# Cooling Effect on Two Wheeler Helmet with PCM

**R. Alex Arputhanathan[1] B. Gokulakrishnan[2] T. Mathan[3] B. Rajkamal[4] R. Rathinavelu[5]**
[1]Assistant Professor [2,3,4,5]Student
[1,2,3,4,5]Department of Automobile Engineering
[1,2,3,4,5]K. S. R College of Engineering Namakkal, India

*Abstract*— The most common discomfort is that, heavy sweat occurs due to excessive heat formation. This mainly focuses on absorbing the heat produced inside the helmet. To achieve this, a suitable phase change material (PCM) is packed into a pouch and placed between the helmet and the wearer head. The heat from the wearer head is transferred to the PCM by conduction through a heat collector which is spread over the wearer head. The cooling unit is able to provide comfort cooling up to 2.10 h when the PCM is completely melted. The PCM helmet cooling system is simple and has potential to be implemented as a practical solution to provide comfort cooling to the motorcycle riders.

***Key words:*** PCM, Cooling effect on Two Wheeler Helmet

## I. INTRODUCTION

Our aim is to make comfort on head sweat due to wearing helmet. Excessive heat and sweat formation due to wearing of helmet has been remaining as an unsolved problem. So, the two wheeler riders reduce the usage of helmet. It's high time to find an effective and economic solution for this problem. This paper seeks a practical solution for this problem using Phase Change materials.

## II. OBJECTIVES

To absorb heat present in the air using a Phase Change Material (PCM) by allowing conduction over the helmet to take place.

## III. BASIC DESIGN

The design of helmet initially made pictorially and a theoretical stress analysis was carried out. The various views of the helmet were taken and based on this design the fabrication work has been carried out. The views of the design from various directions are presented in fig.1.

Fig. 1: Basic Design

### A. PCM Selection

The phase change materials are selected based on their melting point and the operating temperature range. The table 1 shows the list of commercially available PCMs of which HS22 and HS24 was selected and compared.

## IV. DESIGN CALCULATIONS

### A. Stress Analysis

A theoretical stress analysis has been made to check the helmet. The helmet was considered to undergo an impact load when falling from a height. The helmet has been considered as a hollow spherical shell and its strength initially found. In all the cases the stress induced due to impact load was found to be less than the safe stress of the helmet material which is usually polystyrene.

- Circumference of the helmet = 860mm
- Outer radius of the helmet, R = 136.87mm
- Thickness of the plastic casing, t = 4mm
- Inner radius of the helmet, r = R-t = 132.87mm
- Surface area under impact load, $a = 2*\pi*R^2 = 2*3.14*(0.136^2) = 0.1177_{sq.m.}$
- Height of fall, h = 1.60m
- Length of object exposed to impact= 0.004m

– Load acting on the helmet under impact is,

$$P = W (1+ (1 + (2Hae / W * l))^{.5})$$

### B. Stress Analysis for Full Helmet

Normal load, w = 200 N

Young's modulus of polystyrene,

$$E = 2.5 * 10^{9} N/m^{2}$$

Therefore,

$$P = 200 (1 + (1 + (2 * 1.60 * 0.1177 * 2.5 * 10^{9} / 200 * 4 * 10^{-3}))^{.5}) = 6.86 * 10^{6}$$

And

$$\text{Stress } \sigma_1 = P / a = 6.86 * 10^{6} / 0.1177 = 58.28 \text{ M Pa}$$

### C. Time of Cooling Effect (HS22)

Another calculation has been done to calculate the minimum time for which the PCM can give its cooling effect. A peak temperature of 38$^{\circ C}$is assumed and the calculation is shown below.

*1) Specifications*

- PCM employed: HS 22
- Operating temperature: 23°C
- Enthalpy: 185kJ/kg
- Density: 1540kg/M$^3$

*2) Assumptions*

The bag containing phase change material is assumed as a flat plate.

