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Application of PCM in Helmet Interlinings

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***Abstract*: Phase change material (PCM) is used in the helmet cooling system design to absorb and store the heat generated by the wearer's head and provide comfortable cooling for the user. The PCM is tucked away in a pouch and positioned between the wearer's head and the helmet. By conduction through a heat collector that is positioned above the wearer head, heat from the wearer head is transferred to the PCM. For the cooling system, there is no need for an electrical power supply. The wearer would not experience an uncomfortable and dangerously hot environment on the head that would impair their attentiveness because the temperature on their head is kept slightly above the PCM temperature. The cooling unit is able to provide comfort cooling up to 2 h when the PCM is completely melted. The stored heat from the PCM pouch would then have to be discharged by immersing in water for about 15 min to solidify the PCM before re-use. 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.**

***Keywords*: PCM, helmet cooling, PCM pouch, wearer head, comfort, practical solution.**

1. Introduction

According to universal consensus, wearing a helmet dramatically reduces the likelihood of injuries and fatalities in motorcycle accidents. Thus, many nations have legislation mandating that motorcycle riders wear appropriate helmets. A motorcycle helmet's main characteristic is safety. Modern helmets are made of polycarbonate and frequently fortified with Kevlar and carbon fibre. The helmet is made up of two main protective parts: an outer shell that is thin and made of acrylonitrile butadiene styrene (ABS) plastic, fibreglass, or Kevlar, and an inner liner that is soft and thick and typically has a thickness of one inch and is made of either expanded polystyrene foam or expanded polypropylene foam. The thermal insulation employed in the foam liner is quite similar to that used in refrigerators. The hard outer shell serves as a barrier to stop sharp objects from piercing the helmet and as a support structure for the inside liner. The inner foam liner's purpose is to deflect the crush of an impact

2. Helmet Interlinings

The most efficient area of the body experiences minimal heat exchange with the outer wall thanks to the one-inch-thick insulation liner lining the interior of the helmet. The wearer's head is put in an uncomfortably heated and hazardous environment as a result. A temperature of between 37 and 38 degrees Celsius can be easily reached within the helmet. Due to a dulling of the senses and a decline in mental clarity, this can have very substantial and potentially disastrous impacts on the rider's physiological and psychological state. The head is found to cool the body the most effectively of any other portion. due to the maximum skin temperature and abundant constant-volume blood flow. It has been thought that head cooling is a must in order to give the rider overall thermal comfort.

3. Air Cooled System

It is possible to perform some sensible fixes to calm the mind. The air-cooled system using an air blower or vents is the most common and commercially viable technology. Certain cooling methods chill the air coming into the helmet with liquid. The air duct in certain air-cooled systems is attached to the helmet's chin bar. Only race car drivers are the target market for this design. The air-cooling systems employ vents to let ambient air circulate through the interior of the helmet and dissipate heat. It is questionable whether these systems are appropriate for tropical nations with high ambient temperatures, despite the fact that these designs may be employed by motorcycle riders. It is therefore desirable to implement a different, more straightforward cooling mechanism for motorcycle helmets.

4. Disadvantage of TEC

More recently, Buist and Streitwieser have developed a method for transferring heat from the inside of the helmet to an external finned heat sink using a thermoelectric cooler (TEC). It is demonstrated that using a thermoelectric cooling system to cool the head is a practical option. The thermoelectric cooler must be connected to a direct current (DC) power source, though. A tiny battery installed within the helmet or the motorcycle's battery can provide the DC power source. Thermoelectric cooling is a straightforward concept. The battery being included into the helmet's construction makes it heavier. Also, a design that has an electrical line hanging from the helmet to the motorcycle battery is risky. In this work, a straightforward substitute for the motorcycle helmet's cooling system was proposed.

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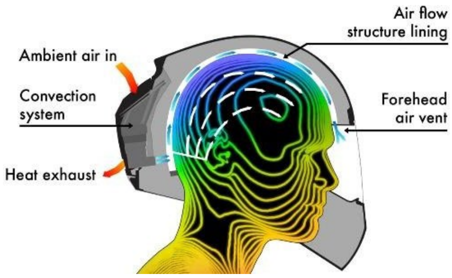

Fig. 1. Thermoelectric cooler

5. Helmet Cooling System

Phase change material (PCM) is used in a helmet cooling system that doesn't need an external power source to provide cooling for the head by absorbing all the heat produced by the head at a relatively constant temperature. As a result, the interior is kept at a temperature that is close to the PCM's melting point and provides the head with a thermally comfortable environment without the need for an electrical power source. Between the head and the helmet, the PCM is tucked away in a pouch. The PCM starts to melt when the temperature of the head skin rises over the PCM's melting point since it is absorbing heat from the head at that point.


Fig. 2. PCM pouch

Every form of safety helmet can incorporate a PCM-cooled system. Because to its straightforward design and ability to function without a power source, the PCM-cooled system is perfect for any type of safety helmet. Depending on how they will be used, safety helmets' construction and design may vary. For instance, the structures of safety helmets worn by race car and motorcycle drivers and construction site workers will be very different. These helmets need a good cooling system despite having distinct constructions. For these safety helmets, the PCM-cooled helmet will work.

