FINAL YEAR PROJECT REPORT

PCMs Incorporated Textile Laptop cooling pad

Project Advisor

Mr Haseeb Akram

Submitted By

Syed Ejaz Hassan Gillani	081120-101
M.Irfan Hayat	071020-108

School of Textile and Design (STD)

University of Management and Technology

PCMs Incorporated Textile Laptop Cooling Pad

Project Report submitted to the

School of Textile and Design (STD)

For partial fulfilment of the requirement for the degree of

BS Textile Engineering

By

Syed Ejaz Hassan Gillani	081120-101
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April 2nd, 2013

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ACKNOWLEDGEMENTS

In the name of Allah, the Most Gracious and the Most Merciful. Peace and blessings of Allah be upon Prophet Muhammad (P.B.U.H)

All Praise and thanks be to Allah. We praise and thank Him, ask Him for His help and forgiveness. We testify that there is no deity but Allah alone, without any partners, and that Muhammad (P.B.U.H) is His 'Abd (Worshiper) and Messenger Sallallahu 'AlaihiWaSallam.

We would like to express our gratitude towards our parents & members of UMT for their kind co-operation and encouragement which help us in the completion of this final project report and plant designing.

I take immense pleasure in thanking **Mr HaseebAkram***(Project Advisor);* ***Dr Nabeel Amin*** *(Director School of Textile and Design)*for having permitted us to carry out the work by guiding us through proper channel.

Words are inadequate in offering our thanks to STD faculty and staff for their attention, supervision& devotion.

ABSTRACT

Abstract

While you use laptop or notebook for a long period of time, you may realize that laptop get hot. Hot enough to toast your legs and it is very uncomfortable to continue using the laptop on your lap. The heat generates from laptop also reduce the lifetime of your internal components of laptop and make it halt and you need to restart your system. The project is to introduce Phase change material PCMs into Textile pad in order to prevent heating for sufficient long time and to protect your lap from the heat of the laptop. In order to do this we explain the types of material along with melting point and we detect the temperature of the laptop with different ways and according to that detected temperature we get the required chemical and introduced it into textile pad.

Chapter-1 Methodology

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1.1 Background knowledge

In order to do this project first we have to the basis of this project and the information regarding the material its working and its type and how the material could be incorporated into the Textiles

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1.1.1 What are PCMs

Phase Change Material

The process of “Phase Change” is the changing of one form or state of a material into another form and those materials which experience these changes are known as Phase Change Materials

During this process such materials absorb, store and release heat energy. Phase change materials are also known as “Latent Heat Storage materials”.[4]

1.1.2 History of PCMs

History of PCMs Development

NASA (National Aeronautics and Space Administration`s) research program in 1970 originates the Phase Change Material (PCM) technology.[1]

In 1950, Space suits were invented and NASA engineers were looking for garments which would be comfortable for astronauts and that would even protect them from extreme temperature fluctuations.[2]

Initially a liquid-cooled garment was developed by engineers from the Lyndon B. Johnson space centre. That space suit garment consisted of small channels that ran water through it and the design was categorized as an active control system by NASA and afterwards NASA went on looking for a passive control system.[2] There Research program identified many phase change materials in which “Lithium Chloride” was being used as PCM to protect there space instruments, however it was not suitable for normal Textile applications. NASA even used PCMs on Lunar Rover and Skylab projects.[3]

In 1987, Yvonne G. Bryant and David P. Colvin of Research and Development Corp explained the possibility of incorporating PCMs within textile fibres and the patent were issued in 1994.[3]

In 1987, NASA worked with Triangle Research and Development and develop the first encapsulated Paraffin in order to use in the space suits.[2]

Microencapsulation of PCM is required in order to incorporate PCM within fibre. The Netherland, Courtaulds fibres company has produced Acrylic fibres and in doing so this company found out a require criteria regarding microencapsulated PCMs, for example the particle size, uniformity of the particle of size, its stability towards chemical and mechanical actions, the ratio of core-to-shell etc.[3]