- Ambient temperature 38°C
- Temperature of PCM 23°C

*3) Data*

- Mean film temperature is 37°C
- The length of the bag exposed is 10cm
- Breathe 5cm
- Velocity of air is 35 Km/hr

*4) Properties*

- For air at 37°C, from HMT data book,
- Kinematic viscosity, $\nu$=16.96* 10$^{-6}$ m$^2$/s
- Thermal conductivity, k= 0.02756 W/mk
- Prandtl number, Pr = 0.669.

a) Reynold's number,

$$Re = (U\infty * L)/ \nu = (9.7222*0.1)/ (16.48*10^{-6}) = 58993.932$$

So,

b) Coefficient of heat transfer,

$h = 0.662*(k/L)*Re^{0.5} Pr^{0.333} = 0.662*(.02756 /0.1)*(58993.932)^{0.5}*(0.669) = 29.646 \text{ W/m}^2\text{K}$.

c) Heat transferred

$$Qt = hA\Delta T = 29.646*5*10*10^{-4}*15= 2.22345W$$

d) Heat absorbed by PCM

$$Qp = mC\Delta T =0.3*3.04*10^{3} *15 = 13680 =13680J$$

| S. No | Time (mins) | Temperature inside the helmet (ºC) |
|---|---|---|
| 1 | 05 | 35 |
| 2 | 10 | 34.5 |
| 3 | 15 | 34 |
| 4 | 20 | 34 |
| 5 | 30 | 32.5 |

Table 1: Heat absorbed by PCM

Cooling time =13680*60/2.372*10$^3$ =346.037 = 5.76 hrs

### D. Time of cooling effect (HS 24)

Another calculation has been done to calculate the minimum time for which the PCM can give its cooling effect. A peak temperature of 38$^{\circ C}$is assumed and the calculation is shown below.

*1) Specifications*

- PCM employed: HS 24
- Operating temperature: 25°C
- Enthalpy: 185kJ/kg
- Density: 1540kg/m$^3$

*2) Assumptions*

The bag containing phase change material is assumed as a flat plate.

- Ambient temperature 38°C
- Temperature of PCM 25°C

*3) Data*

- Mean film temperature is 37°C
- The length of the bag exposed is 10cm
- Breathe 5cm

Velocity of air is 35 Km/hr

*4) Properties*

- For air at 37°C, from HMT data book,
- Kinematic viscosity, ν=16.96* 10-6 m2/s
- Thermal conductivity, k= 0.02756 W/mk
- Prandtl number, Pr = 0.669.

a) Reynold's number,

$$Re = (U\infty * L)/ \nu = (9.7222*0.1)/ (16.48*10^{-6}) = 58993.932$$

So,

b) Coefficient of heat transfer,

$$h = 0.662*(k/L)*Re^{0.5}\, Pr^{0.333} = 0.662*(.02756 /0.1)*(58993.932)^{0.5}*(0.669) = 29.646\ W/m^2K.$$

c) Heat transferred

$$Qt = hA\Delta T = 29.646*5*10*10^{-4}*12= 1.77876W$$

d) Heat absorbed by PCM

$$Qp = mC\Delta T =0.3*3.04*10^3 *12 = 13680 =10944J =4.61\ hrs$$

| S. No | Time(mins) | Temperature inside the helmet (ºC) |
|---|---|---|
| 1 | 05 | 36 |
| 2 | 10 | 35.5 |
| 3 | 15 | 34 |
| 4 | 20 | 34.5 |
| 5 | 30 | 32.5 |

Table 2: Heat absorbed by PCM

Cooling time $=13680*60/2.372*10^3 =276.829= 4.16$hrs

## V. TESTING AND RESULTS

A practical test was conducted by riding a bike using our prototype and the temperature reduction inside the helmet was noted. Tests have been conducted. In one test for a constant time period of 30 minutes, the bike was rode at different speeds and the temperature change was noted. The results are shown in table for HS22 and HS 24.

Table Temperature Distribution at Constant Time of T=30 Minutes

## VI. PRACTICAL APPLICATION & COST

This project is practically viable as all the parts are already available. The cost of the helmet would rise by Rs.50Rs.100 and may decrease further by mass production.

## VII. ADVANTAGES

No electric power is required. This is very simple in construction.

## VIII. CONCLUSION

After doing these suitable modifications in the helmet, we're sure that the helmet will no longer be a symbol of discomfort but would conversely promote the riders to wear it. HS 22 given the cooling effect more on the helmet for long hours than HS24.

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