A helmet cooling system employing PCM is designed and put into practise. For motorcycle helmets with brief riding times of up to two hours, the PCM-cooled system is intended.

Before the helmet can be worn again, the PCM's heat storage would need to be released to the environment for between 13 to 25 minutes.

6. Design of PCM Helmet

A. PCM Cooled Helmet Concept Design

In Fig. 3, the fundamental elements of the PCM-cooled helmet are depicted. The PCM pouch is the main element of the cooling system for the helmet. The bag encloses the PCM. A flexible copper heat collector offers a reliable thermal channel for transferring heat from the wearer's head to the PCM pouch. The vinyl cushion that the heat collector is attached to is filled with a water-based solution (gel). The vinyl cushion makes the inside of the helmet cosy.

The problem of design specifications:

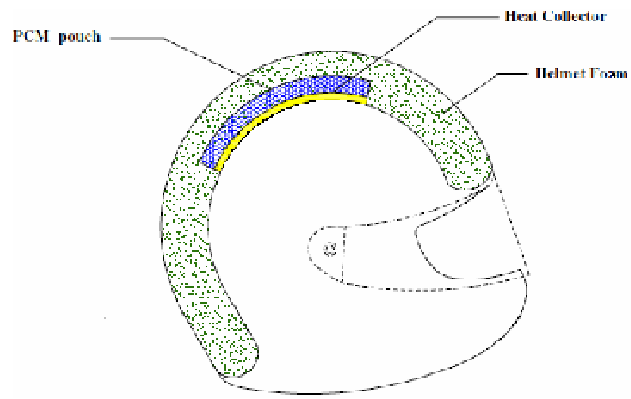

Fig. 3. Implementation of PCM pouch in helmet

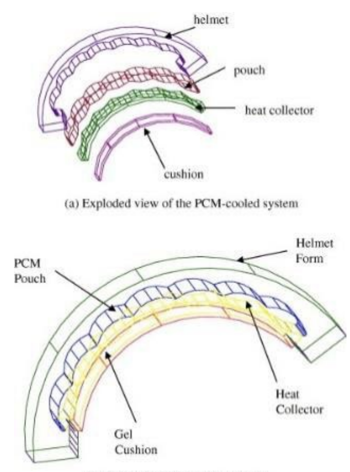

Fig. 4. Implementation of PCM pouch in helmet

The PCM-cooled helmet is intended to keep the skin temperature on the head at roughly Tskin = 30 °C. It is intended to be able to continually cool the head for up to 2 hours, or "tload," which stands for loading time. Following the loading period, the heat that has been stored in the PCM pouch needs to be released into the surrounding air, which is done during the discharging time, or tdischarge. The helmet is made to make it simple and quick to remove the PCM pouch for discharge.

7. Attaching PCM to Helmet

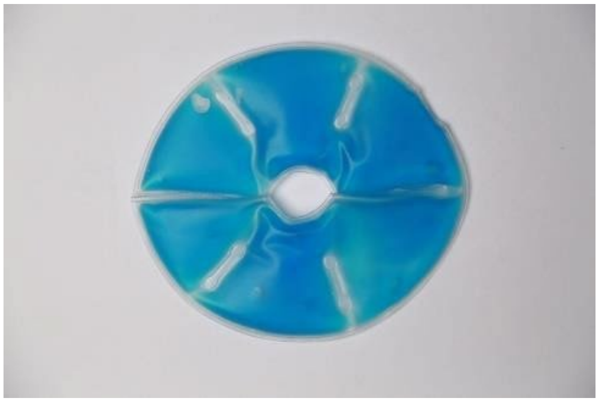

Fig. 5. PCM pouch

Fig. 6. Attaching PCM in to a fabric pouch

Fig. 7. A rider wearing PCM helmet

8. Benefits of Using PCM

Absorbs extra heat when you're overheated, which helps to reduce your temperature. enables you to warm yourself by releasing heat when you are cold. significantly decreases the need to add and remove layers when activity levels fluctuate. To make helmets more comfortable in the heat Heavy sweating is the most common discomfort encountered by helmet wearers, hence a new cooling unit was inserted between the wearer's head and helmet to provide thermal comfort to the wearer head. The PCM bag absorbs the heat generated inside the helmet through conduction. The PCM cooling system for helmets is easy to use and has the potential to be deployed as a workable solution to give helmet wearers thermal comfort.

9. Drawbacks of PCM

PCMs act as a thermal shock absorber by reducing the pace at which the wearer's individual microclimate changes temperature. It slows down the rate at which someone will overheat or freeze. Heat generation can be an issue in cold weather since it can lead to perspiration, which in turn accelerates evaporative cooling and eventually compromises the body's ability to regulate its own temperature.

10. Conclusion

It is demonstrated through easy calculations utilizing thermal resistance networks that the PCM-cooled helmet system presented in this research can be integrated into a regular helmet to provide cooling of the head for approximately 2 hours without the requirement of an external power supply. The PCM-cooled helmet's drawback is that it must first release the heat it has accumulated before it can be used again. By using PCM with more heat storage, the PCM-cooled helmet's usefulness can be increased.

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