head injury can mean brain injury so to avoid deaths during accidents it is advisable to wear helmets. Helmet is protective equipment for bike rider. The outer shell is made up of polycarbonate plastic ,fiber glass and soft inner layer is made of expanded polypropylene EPS foam.it is a shock absorber to support the head during collisions. Government is enforcing strict laws about safety and awareness on wearing helmet all over the country. These strict rules are not being followed by most of the people due to various reasons like discomfort and cost. Generally discomfort due to sweat formation inside the helmet is one of the major considerable reasons for not wearing helmet. Especially in high temperature regions like anantapur, where the vehicle riders are highly reluctant to wear the helmet for this reason. It is therefore proposed design and implements a cooling system to cool the inner area of the helmet so as to ensure comfort to the person who wears the helmet. The proposed cooling system shall be small and light in weight so that the mobility of the helmet is not restricted, further the weight of the helmet is within the limits. This proposed cooling system works on thermoelectric effect which is generally stated as the junction of two dissimilar metals the energy level of conducting electrons is forced to increase or decrease. A decrease in the energy level emits thermal energy, while an increase will absorb thermal energy from its surrounding. The cooling produced based on peltier effect is discovered in 1834. The basic design of thermoelectric helmet consists of various components like peltiermodule, cooling chamber and heat sink. The electric power will supplied by means of 12volts DC battery. The peltier module is a semiconductor based electric component that functions as a small heat pump. The above components will be arranged in order to produce the appropriate cooling effect inside the helmet. The numerical and experimental results showed a good agreement and indicated that the temperature inside the helmet was reduced with time. The prototype of cooling system based on thermoelectric system for a motorcyclist helmet has done. The targeted cooling performance is achieved and the temperature reduced from 350centigrade to 280centigrade within 10 mins. The cop obtained 2.35.In this project comparing the difference cooling produced inside the helmet in stable condition and by forced circulation of air.**

I. INTRODUCTION

Conventionally, Refrigeration is a process in which the heat is taken away from one location to another by external work. This work for heat transport is generally driven by means of mechanical work, and also driven by magnetism, laser and in different other ways. In today's engineering world there are a lot of applications of refrigeration, which not only limited to air conditioners, heat pumps, cryogenics, refrigerators and industrial freezers.

The basic principle i.e.,Peltier effect, upon which thermoelectric refrigeration is based, was known to the world since 1834. In Thermoelectric refrigeration transfer of heat from one location to another is carried out by electrons instead of refrigerants. In thermoelectric refrigeration the electrons carries heat from the location where cooling is required to the other location where heat sink is placed. This heat sink generally placed outside.

Electrons, rather than refrigerants, carry away the heat. Fins on the evaporator increase the heat flow. Air flow on the fins on hotter side will take away the generated heat. Semiconductors are made from elements such as germanium, silicon, or a combination of elements. Semiconductors may be processed in such a way that in N-type semiconductor the electricity is by flow of electrons and in P-type semiconductor the electricity flow is by holes which bears a positive charge. Thermostat inside the refrigerated space regulate the current flow through the rectifier. The transformer-rectifier supplies a controlled dc current to the modules. In this manner, the temperature inside the refrigerator is controlled. Moving parts are not there in thermoelectric refrigeration. Aside from the construction of the modules, it is very simple. Thermal efficiency is low. The amount of refrigerating effect we get for the electrical energy spent is not more than that we get with a conventional compressor-type refrigeration system. We can reverse the hot and cold surfaces by reversing the direction of the current into the thermoelectric module. Thus, for cooling and heating an insulated space same device can be used.

A thermoelectric refrigeration often used in nuclear submarines for their cooling and heating purpose. The thermoelectric refrigeration is also often used to control temperatures in electronic equipment (computers, aerospace devices, etc.).