Many other companies like Hills Inc, West Melbourne, Fiber innovation Technology inc and SSRC in new Orleans etc have been doing research and development in PCMs in Textiles. [3]

1.1.3 Working Principle

Working Principle of Phase Change Material

Material can be found in four different states i.e. Solid, Liquid, Gas, Plasma while others like crystalline, colloid, glassy, amorphous are also considered to exist.[4]

When a material or substance changes from one form to another heat is absorbed or released and this absorbed or released heat is called latent heat as it helps to change the one form of material into another.[4]

Upon heating solid material changes from solid to liquid state and in this way it absorb large amount of heat from the surrounding until it reached its melting point because once the material is completely melted ,the storage of heat stops. The reaction which occurs from solid to liquid is “Endothermic reaction” as the heat is absorbed by the system and it causes “Cooling effect”.[5]

When the outside temperature drops the material turns back to solid from liquid state and release the amount of stored energy and in this way “Exothermic reaction” occurred hence gives a “Warming effect”.[5]

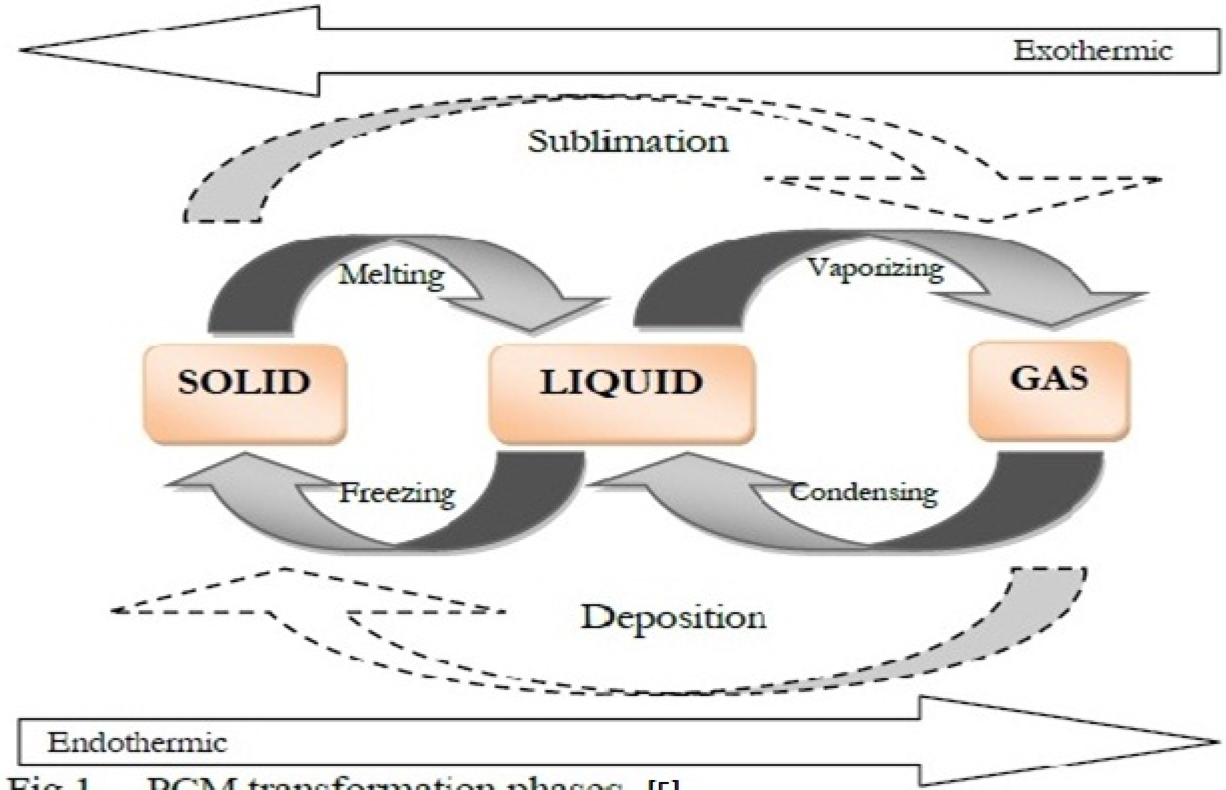

Fig 1 PCM transformation phases [5]

