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HELMET COOLING SYSTEM USING PHASE CHANGE MATERIAL FOR LONG DRIVE

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ABSTRACT

The helmet is critical safety equipment for a two wheeler drivers. The primary purpose of helmet is to protect the head against injuries and to safeguard the eye from sunlight and dust particles. It is crucial that the motorcyclist is comfortable while wearing the helmet. The inconvenient equipment may affect concentration and create hazards that could lead to accidents. The motorcyclist can be affected by temperature which results in loss of concentration. This work focuses on absorbing the heat produced inside the helmet. To achieve this, a suitable Phase change material (PCM) Glauber Salt is encapsulated inside an Aluminum Foil. In addition, holes are created on the front and rear sides of the helmet. This allows circulation of fresh air flow inside the helmet so that the heat produced in the helmet is instantaneously tapped out. Thus continuous cooling is achieved till it he entire PCM fuses. Solid works is mechanical design software; provide tools to help you implement a sophisticated standard based architecture. Solid works software sketcher is used model and flow simulation, heat is removed by providing the phase change material.

Keywords: heat, glauber salt, phase change, PCM fuses, solid works.

1. INTRODUCTION

The visor is made of a strong and transparent material, e.g. polycarbonate, and is designed to protect the face of the rider from wind, dust and insects. In addition, the visor is equipped with a water- and scratch-proof coating. Manufacturing a distortion-free visor including a reliable opening mechanism not only calls in a manufacturer's development strength, but is equally dependent on the right production technology. During an accident, the hard outer shell has to both absorb and disperse the impact. At present, outer shells are generally made of thermoplastics or fibre-reinforced polymer (FRP), a composite material consisting of a synthetic resin reinforced with, for instance, fibreglass.

Despite its rounded shape, an EPS liner is much too hard to guarantee a good fit. The comfort padding, which consists of a sufficiently firm synthetic foam pad covered with a skin-friendly fabric, is thus all the more important.

The system ensures fresh air is ducted into the helmet and exhaled air and humidity are vented out. Figure-1 shows the various parts of helmet.

A special synthetic - fibre chin strap that fulfils the strict breaking-and tensile-strength requirements serves to secure the helmet firmly on the head of the rider. The retention system is attached to the helmet with strong metal rivets.

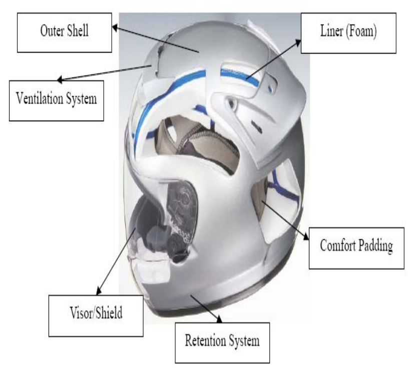

Figure-1. Various Parts of Helmet

Figure-1 shows the parts of helmet. The liner protects the wearer's head by absorbing the remaining force of the impact that was already partially absorbed and dispersed by the outer shell. The liner located on the inside of the shell is made of lightweight and highly impact-absorbing EPS (expanded polystyrene).

PCM materials have high heats of fusion so they can absorb a lot of energy before melting or solidifying [1]. A PCM temperature remains constant during the phase change, which is useful for keeping the subject at a uniform temperature. Figure-2 shows the protection and comfort of PCM Helmet.

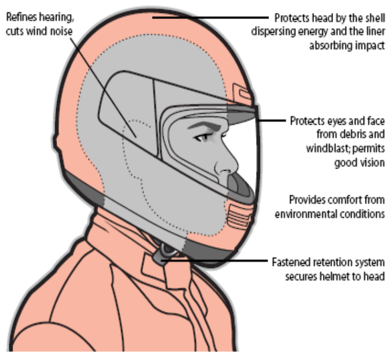

Figure-2. Protection and Comfort of PCM Helmet.

Comparison of how long a PCM will remain at a constant temperature during the phase change calculated in Equation 1

$$D.I = \frac{hf\,\rho}{\Delta T} \qquad (1)$$

Uncomfortable individual protective devices may affect performance of drivers and create disturbances that could lead to accidents. There are numerous factors that can influence the user comfort level. One of the most important factors is temperature [2]. This work mainly focuses on absorbing the heat produced inside the helmet.

To achieve this, a suitable Glaubersalt PCM has been encapsulated inside an Aluminum Foil [3]. Also holes are drilled on the front and rear sides of helmet. This allows fresh air (reaction air coming opposite to riding direction) to continuously flow in and out of the helmet so that the heat produced in the helmet is instantaneously tapped out. Thus continuous cooling is achieved till the entire PCM fuses.