One of the important piece for bike rider is helmet. There available many varieties of helmet designs in the market, the main consideration in designing the helmet is comfort of the rider to wear it. The helmet is made up of mainly two components, outer shell is with a thin and hard material called polycarbonate plastic and fiber glass, the inner part is made up of expanded polystyrene(EPS) foam. When accident occurs sudden collisions will happen then the polystyrene foam serves and the damper which absorbs the shock and this inner layer will crush first by increasing the distance of direct impact from the outer side object this reduces the unfortunate happenings. Indeed, the liner has high heat insulation properties which results in low heat transfer between inner and outside air of the helmet. This creates an uncomfortable and dangerous environment to the head, especially for long distance travel. Some of the previous studies estimated that the head temperature will increase to 380C during transit (Carpenter(1987), at this temperature it is very difficult to concentrate on the riding which is why the accidents are occurring. Therefore, while designing the helmet the comfort level of bike rider is main concern.

II. LITERATURE REVIEW

The In this chapter the literature survey pertaining to the various thermoelectric devices for the application of heating and cooling is presented.

Carpenter, B., 1987 Heads, Helmets and Heat. Road Rider Magazine.

Projected that temperature in the helmet during such conditions reaches 38°C. In this temperature, it is very hazardous to travel due to a reduction in the ability to concentrate. Therefore, keeping a bike rider cool during transit has been at the forefront of helmet design considerations.

Tan and fok, have taken a simplified approach to their design with a solution that requires no power supply for operation. What they needed is the PCM which is to be placed in the bag in between head and the inner boundary of the helmet. When the surface temperature of the rider's head is greater than the melting temperature of the PCM, the absorption of heat from the head causes the PCM to melt.

Hsu et al found that the temperature of white helmet can be 4 to 7 C lower than other colored helmets and the proper use of reflective materials on the surface can also result in lower interior temperature. Insulation in the form of inner lining is also a popular solution. However, insulation can also hinder the dissipation of the heat generated from the head to the ambient in cold weatherConditions.

Buist, R.J and G.D streitwieser, 1998 found that cooling motor cyclist helmet with thermoelectric module and experiments are conducted on the prototype to analyze the performance of the cooling system.

Clark and Toy found that the heat loss from the head is about 10 W for a skin temperature of 33 C and ambient temperature of 23 C. To dissipate the heat generated from the head, most helmets rely on forced convection generated by the relative motion between the motorcyclist and the air during the ride. The forced convection is created on the outer surface of helmet as well as on the head surface.

Holland et al,found that the exchange of air between the helmet microclimate and the ambient environment was fastest for helmets with top vents. However for safety reason, it is desirable for the motorcycle helmet to fully cover the top of the head. Hence, creating adequate ventilation at the top of the motorcycle helmet may not be feasible. The lack of ventilation at the top of the motorcycle helmet can greatly hinder the forced convectionProcess.

Tan et al, 1998 had proposed the conceptual design of a PCM--cooled helmet. Theoretically, the effective use of PCM has great potential for cooling a helmet.

However, to further develop the concept, it is necessary to identify the factors that would influence the PCM cooling in this application. It aims to identify experimentally the influences of the simulated solar radiation, wind speed, and heat generation rate on the PCM cooling process.

Clark, R.P., Toy, N,forced around human head and calculated the forces which acts while wearing the helmet. The experimental investigation taking place where analysis of the forces are calculated. Many previous research researchers made helmet cooling with the use of phase change material and by using solar panels, by using thermoelectric technology.The function of Phase change material is to store cold thermal energy in night as cold side and it is used to reduce temperature of thermoelectric module in day period. The phase change materials used to cool the inside of the helmet.

Thermo electric technology is fast replacing convection cooling system. A few works have been reported on the application of thermoelectric cooling system to a helmet. Motivated by the works quoted in the literature survey an effort is made to study the suitability of thermoelectric cooling in a helmet.

III. HELMETS

A helmet is a form of protective layer wear to protect the head from injuries. The first use of helmets was by Assyrian soldiers in 900BC,who wore thick leather or bronze helmets to protect the head from blunt object and sword strikes andblows in war. Soldiers even now wear helmets which are made up of low weight materials like plastic.