In order to compare the amount of heat absorbed by PCM in ordinary heating process, Water is taken as PCM. When ice is heated and it melts into water, in this process it absorbs approximately a latent heat of 335kj/kg. if water is more heated a sensible heat of only 4kj/kg is absorbed while the temperature rises by 1 Degree Celsius.[4]

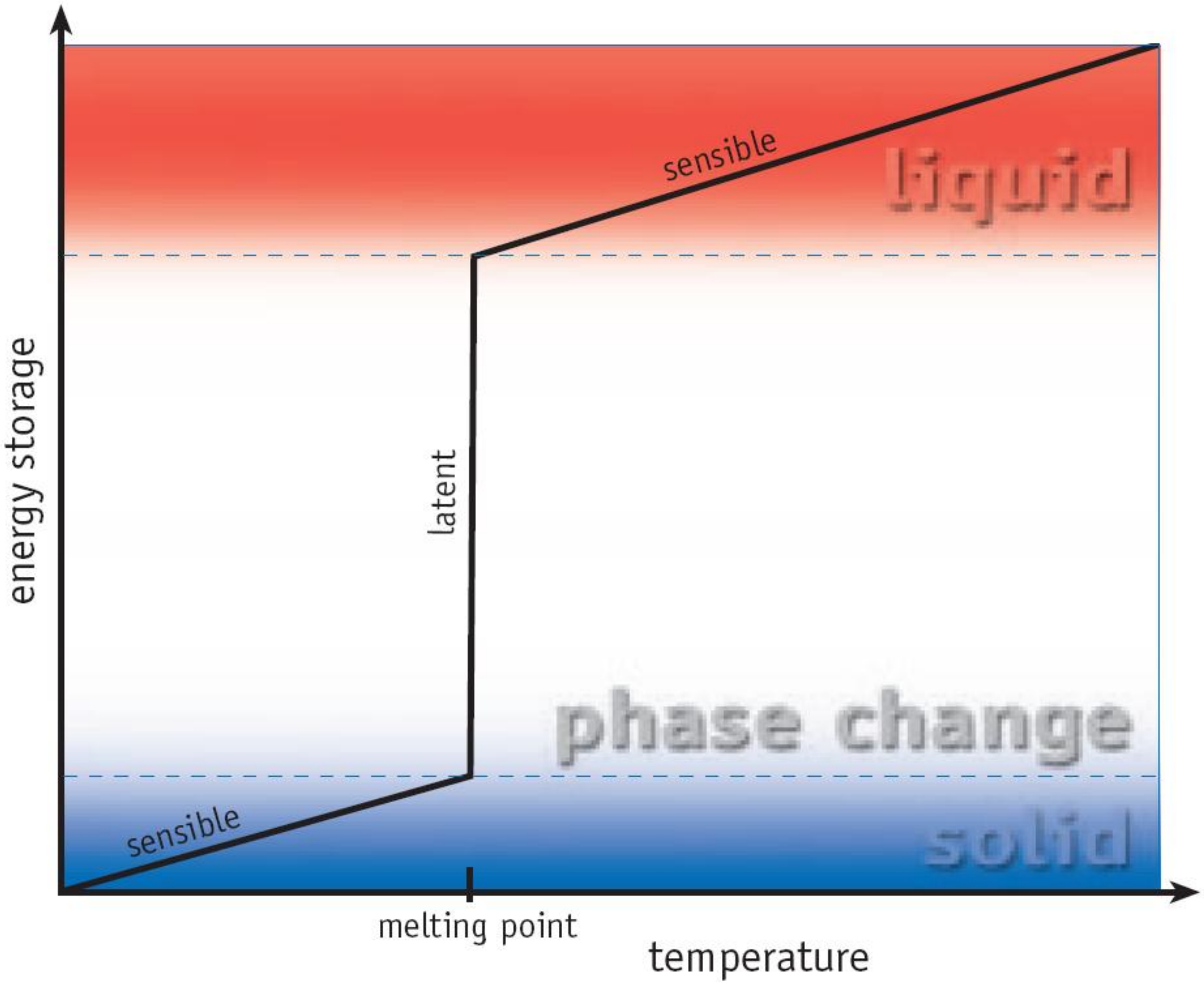

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Fig: 2 Comparison of sensible heat and latent heat [6]

