SMART TEXTILES CREATED BY THE APPLICATION OF PHASE CHANGE MATERIAL (PCM)

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A Phase Change Material (PCM) absorbs or releases a large amount of so-called “latent heat” when it melts or crystallizes in a material-specific temperature range.

The temperature of the PCM remains constant during the entire phase change process.

Example: ice/water phase change.

The fact that a large amount of latent heat is absorbed or released without any temperature change makes a PCM highly desirable as a means of heat storage.
Phase change materials (PCMs) are characterized by:

- Phase change temperature range,
- Latent heat storage capacity.

Common PCMs:
- Paraffins,
- Salt hydrates.
Thermal Effects Provided by the PCM

- Cooling effect by absorbing latent heat,
- Heating effect by releasing latent heat,
- Thermo-regulating effect by an alternating absorption and release of latent heat.

Influences on efficiency and duration of the PCM’s thermal effects:
- Latent heat storage capacity of the PCM,
- PCM-quantity,
- Trigger temperature,
- Product design.
Containment

Microencapsulated PCMs in fibers, yarns, nonwovens or foams.

PCM macro-encapsulated in various coating compounds.
Applications of Textiles Treated with PCM
Heat Flux Control Feature

In a garment application, the PCM controls the heat flux through the garment layers by either absorbing or releasing latent heat.

1. Body heat release > heat flux through the garment
⇒ Latent heat absorption by the PCM.

2. Body heat release < heat flux through the garment
⇒ Latent heat release by the PCM.
Adaptive Thermal Insulation Properties of Textiles with PCM Treatment

- By controlling the heat flux through the garment layers, the PCM adapts the thermal insulation of the garment system to prevailing needs.

- Thus, textiles equipped with PCM possess adaptive thermal insulation properties.

- Because of the temperature-initiated adaption of thermal insulation properties, textiles treated with PCM are considered to be “smart” materials.
A computer simulation procedure is used for:

- PCM-selection
  (based on the operation temperature range),
- Determination of the necessary PCM quantity
  (based on the desired duration of the thermal effects),
- Product design,
- Simulation and determination of long-term thermal effects
  (based on heat balance calculations).
PCM Selection

Ski suit ensemble

Temperature in °C

Ambient temperature: 5 °C

Ambient temperature: -15 °C

Underwear - Sweater - Liner - Insulation - Shell layer
Determination of the PCM Quantity

Activity simulation and heat balance calculation:

Body heat release = heat transfer through the garment
+/- latent heat absorption / latent heat release by the PCM

1: walking  2: standing  3: sitting  4: skiing

Skiing

Heat transfer/release in kJ

Time in minutes

Body heat release during activities
Heat transfer through the garment system
Measurements of the Adaptive Thermal Insulation Properties

- Transfer of the PCM’s latent heat absorption / latent heat release into insulation terms,
- Separation of the basic thermal resistance $R_B$ of the textile carrier material and the temporary “adaptive thermal resistance” $R_A$ provided by the PCM integrated therein.
- This allows for a comparison of the thermal performance of textiles with and without PCM treatment as well as textiles with different variants of PCM treatment.
Tests of PCM treated textiles show significant differences in thermal performance due to variations in the carrier material’s structure, the PCM quantity and the latent heat storage capacities.
The application of PCMs adds a thermo-regulating feature to textiles which controls the heat flux through the material and adapts the heat flux to prevailing needs.

Because this thermal effect is triggered by temperature, textiles with PCM treatment are considered to be “smart” materials.