In civilian life, helmets are used for recreational activities and sports (e.g. jockeys inAmerican football, horse racing ,cricket,ice hockey, rock climbingandbaseball; dangerous work activities (e.g. construction ,mining, riot police);transport(e.g. motorcycle helmets and bicycle helmets). Since 1990s helmets are made from plasticorresinwhich are reinforced with fine glass fibers.

All helmets attempt to protect the users head by absorbing mechanical energy and protecting against penetration. Their protective capacity andstructure are altered in high energy impacts. Beside their energy –absorption capacity, their weight and volume increases the injury risk for the users head and neck. Anatomical helmets adapted at the end of the 20th century.

Helmets used for different purposes have different designs. For example motorcycle helmets and bicycle helmets must protect against blunt impact forces from wearers head striking the road .A helmet designed for rock climbing must protect against heavy impact, and against objects such as small rocks and climbing equipment falling from above .practical concern also dictate helmet design: a motorcyclist helmet should be aerodynamic in shape.

Road traffic injuries are a major public health problem and a leading cause of death and injury around the world. Each year nearly 1.2 million people die as a result of road crashes, and millions more are injured or disabled. In many low-income and middle-income countries, where motorcycles and bicycles are an increasingly com-mon means of transport, users of two-wheelers make up a large proportion of those injured or killed on the roads. Motorcycle and bicycle riders are at an increased risk of being involved in a crash. This is because they often share the traffic space with fast-moving cars, buses and trucks, and also because they are less visible. In addition, their lack of physical protection makes them particularly vulnerable to being injured if they are involved in a collision.

In most high-income countries, motorcycle fatalities typically comprise around 5% to 18% of overall traffic fatalities. This proportion reflects the combined effect of several important factors including the relatively low ownership and use of motor-cycles in many developed countries, and the relatively high risk of these motorcycles being involved in crashes involving fatalities. Typically, these risks are much higher for motorcycle than for vehicle travel.

In low-income and middle-income countries, car ownership and use rates is generally much lower than in high-income countries. However, the ownership and use of motorcycles and other two-wheelers is generally relatively high – for example, in India 69% of the total number of motor vehicles are motorized two-wheelers, considerably higher than in high-income countries. Reflecting this difference, the levels of motorcycle rider fatalities as a proportion of those injured on the roads are typically higher in low-income and middle -income countries than in high-income countries.

The technical expertise behind the design of high quality helmets is based on an understanding of what happens to the head in the event of a motorcycle crash. This section describes what happens in the event of a motorcycle crash, and then explains how a helmet works to reduce this effect.

IV. EXPERIMENTAL SETUP

Human life is so precious and valuable, that it should not be compromised under any cost. The concern over the safety of vehicle drivers has pushed for invention of new 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, where the rider has not worn a helmet. It is not that people are very negligible 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. The experimental setup completely eliminates the problem of sweat formation and create comfort human condition inside the helmet. The experimental setup consisting of main components are

1. Thermoelectric module
2. Heat sink
3. 12 volts DC battery

Thermoelectric Module

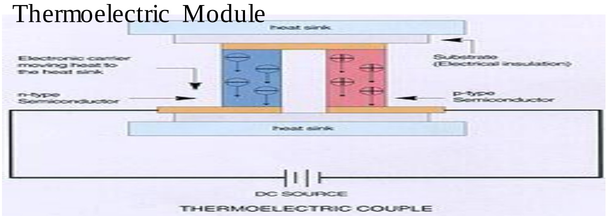


Fig.4.*1 thermoelectric module*

Specifications of Thermo Electric Module:

1. 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.
2. There are 127 couples in single module; 40mm x 40mm x 3.8mm size.

Two unique semiconductors, one n-type and one p-type, are used because they need to have different electron densities. The semiconductors are placed thermally in parallel to each other and electrically in series and then joined with a thermally conducting plate on each side. When a voltage is applied to the free ends of the two semiconductors there is a flow of DC Current 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 morebound. 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.