From the above figure it is clear that the amount of energy absorbed by the solid is utilizing in breaking up the intermolecular forces of attraction between the molecules and in this way there no change in the temperature and the temperature remains constant while the material change its phase.[7]

1.1.4 Classification

Classification of PCM Materials

Phase change materials are classified as “Organic materials”, ”Inorganic materials” and “Eutectic”, in which Organic material and Inorganic materials are further classified as :

Organic Material: Paraffin’s, Parrafin waxes and Fatty Acids.

Inorganic Material: Salt Hydrates and Metallic’s

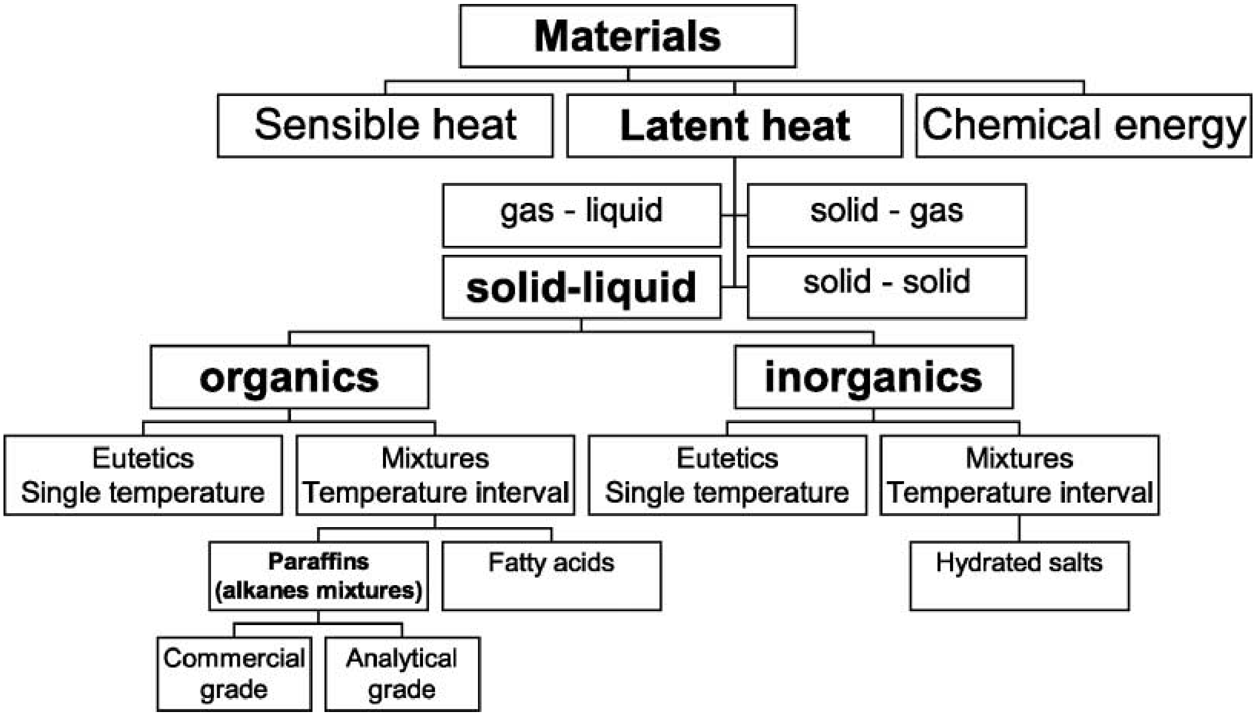


Fig:3 Classification of Phase Change Materials.[9]

There are large number of Organic and Inorganic compounds which can be taken as PCMs upon their melting temperature range and latent heat of fusion.

