

PCM Based Cooling Jacket

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ABSTRACT

To diminish a healthcare worker's thermal discomfort in a moderately hot environment, a new microclimate cooling jacket was designed. This cooling jacket was intended to be worn under the personal protective equipment (PPE). These encapsulated phase change materials (PCMs) in the form of macrocapsules were used. The cooling effect is based on the latent heat absorption of phase change material; a highly-productive means of thermal storage. Two kinds of macrocapsules were selected: n-Eicosane (melting point 35 °C) and Octadecane (melting point 28 °C).

MacroPCMs were inserted into small knitted sacks, which were then adhered to the inner surface of the jacket i.e. near the skin. Air gaps between the macroPCM particles facilitate both heat and moisture transport through the jacket. The goal of PCM is to create reusable energy to maintain body temperature, as well as to optimize the performance of protective wear such as jackets. When the wearer's body temperature increases or decreases, the PCMs applied to the fabric will change state helping to regulate the wearer's body temperature by providing warmth or cooling. Maintaining a stable body temperature can improve working conditions and provides comfort.

Key Words: Phase Changing Materials, PPE, macrocapsules, MacroPCM.

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INTRODUCTION

Phase Change Materials (PCMs) have been suggested as latent energy storage materials. This theory derives from the use of chemical bonds to store and release heat. The thermal energy transfer occurs when a material changes from a solid to a liquid, or from a liquid to a solid. This is called a change in state, or "phase." PCM, proven to possess thermal-regulating characteristics, is proposed for applications in clothing materials in conditions that require workers to face extreme temperatures. PCM also is believed to conserve energy and maintain certain temperatures, so PCMs have been chosen for latent energy storage materials.

Cooling jacket fall into two categories: liquid- or air-cooled jackets and phase change material jackets. Liquid- or air-cooled jackets provide efficient cooling, but the worker is restricted in movement due to auxiliary equipment required to circulate the fluid. PCM jackets consist of a torso garment containing pockets surrounding the chest cavity that holds the PCM packs. Body heat carried to the surface of the skin by the circulatory system is absorbed by the PCM packs. A garment loaded with packs is completely unattached to any external devices, making it much more portable than liquid- or air-cooled garments. Cooling Jacket is required to diminish thermal discomfort in a moderately hot environment, designed especially for doctors and healthcare workers working 10-12 hours in PPE, continuous use of PPE cause discomfort and fatigue. Cooling jackets reduce body temperature and protect from heat stress and heat-related injuries, Ice packs on the other hand are difficult to carry and may even cause numbness in particular part of the body and cannot be used for long hours.



Fig 1: Discomfort of the doctor while wearing normal PPE kits

SOLUTION

PCM based Cooling Jacket has features like Lightweight and durable, cools in just 15-20 minutes, lighter than water vests, lasts longer than water-based vests, no wear and tear problem, provide cooling sensation for about 6 hours, no risk of ice burns or condensation, reusable; activate in freezer or simply cool water, non-toxic and environment friendly and doesn't require any separate, expensive equipment or electricity for charging.

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Fig 2: Prototype design

The cooling jacket was intended to be worn under a chemical protective garment. As coolants, encapsulated phase change materials in the form of macrocapsules were used.

The cooling effect is based on the latent heat absorption of phase change material; a highly-productive means of thermal storage. MacroPCMs were inserted into small knitted sacks, which were then adhered to the inner surface of the vest i.e. near the skin. Air gaps between the macroPCM particles facilitate both heat and moisture transport through the jacket.



Fig 3: Parts of Cooling vest

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Parts of Cooling vest

- 1) T-shirt
- 2) Cooling Jacket
- 3) PPE

METHOD OF PREPARATION

The first step involved dissolving three-isocyanate (Toluene- 2,4,6-triyltriisocyanate) in double amount of ethyl acetate in the homogenizer. Then n-eicosane or octadecane was added and the solution was stirred until it is completely dissolved. Next, PVA aqueous solution (5% weight) is added to the solution.

Once all chemicals were added, the solution is mixed in the homogenizer for ten minutes at a temperature of 40°C to create a completely homogeneous solution. Stirring is continued until polymerization occurred and the ethyl acetate is completely volatile. Macroencapsulated phase change materials (PCMs) are successfully prepared by in-situ polymerisation and interfacial condensation.

An interlock material can be made of a 35% cotton/65% polyester blend. The interlock material had two layers and between these layers was a coated PCM fabric.

All the layers were surrounded by PANEX, a woven carbon fabric, which formed an outer shell. This combination of layers would provide protection and cooling to the between the jacket.

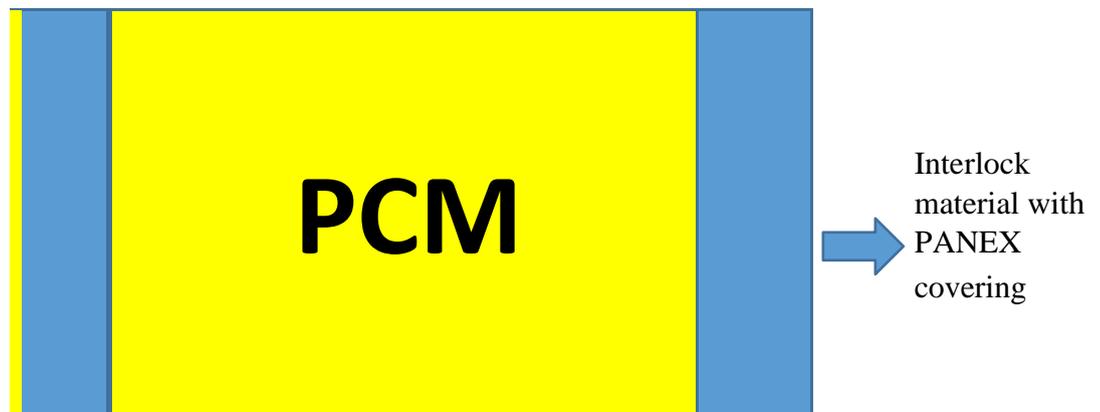


Fig 4: Pictorial representation of PCM with PANEX Covering

PROTOTYPE DESIGN



Fig 5: Representation of our design for our prototype

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COST

1. Toluene-2,4,6-triyltriisocyanate = 6000/100g
2. Ethyl acetate = 65/kg
3. N-Eicosane = 18000/kg
4. Octadecane = 17000/kg
5. Polyvinyl Alcohol (PVA) = 165/lt

Cost of 1 Jacket:

Toluene-2,4,6-triyltriisocyanate = 600 (10g)	Ethyl acetate = 1.3 (20g)
N-Eicosane	= 1800 (100g)
Octadecane	= 1700 (100g)
Polyvinyl Alcohol (PVA)	= 8.25 (50 ml)
TOTAL	= 2509.55 FOR 1 Jacket

If we compare the price of this vest with the reusable PPE kit developed by the Gujrat-based company named Sure Safety which says it charges about Rs 25 lakh to Rs 30 lakh including piping with one-time installation and decontamination chamber for a set of 10 PPE kits and additional kits being charged from Rs 10,000 to Rs 15,000, our prototype is way cheaper, non-toxic, easy-to-develop, safe, doesn't require extra equipment and maintenance and easily cleaned via soap water. Our prototype can stand out from the rest of the products currently in use as it is much safer than these products, especially in the time of COVID-19. [1]

APPLICATIONS OF COOLING JACKET

This jacket is useful for Doctors and healthcare workers working using current PPE kits, Military men working in harsh climate, Athletes while exercising, Fire Fighters, Workers working in industries at elevated temp and can be used in hospitals as chilling therapy

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