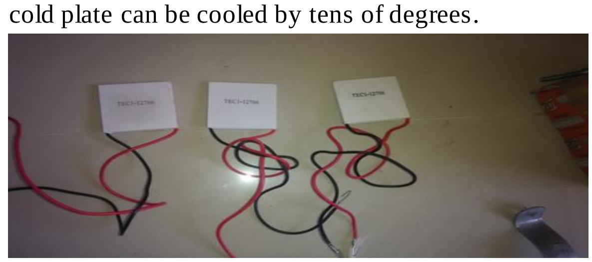


Fig.4.1 *PELTIER MODULES*

Heat Sinks:

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. 4.3.12- *volts dc batteries*

Specifications of Batteries:

1) 12 volts DC rechargeable batteries
2) 3.25 amps battery capacity

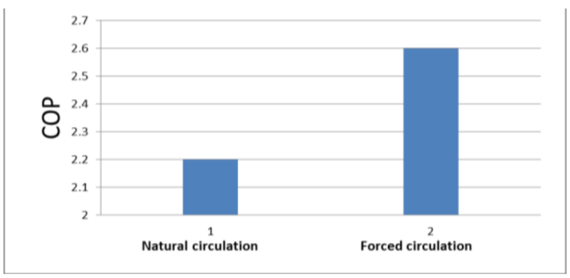
In order to cope with therelatively high power needed by the components in the helmets, three 12V lithium polymer rechargeable batteries are used. The entire power source is supplied through these batteries individually for three peltiers. The individual battery gives 5 hours of charging and these batteries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

V. RESULTS AND DISCUSSION

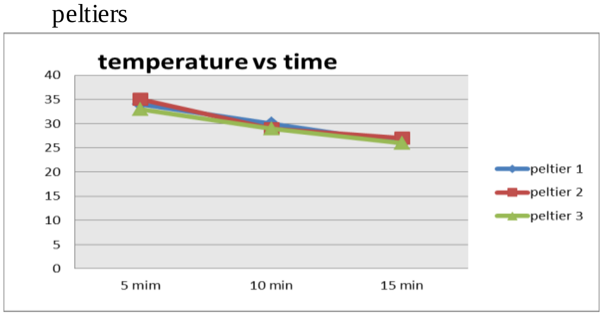
A prototype of motorcycle helmet fitted with three number of Peltier module (TEC 1-12706) is fabricated to study the cooling effect .as a second case heat sinks were fixed to each of the module at the outer surface of the helmet. The prototype is tested for its cooling performance under natural convection and forced convection conditions .The experimental results in the form of peltier inside and outside temperatures are presented at time intervals of 3 mins.The experiments were conducted during May 2017 when the ambient temperature are close to 400C.The experiment results indicate that the inside temperature of the helmet is reduced by about 60C as compared to ambient temperature within 20 mins.The temperature drop is found to be higher when heat sinks are attached.

GRAPHS:

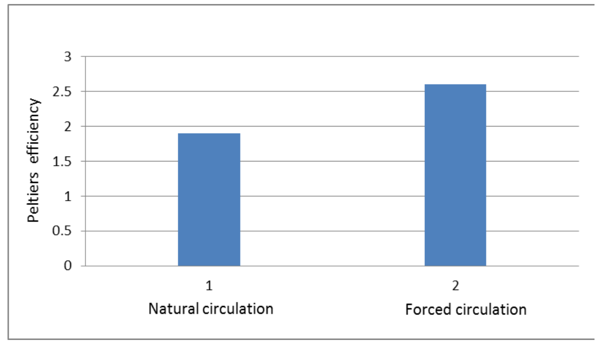
1. Comparison of three peltiers c.o.p with natural circulation of air and forced circulation of air



2. Graph between temperature vs time for three peltiers



3. Comparison of three peltiers efficiency with natural circulation of air and forced circulation of air



DISCUSSION:

The experimental results shown in above tables clearly indicate that providing Peltiers in the helmet cause the comfort conditions for the motorcyclist. A moderate temperature drop between the inside and the ambient temperature is noticed with Peltier, without heat sink and considered temperature drop are noticed in case of Peltier with heat sinks. The c.o.p of the Peltiers was calculated under natural and forced circulation conditions. The c.o.p's of the Peltier is found to be higher under forced circulation condition.