Paraffin's (Organic compound)

Paraffin's are made up of straight chain of hydrocarbons, n-alkanes CH3–(CH2)–CH3. The melting temperature of hydrocarbon can be increased in with the increase in number of carbon items.[4]

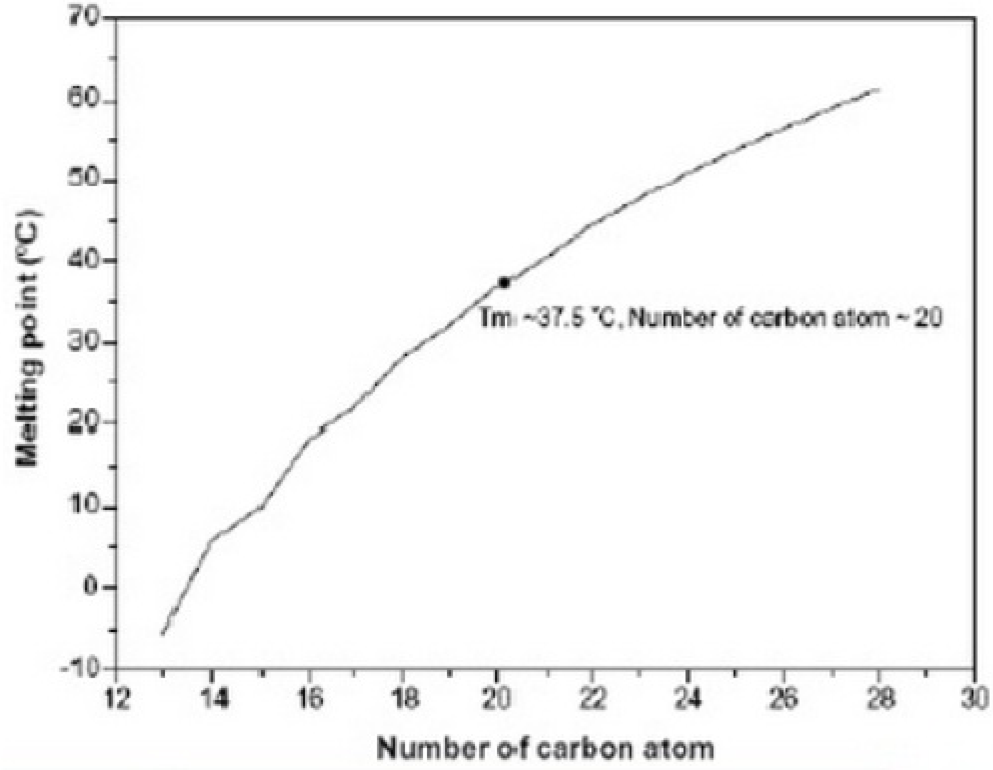


Fig: 4, *PCT vs No. of Carbon atoms [*1*]*

These materials have good thermal storage capacity and the materials are proven to freeze without supercooling. They also have the advantages of chemical stability over many heating and freezing cycles, The got high heat of fusion, they are non-corrosive, compatible with most all materials and non-reactive to most materials of encapsulation.[8]

Paraffin’s are chemically inert and stable below 500 C . Paraffin’s show little volume changes on melting and show low vapor pressure in the melt form. It show good nucleating and congruent melting properties. There are also few undesirable properties like low thermal conductivity, flammable and not compatible with the plastic containers but all can be eliminated by modifying the wax and the storage unit. [10]

Polyethylene glycol (organic compound)

“Paraffin waxes have the heat storage capacity of 150-200kj/kg with the PCT or melting temperature ranges from 35º C to 63º C. According to the end use of product different phase change temperature for PEG can be chosen as per Table: 2. The melting temperature for polyethylene glycol increases with increase in molecular weight.”[1]