Glauber's salt is being sold commercially. Glauber's salt usually varies its phases at 90°F and has a 108-BTU-per-pound latent heat [4]. Owing to its high latent heat characteristic, Glauber's salt needs comparitively less storage volume than either rock or water. This property leads to lower storage facility cost and more usable space within the home to counteract the material's relatively high cost. PCM's do have some chemical traits that can present problems in heat storage and transfer; but most have been or are being overcome. One is that PCM's tend to overcool as heat is withdrawn. This means that, rather than giving up its latent heat at the phase-change temperature, salt PCM's may remain a liquid until they fall to possibly 15-30°c [5]

Solid works is mechanical design software which provides tools to implement a sophisticated standard based architecture. Solid works software sketcher is used model and flow simulation, heat is removed by providing the phase change material. Properties of phase change materials are depend upon high volumetric latent heat storage capacity, availability and low cost, sharp melting point, high thermal conductivity, high heat of fusion, Non-flammable.

2. METHODOLOGY

A. Problem Definition

The thermal comfort for motorcyclist during hot weather is important as it can affect the physiological and psychological condition of the rider. This paper examines the use of PCM to cool a motor cycle helmet and present the software analysis on the influence of the solar radiation wind and heat generation rate on the cooling system. Figure-3 shows the flowchart of the proposed scheme.

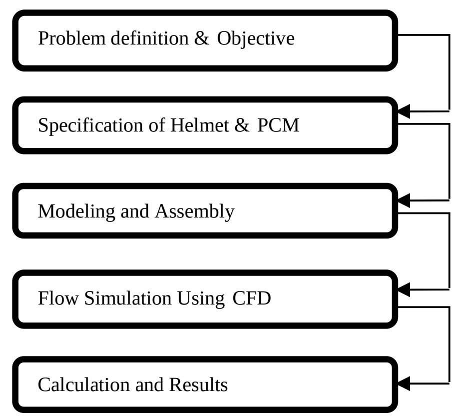

Figure-3. Flowchart of the proposed scheme

Table-1. Specification of Helmet.

Layers	**Material**	**Density g/cm^3**	**Thermal Conductivity** (W/mK)	**Melting point** (°C)
Outer shell	Polycarbonate	1.20 – 1.22	0.19 to 0.22	155
Thermocole	Polystyrene	0.96-1.04	0.033	240
PCM	Glauber salt	1.464	-	32.38
Inner foam	Polystyrene	0.96-1.04	0.033	240

The outer shell of helmet has the ability to beat impacts. The helmet lessens the impact by absorbing energy and prevents head from injury. Thermocole is basically a polystyrene material with hard and brittle nature. It is an inexpensive resin per unit weight. Sodium sulphate is the sodium salt of sulphuric acid. The glauber's salt is wrapped inside aluminium foil and is kept in between the foam and thermocole [6]. Foam is good thermal insulator. The heat is removed by providing the holes. While the holes are provided for air exchange, the heat energy with PCM kept inside resulting in an extension of the duration of fusion. Figure-4 shows the air flow area in PCM helmet.

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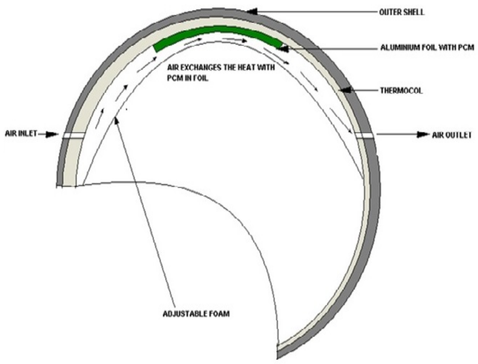

Figure-4. Air flow area in PCM Helmet.

B. Software Used

The solid works 2014 is used as modeling tool for both part and assembly. Figure-5 shows the assembled view of PCM Helmet.

3. RESULTS AND DISCUSSIONS

A. Flow simulation using CFD

Computational Fluid Dynamics (CFD) uses numerical method to solve the fundamental non-linear equation that describes fluid flow for predefined geometrics and boundary conditions. CFD applies numerical methods is called Discretization to develop approximations of the governing equation. Boundary condition is the temperature. Domain is discretized into finite set of control volumes or cells called grid or mesh [7]. Figure-6 shows the CFD for PCM Helmet.

Table-2. CFD Results.

