International Journal of Interdisciplinary Innovative Research & Development (IJIIRD)
ISSN: 2456-236X
Vol. 03 Special Issue | 2019

A Review on Cooling Helmet

SAGARICA DESHMUKH
Department of Mechanical Engineering, Datta Meghe College of Engineering, Airoli, Maharashtra

ABSTRACT

A helmet is a device which provides safety from foreign elements to the most critical part of the body that is head. Along with safety a smart helmet can also provide cooling to improve the performance. According to Indian statistical institute, the output of labor intensive work reduces by 3 percentages per degree Celsius. This paper deals with the effective and modest ways to build a smart cooling helmet. This helmet can mostly be used in civil services (like police etc), construction site worker and also by bikers. It thus proposes design and implementation of a cooling system to cool the inner surface so as to ensure comfort by the wearer. There are mainly two types to achieve it, one which is solar powered and the other which requires no power source. The solar powered uses peltier effect theory and the other uses PCM to obtain cooling. The effort is been made to study the suitability and effects of these two types of cooling systems in the helmet.

KEYWORDS: PCM, Solar powered helmet, peltier effect

1. INTRODUCTION

The helmet is a critical piece which is used to protect the wearer from any external harm as in case of industrial worker or any civil services personal. As well as with protection a helmet can be substantially used to have cooling effect so as to increase efficiency. The helmet is so design so as to make user appeal it in terms of cost and aesthetics.[2] A conventional helmet has a shell, harness, harness fixing, headband, peak, sweatband, chinstrap. A shell which is a rigid outer section of the helmet, and is usually made from polyethylene, ABS or fiberglass hardened with polyester resins. A shell is basically known for its basic function to provide protection from a falling object by reducing the impact of striking on the wearers head.[1]

A system of protection with cooling uses simple ways unlike conventional refrigeration system. The refrigeration system requires some external work in the form of mechanical, and now a day's uses magnetic and many other different forms. The external work is used to transport the refrigerant from high temperature zone where the heat is extracted to low temperature zone where the heat in dumped. In today's engineering world there the applications of refrigeration are not limited to air conditioners, heat pumps, cryogenics, refrigerators etc but also provide a wider scope of application.[3]

In 1834, the concept of peltier effect on which the principle of thermoelectric refrigeration was based was known to the world. It uses semiconductor elements such as silicon, germanium or combination of both elements. The semiconductor is an element in which electrons do most of the conduction in N-type and the holes in P-type. From the statement it could be understood that the holes or the electrons caries away the heat instead of refrigerant as in conventional methods. This thermoelectric refrigerant produces hot and cold zones at two junctions. The hot junction is mostly placed with the fins so as to carry away the heat and the cold junction produces cooling effect desired. The fins increase the surface area for faster heat deception to the surrounding. The thermocouple requires a small DC supply to operate. The current flow is regulated through the rectifier which is powered by the DC current given. The controlled supply is used to produce appropriate temperature difference. Apart from construction, the thermocouple is easy to operate. The only disadvantage it could have is low thermal efficiency as compared to regular refrigeration system. 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. The system also can be used for reversed effect also that is by reversing the supply current the hotness and the coldness of the junctions can be altered. This phenomenon adds to the use of proper insulation material in between the two plates. Due to all these properties it has wide range of applications such as nuclear submarine, computers, aerospace devices etc.[3]

This paper also deals with the cooling effect which is produced by the materials like PCM or phase changing materials. These materials do not require external source of energy like electrical supply as required in peltier plate. The PCM changes it phase mostly from solid to liquid to produce cooling effect. The material acts as a sink and absorbs latent heat from the base. The pouched PCM in the form of cell is placed in the inner surface of the helmet which faces the head of the wearer. The heat collector by the means of conduction absorbs heat from the skin and transfers it to the PCM. The temperature of the wearer is so maintained to get the temperature difference just below the PCM's temperature. The temperature gradient maintained helps the wearer to produce better efficiency. The types of PCM's which can be used include Paraffin Waxes, Hydrated Salts, Non-Paraffin Organics, and Metallic.[4]