Fatty acids (organic compound)

The general formula for describing all fatty acids is CH3(CH2)2n_COOH. They have high heat o fusion as compare to paraffin’s. Fatty acids have reproducible melting and freezing behaviour with no supercooling.There major problem is that they are 2-2.5 more costly than that of technical grade paraffin’s.[10]

Salt Hydrates (Inorganic compound)

The material comprises of inorganic salt and salt with formula $M \cdot nH_2O$, where M is an inorganic compound. The dehydration of hydration of the salt is actually the solid-liquid phase transformation of salt hydrates. Salt hydrates are very important PCMs because of there characteristics like high latent heat of fusion per unit volume, relatively high thermal conductivity also most twice of the paraffin’s, small volume changes on melting. These compounds are compatible with plastics as well and not very corrosive but slightly toxic. Mostly salt hydrate storage is inexpensive.

There are even few drawbacks of salt hydrates one of them is its incongruent melting occurs because the release water of crystallization is not enough or sufficient to dissolve all the present solid phase and this is due to the difference between the densities and in this way the anhydrous salt (lower hydrate) settles down at the bottom of the container.

Most salt hydrates have poor nucleating properties which results in supercooling of the liquid before crystallization beings. In order to avoid this situation add a nucleating agent.[8][10]

Metallics

This category has been not taken seriously for to be used as PCMs because of its weight issues. This category lies around low melting metals and metal eutectics. There few characterizes are low heat of fusion per unit weight, high heat of fusion per unit volume, high thermal conductivity, low specific heat and relatively low vapour pressure.[8],[10]

Eutectics

“A eutectic is a minimum-melting composition of two or more components, each of which melts and freeze congruently forming a mixture of the component crystals during crystallization. Eutectic nearly always melts and freezes without segregation since they freeze to an intimate mixture of crystals,

Leaving little opportunity for the components to separate. On melting both components liquefy simultaneously, again with separation unlikely.”[10]

Overall comparison of PCM Materials

Organic PCMs

Paraffin (C_nH_{2n+2}) and fatty acids ($CH_3(CH_2)_{2n}COOH$)

- **Advantages**
    1. Freeze without much supercooling
    2. Ability to melt congruently

3. Self nucleating properties
4. Compatibility with conventional material of construction
5. No segregation
6. Chemically stable
7. High heat of fusion
8. Safe and non-reactive
9. Recyclable

- **Disadvantages**
  1. Low thermal conductivity in their solid state. High heat transfer rates are required during the freezing cycle
  2. Volumetric latent heat storage capacity is low
  3. Flammable. This can be easily alleviated by a proper container
  4. To obtain reliable phase change points, most manufacturers use technical grade paraffins which are essentially paraffin mixture(s) and are completely refined of oil, resulting in high costs[11]

Inorganic

Salt hydrates (M_nH_2O)