V.CONCLUSION

The experiments have been carried out under four different situations viz. peltiers without heat sink, peltiers with heat sink, peltiers under natural convection, and peltiers under forced convection. From the investigation it is concluded that the helmet inside temperature are decreased by 2.1(0c), 3.2 (0c), 6.1 (0c) in 10, 15, 20 mins time respectively in case of peltiers without heat sink and the helmet inside temperature decreased by 2.8(0c), 3.7(0c), 8.0(0c)in 10, 15, 20 mins time respectively in case of peltiers with heat sink. Under the natural convection conditions the inside cabin temperature reduced by 6.3(0c) in 20 mins of time and by forced circulation of air flow the temperature reduced by nearly 8.5(0c).The cop and efficiency of the natural circulation and forced circulation condition is 1.85 and0.76% and 2.65 and 2.86% respectively. The COP (coefficient of performance) and efficiency of the peltier by using forced circulation of air is found to be better than that under natural convection conditions.

As the motorcyclist move at an average speed of 30 kmph the COP expected to be further higher at actual operating conditions. In this project thermoelectric helmet is demonstrated and the results revealed that such a module as proposed in this work ensures comfort conditions for the motorcyclist.

REFERENCES

[1] Carpenter, B., 1987. Heads, Helmets and Heat. Road Rider Magazine.

[2] Bill, C., 2009. Zeus ZS-806 Helmet Review. http://www.webbikeworld.com. Retrieved October 2, 2009.

[3] Tan, F.L. and S.C. Fok, 2006. Cooling of helmet with phase change material. Journal of Applied Thermal Engineering, 26: 2067-2072.

[4] 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.

[5] Prange, M., 2003. Presentation at the Review of Pediatric Head and Neck Injury Conference held at the Childern's Hospital of Philadelphia, Philadelphia, PA.

[6] Johnson, D.A. and J. Bierschenk, 2005. Latest developments in thermoelectrically enhanced heat sinks. Electronics Cooling. http:// www.electronics-cooling.com. Retrieved March 8, 2009.

[7] Akbar-Khanzadeh, F., Bisesi, M. S., Comfort of Personal Protective Equipment, Applied Ergonomics,26 (1995), 3, pp. 195-198.

[8] Airaksinen, M., Tuomaala, P., Holopainen, R., Modeling Human Thermal Comfort, Presented at CLIMA 2007 – Wellbeing Indoors, Helsinki, Finland, 2007.

[9] Hsu, Y. L., Tai, C. Y., Chen, T. C., Improving Thermal Properties of Industrial Safety Helmets, Journalof Industrial Ergonomics, 26 (1999), 1, pp. 109-117.

[10] Hachimi-Idrissi, S., et al., Mild Hypothermia Induced by a Helmet Device: aClinical Feasibility Study,Resuscitation, 51 (2001), 3, pp. 275-281.

[11] Buist, R. J., Streitwieser, G. D., the Thermoelectrically Cooled Helmet, Proceeding,17thInternational Thermoelectric Conference, Arlington, Tex., USA, 1988, pp. 88-94

[12] Rasch, W., et al., Heat Loss from the Human Head during Exercise, Journal of Applied Physiology, 71 (1991), 2, pp. 590-595.

[13] Clark, R. P., Toy, N., Forced Convection around the Human Head, Journal of Applied Physiology, 244 (1975), 2, pp. 295-302.

[14] Holland, E. J., et al., Helmet Design to Facilitate Thermoneutrality duringForest Harvesting, Ergonomics, 45 (2002), 10, pp. 699-716.

[15] ***, Fresh Air System Technology: Airflow cooled helmet, http://www.fastraceproducts.com.

[16] Jwo, C. S., Chien, C. C., Solar Power-Operated Cooling Helmet, U. S. Patent 200701376845A1, 2007 .

[17] Shen, W., Tan, F. L., Thermal Management of Mobile Devices, Thermal Science, 14 (2010), 1, pp. 115-124

[18] Houdas, Y., Ring, E. F. J., Human Body Temperature, Its Measurement and Regulation, Plenum Press, New York, USA, 1982