2. HELMETS

2.1 Helmets without Power Source

Since a study shows that high efficiency can be obtain by cooling head rather than other parts of cooling the helmet uses phase changing material (PCM) which relatively absorbs the temperature from the head which is in contact with head. The enclosed cell type structured pouches are placed in the inner surface of the helmet. When the temperature of the head skin is above melting temperature of PCM, it begins to melt. The temperature gradient is maintained so as to produce cooling effect to the wearers head. It can be installed in any kind of safety helmet due to its simple structure and its efficiency to operate without power supply. The phase changing material such as Sodium sulfate dehydrate could be effectively used due to its following properties:

Table 1.1 properties of Sodium sulfate decahydrate[4]

Description	value
Working range	$19 – 39^0$ c
Melting temperature	30^0 c
Latent heat	35 W h/kg/^{0} c
Maximum temperature	60^0 c
Thermal conductivity	0.5-0.6W/m/^{0} c

The pure salt hydrates have a disadvantage of super cooling. The liquid PCM has the ability of cooling several degree Celsius below melting before solidification start, thus given wide range of application. The phase change does not occur at uniform temperature gradient. The nucleating agent such as borax can be added to overcome the problem of super cooling, included with a disadvantage of narrow range of phase change. Due to its property of expansion, PCM is always incorporated with extra volume of about 5% more. The pouch which is placed in the inner surface of the helmet is mainly made of thin and flexible aluminum foil. The property such as high thermal conductivity of aluminum increases heat transfer rate. The pouches are subdivided into small compartments known as cells instead of a whole complete bag. This is done to reduce the movement of liquid inside the pouches as PCM melts. When the PCM becomes completely liquid, then it needs to be unloaded so as to bring it back to the solid state. The pouches can be reuse by placing the melted PCM pouch into the ice water at 0^0 c or normal water at the room temperature (20^0 c).

2.2 Helmet with Power Source

The construction of helmet is simple and unique which allows accommodating different changes. The development of cooling system in a helmet using thermoelectric technology provides a great deal of temperature gradient to be obtained. The thermo electric effect is the direct conversion of electrical voltage to temperature difference and vice-versa.[7] It has the ability perform the same cooling function as in absorption refrigerators. It works on the principle, thermal energy extraction from one region and reducing temperature from other which acts as a heat sink of higher temperature. The See beck effect states that thermoelectric device creates a voltage when subjected to temperature difference at junction. Conversely pettier effect states that when voltage is applied, it produces a temperature difference at junction.

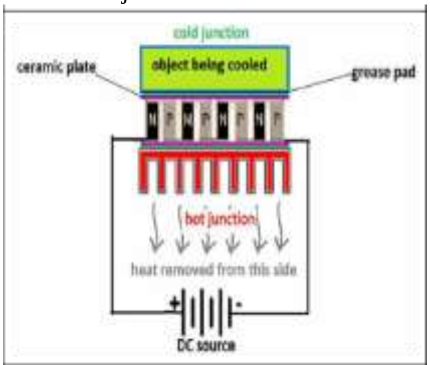

Fig. 1.1 Principle of peltier effect [5]

This peltier plate is been energized by solar panel which is been mounted on the top of the helmet. A flat solar cell module which converts energy of sun light into electric energy connect to the power output terminal of peltier plate. The photovoltaic module is been made by the assembly of solar cells to generate and supply electricity to its output. Each module is rated and tested under standard conditions and its DC power output which typically ranges from 100-350 watts. The area of the module determines the efficiency of the panel, for example an 8% efficient module will have half the area of 16% efficient module of 230 watts. The series connection of the PV modules is used to achieve desired output voltage and parallel modules used to achieve desired current capacity. The series connection is also known as voltage divider circuit and the parallel connection is also known as current divider circuit. In case of lack of sun light the power can be stored using battery by pre charging it with the before available solar energy. [3]

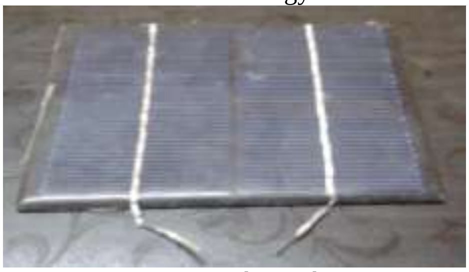

Fig. 1.2 Solar panel

The most common batteries with high rechargeable capacity that is lithium ion batteries are used. The lithium ions move towards the positive electrode during discharging and back to the negative electrode during charging. The intercalated lithium compound is used on electrode material which allows its capability of recharging itself. The electrolyte provides the passage for ionic movement between the two electrodes.