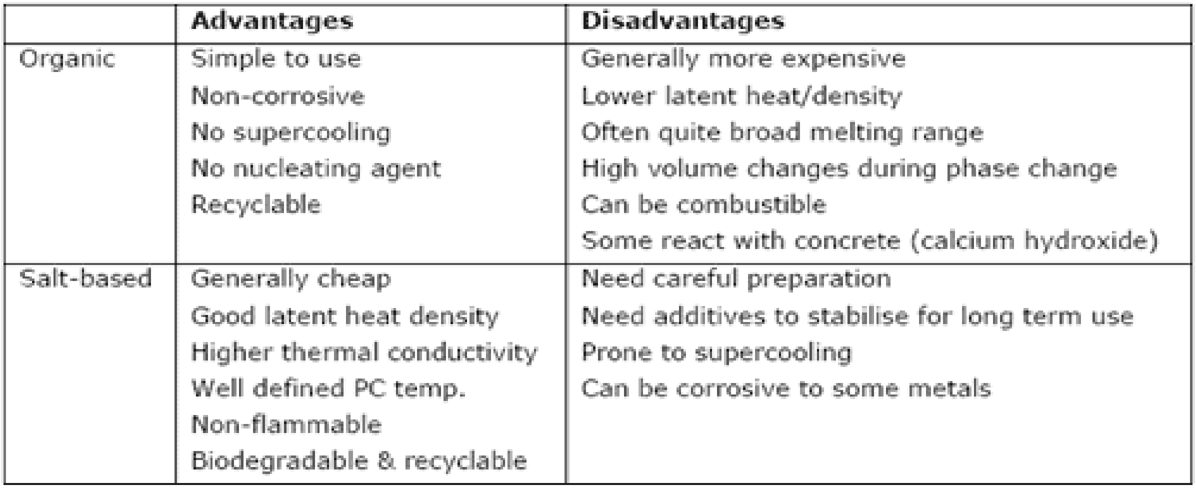
- **Advantages**
  1. High volumetric latent heat storage capacity
  2. Availability and low cost
  3. Sharp melting point
  4. High thermal conductivity
  5. High heat of fusion
  6. Non-flammable
- **Disadvantages**
  1. Change of volume is very high

2. Super cooling is major problem in solid–liquid transition
3. Nucleating agents are needed and they often become inoperative after repeated cycling[11]

Eutectics

Organic-organic, organic-inorganic, inorganic-inorganic compounds

- Advantages
  1. Eutectics have sharp melting point similar to pure substance
  2. Volumetric storage density is slightly above organic compounds
- Disadvantages
  1. Only limited data is available on thermo-physical properties as the use of these materials are very new to thermal storage application[11]



	Advantages	Disadvantages
Organic	Simple to use Non-corrosive No supercooling No nucleating agent Recyclable	Generally more expensive Lower latent heat/density Often quite broad melting range High volume changes during phase change Can be combustible Some react with concrete (calcium hydroxide)
Salt-based	Generally cheap Good latent heat density Higher thermal conductivity Well defined PC temp. Non-flammable Biodegradable & recyclable	Need careful preparation Need additives to stabilise for long term use Prone to supercooling Can be corrosive to some metals

Fig: 5 Advantage & Disadvantages [12]

1.2 Incorporated Technology

PCMs Incorporated Technology

There are various way of incorporating PCMs into textile .Coating, fibre technology, lamination, finishing, injection moulding, foam techniques some of the convenient processes for the incorporation of PCMs into Textile.

Spinning Method

In this process, solution of liquid polymer and fibre can be added with PCMs is then spun by the spinning methods such as melt, dry or wet spinning and extrusion of molten polymers. The extruded fibers/polymers could store and release heat according to the temperature of the environment.[13]

Coating

“To prepare the coating composition, microspheres containing phase change material are wetted and dispersed in a dispersion of water solution containing a surfactant, a dispersant, an antifoam agent and a polymer mixture. The coating would be then applied to a textile substrate. PCM could be incorporated into the textiles by coating using polymer such as acrylic, polyurethane, etc, and applied to
the fabric. There are various coating processes available such as **knife-over-roll, knife-over-air, pad-dry-cure, gravure, dip coating, and transfer coating.”**[13]

Lamination

In lamination technology the PCMs microcapsules mixed into a water-blown polyurethane foam mix and these foams applied to a fabric where the water is taken out by the drying process. It has low cost of production and give a light weight of textile is minimized.[10]

Microencapsulation

“Microencapsulation is the process of enclosing micro sized particles of solids or liquids droplets or gases in the shell structure called microcapsules. Particle size is below 1μm are known as nanoparticles, whereas particles size between 3-800μm are known as micro particles or microcapsules or microspheres. Particles larger than 1000μm are known as macro particles. Microcapsules that have wall less than 2 μm in thickness and 20-40μm in diameter is useful in textile application.