Parameters	Unit	Value	Average Value	Min. Value	Max. Value
SG Av Heat Flux 1	[W/m^2]	22.42	22.60	24.30	20.77
VG-Av Temperature of Solid 1	[°C]	30.00040008	30.00040162	30.00019551	30.00049402

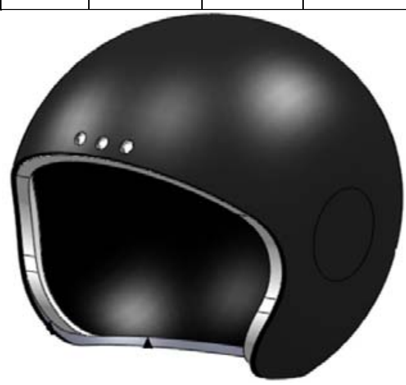

Figure-5. Assembled View of PCM Helmet.

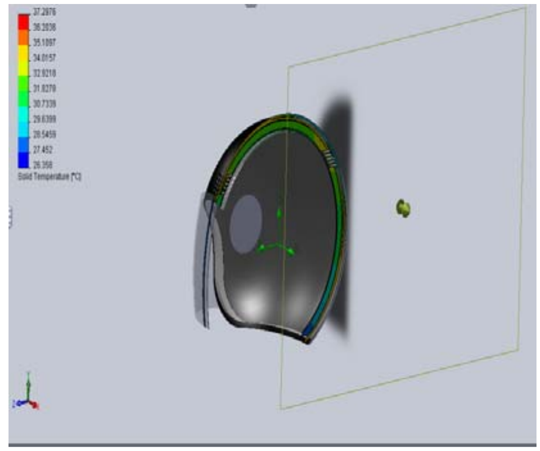

Figure-6. CFD for PCM Helmet.

B. Calculation

From the data, Heat flux = 22W/m^2
Latent heat of PCM = 251KJ per Kg
From diagram, area = 0.05 m^2
Latent heat of PCM = 251000 J/Kg
Therefore for 0.05 m^2 area, 0.05 * 22.42
From diagram, mass = 0.02Kg
= 22.42 * 5/100
Therefore for 0.02Kg,
251000*0.02 = 1.121 watts
Total amount of heat =5020 joules
Which means, for 1 second, PCM absorbs 1.121 Joules
From these data
Time taken for fusion = 5020/1.121
=4478 sec
=1.24hrs

4. CONCLUSIONS

In this paper a thermally comfort helmet has been designed using PCM by providing holes at both front and rear side of the helmet for forced convective heat transfer through air. The result shows that the designed helmet gives the comfort upto 1.24 hour while driving.

REFERENCES

[1] FL Tan., SC Fok. 2006. Cooling of Helmet with Phase Change Material, Applied thermal engineering. pp: 2067-2072.

[2] Sai Cheong Fok., Fock Lai Tan. and Chong Chai. 2011. Experimental Investigations on the Cooling Of a Motorcycle Helmet with Phase Change Material. International Journal of Thermal Science. Vol.15, No.3, pp.807-816.

ARPN Journal of Engineering and Applied Sciences

[3] M. Ravikumar., S.Srinivasan. 2008. Phase Change Material as a Thermal Energy Storage Material for Cooling Of Building. International Journal of Theoretical and Applied Information Technology. Vol. 15, pp. 503-511.

[4] Chadwick Duange G., Sherwood Kim. 1981. Design Consideration in the Use of Glauber Salt for Energy Storage, International Journal of Applied Information Technology. Vol. 15, pp 807-816.

[5] S. K. Mithun., S. Umesh. and Ramjan Pathan. 2013. Conceptual Design of Motorcycle Helmet to meet the Requirement of Thermal Comfort, Ergonomics and Safety, pp: 65-71.

[6] L. F. Cabeza., H. Mehling., H. Hiebler. and F. Ziegler. 2002. Heat Transfer Enhancement in Water When used as PCM in Thermal Energy Storage, Applied Thermal Engineering. 22. pp: 1141-1151.

[7] Prabhu P. A., Shinde N. N. and Patil P. S. 2012. Review of phase change material for Thermal Energy Storage Application, International Journal of Engineering Research and application. Vol. 2, Issue 3, pp: 871-875.

[8] G. Y. Fang., H. Li. and X. B. Xu. 2003. Study of Thermal Properties of a New Phase Change Cool Storage Material, International Journal on Architectural Science. Vol. 4,No. 4, pp: 147-149.

[9] VD Bhatt., K Gohil. and A Mishra. 2010. Thermal Energy Storage Capacity of Some Phase Change Materials and Ionic Liquid. International Journal of ChemTech Research. Vol.2 No.3, pp: 1771-1779.

[10] D Zhou., CY Zhao. and Y Tian. 2012 Review on Thermal Energy Storage with Phase Change Materials. Applied Energy, 92, pp: 593-605.