3. EXPERIMENTAL SETUP

In many industrial working environment, for example construction, mining etc. and also in civil services (police) has high risk of head injuries. So the use of helmet becomes compulsory. But the helmet increases the temperature of the head skin; this makes the use of temperature reducing devices important.

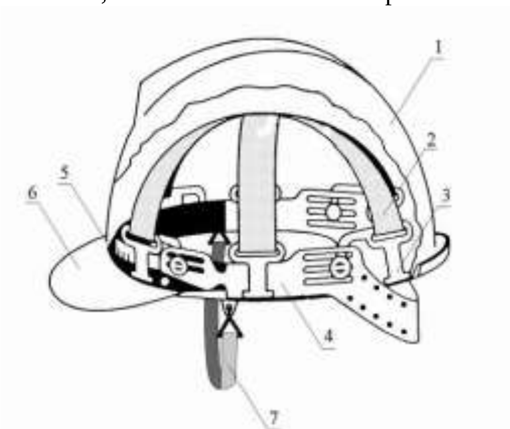

Fig 2.1 Industrial helmet 1 – shell, 2 – harness, 3 – harness fixing, 4 – headband, 5 – sweatband, 6 – peak, 7 – chinstrap. [6]

As shown in the figure the harness provides the space between the helmet and the head skin for the air to flow or to mount some temperature reducing device.

3.1 Solar Power Helmet

The construction helmet or the constable helmet is taken into consideration for the design. The hole is been dilled at the front and top portion of the helmet. The top portion allows the solar panel to fit into and the front portion assembles peltier plate, fins and fan. The battery is been placed below the solar panel and the connections are made. As soon as the switch is turned on the peltier plate produces hot and cold region, the hot region faces outside which is in contact with the fin plate. The fan is operated and the heat is convicted to the surrounding. The solar panel plays as a source of energy but in case of lack of sunlight battery provides the power.

Fig. 2.2 Actual photo of solar power helmet

3.2 Helmets without Power Source

The inner surface of the helmet has space for the PCM pouches to assemble. The flexible copper metal which acts as the conducting element is placed just in contact with the vinyl cushion. The cushion is kept in contact with the head skin and is filled with water based solution. This reduces the effect of the overall super cooling of the PCM. The PCM pouches are sandwiched between the helmet shell and cushion.

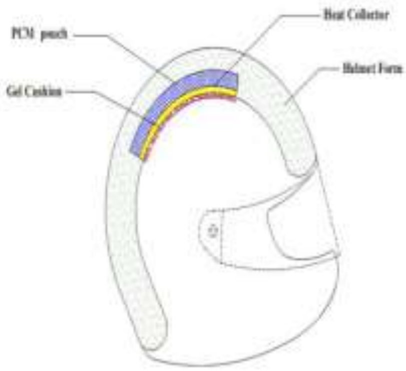

Fig. 2.3 Construction of PCM helmet

4. CALCULATIONS

The calculations are done to check the heat transfer rate in both solar powered helmet and helmet without power source.

Solar powered helmet:

- Current temperature = 30°C
- Achieved temperature = 25°C
- Heat conduction coefficient = 0.03W/mK
- Fin surface area = $21cm^2$
- Thickness of insulating plate = 4mm

Formula:

$$Q = \frac{\text{(Cur. Temp. (°C) – Achi. Temp. (°C)) x Heat Cond. K (W/m-K) x Surf. Area Sq. m}}{\text{Thickness of Insulating Plate T}}$$

$$Q = \frac{30(°C)-25(°C)x0.03(W/m\text{-}K)x0.0021(m2)}{4\ mm}$$

$$= 11.249\ \text{Watts} = 12\ \text{(say) W.}$$

Helmet without the power source:

$$R_{collector} = \frac{t(collector)}{A(collector) X K(collector)}$$

$$R_{collector} = \frac{0.5x\,10^{-2}}{0.03x385} = 4.33x10^{-4} k/W$$

$$R_{cushion} = \frac{t(cushion)}{A(cushion) X K(cushion)}$$

$$R_{cushion} = \frac{0.5X10^{-2}}{0.03X1.6} = 0.1k/W$$

$$Q_T = \frac{T(skin) - T(PCM)}{R(collector) + R(cushion)}$$

$$= \frac{29.6 - 28}{R(collector) + R(cushion)}$$

$$= 15W$$

5. RESULT AND DISCUSSION

The following results were obtained by the two sources:

5.1 Solar powered

The temperature change was been noted with the change in time in minutes so as to obtain required temperature.