Micro particles have a number of interesting advantages (1) to protect the encapsulated substances from the external environment, (2) to mask encapsulated particles like color, odour and taste, (3) to obtain controlled release of the encapsulated PCMs materials, (4) to ease handling of powder-like materials, (5) to gets targeted release of the encapsulated substances, (6) to ease handling of toxic materials. The microcapsules are produced by depositing a thin layer of polymers on small solid or liquid particles, or dispersions of solids in liquids. The core materials in the shell structure may be released by friction, by pressure, by diffusion through the polymer wall, by dissolution of the polymer wall coating.

Microencapsulated materials containing PCM are called encapsulated PCM-microcapsules. The encapsulated paraffin is coated or finished on the surface of the textile material using conventional or unconventional methods".[13]

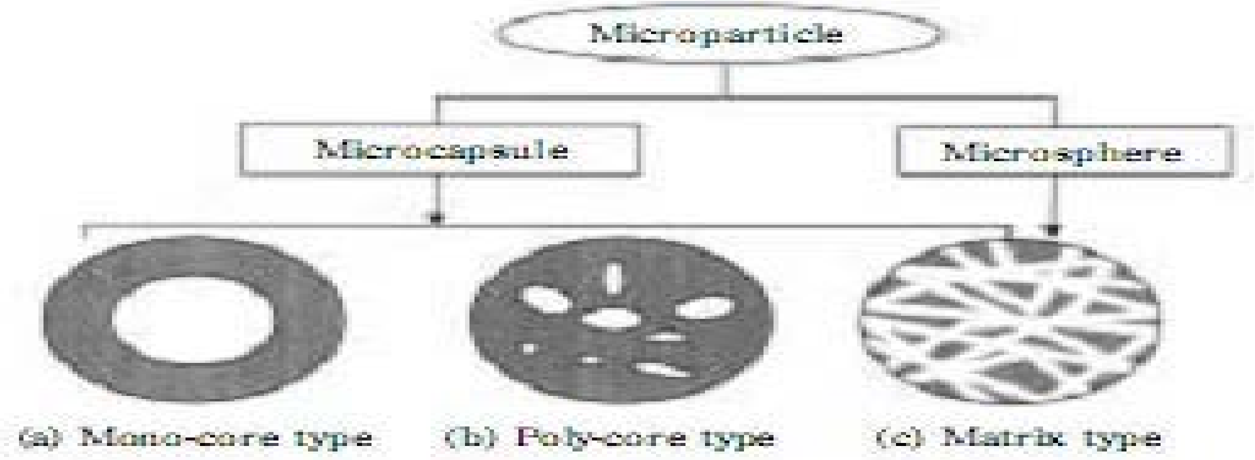


Fig no 6 Classification of Microparticle [13]

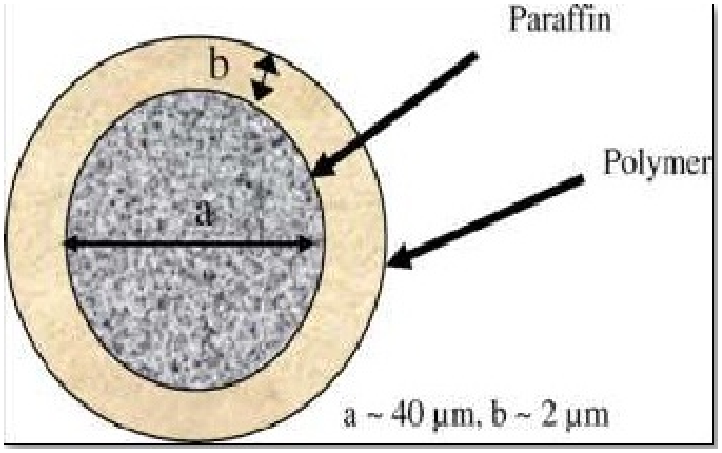


Fig no 7 Parrafin PCM core material with hard polymeric shell [4]

Microencapsulation Techniques

Here is the list of few techniques through which microcapsules can be formed.

1. In-situ Polymerization
2. Interfacial polymerization method
3. Chemical coacervation method
4. Spray drying method
5. Solvent evaporation method
6. Fluidized bed method[13]