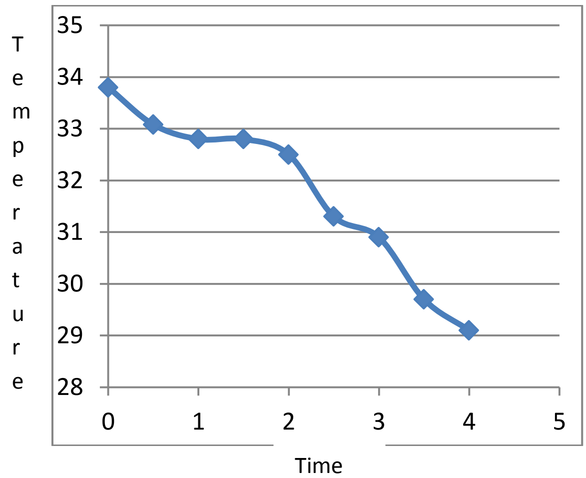

Chart 1.1 Temperature v/s Time graph

An ANSYS simulation was also been done to check the uniformity of the temperature flow rate.

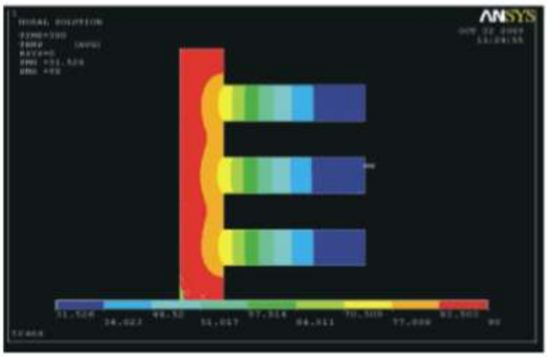

Fig. 3.1 Simulation of heat transfer

5.2 Helmet without power source

An ANSYS simulation shows that due to conduction effect the heat transfer rate along the heat area is improved and is uniform. Due to high thermal efficiency latent heat absorbed also improves. The surface which is facing the shell, due to convection keeps the cap cool. If the convection of the air increases the latent heat loss and accelerate the melting of PCM material. Due to this increased cooling rate is obtained with the time factor being reduced.[4]

6. CONCLUSION

It can be concluded that solar powered helmet has a wide range of application since targeted cooling performance can be achieved, whereas in PCM the time required to achieve the same is more. The solar power helmet has low heat transfer but it is costlier than PCM assembly. For the better performance of solar powered helmet, the problem of noise of internal fan is to be reduced and the high demand rate of power from the solar panel is to be improvised. Similarly performance of PCM can be upgraded by providing proper insulation between the PCM and the helmet shell. The paper provides the future scope of both the types individually and also in a combined form.

7. REFERENCE

[1]https://oshwiki.eu/wiki/Protective_helmets_%E2%80%93_requirements_and_selection
[2] cooling of biker's helmet using peltier module international journal of advanced technology in engineering and science www.ijates.com Volume No 03, Special Issue No. 01, March 2015 ISSN (online): 2348 – 7550
[3] Experimental Study on Generation of Cooling Inside the Motorcyclist Helmet by Using Peltier Module © September 2017 | IJIRT | Volume 4 Issue 4 | ISSN: 2349-6002
[4] Helmet Cooling With Phase Change Material National Conference on Innovative Paradigms in Engineering & Technology (NCIPET-2012) Proceedings published by International Journal of Computer Applications® (IJCA)
[5] https://www.researchgate.net/figure/Peltier-Effect-Refrigerator_fig2_310604958
[6]https://oshwiki.eu/images/4/4c/Figure1_Construction_of_an_industrial_safety_helmet.jpg
[7] Review on Application of Thermoelectric PeltierModule in cooling and power generating Technology. International Journal of Engineering and Technical Research (IJETR)ISSN: 2321-0869, Volume-3, Issue-1, January 2015