New Energy Efficient Roofing Materials With Phase Change Material (PCM) Treatment

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Introduction

Problem:

The roof is a weak point in a building's thermal performance.

Hot days: the living space underneath the roof gets overheated, leading to the decrease in thermal comfort.

Cold nights: significant heat loss through the roof, increased heating loads on the building.

Solution: Application of phase change material (PCM), a highly productive thermal storage medium.

Two Types of Heat Storage

Latent Heat Storage

Change in physical state

Heat absorption during the melting of 1 kg ice into water at 0° C:

335 kJ/kg

Sensible Heat Storage

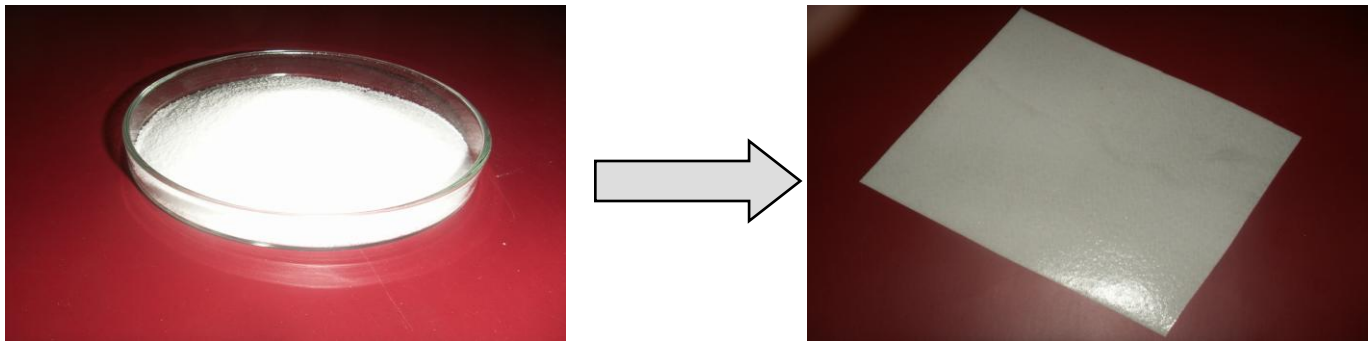
Change in temperature

Heat absorption during the heating of 1 kg water (C = 4.19 kJ/kg K) from 1 ° C to 84 ° C:

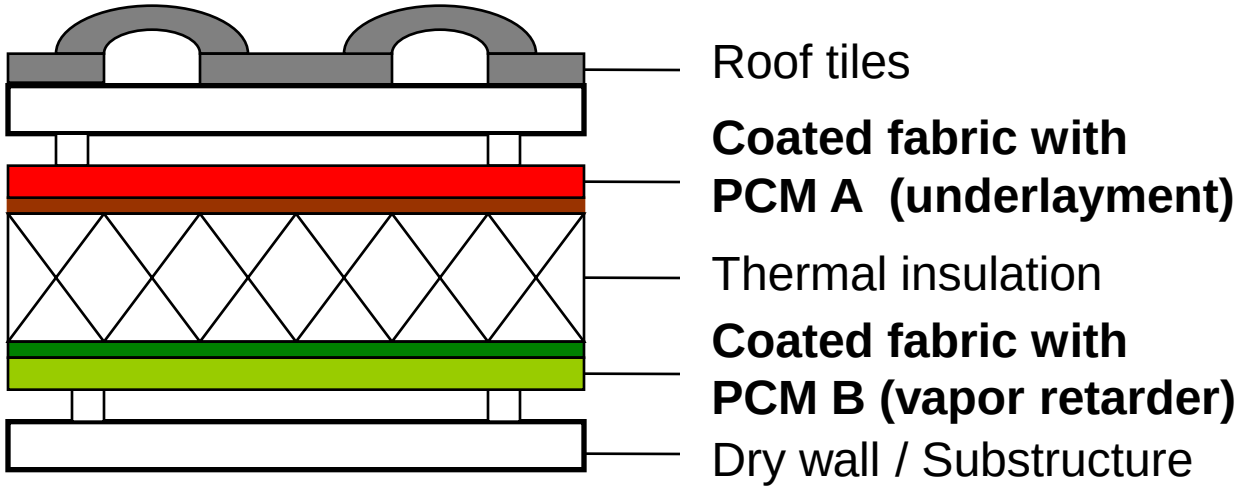
335 kJ/kg

Building Materials with PCM Treatment

- Non-combustible salt hydrate PCMs (A and B) with latent heat storage capacities of about 340 kJ/kg (146 Btu/lb) (PCM A) and 280 kJ/kg (120 Btu/lb) (PCM B) are used.
- PCMs are integrated into a silicone rubber coating compound which is then applied to a textile carrier material by knife over roll coating.



Arrangement in a Roof System



Technical Data of the PCM based Building Materials

Material	Underlayment with PCM A	Vapor retarder with PCM B
Latent heat absorption	55 ° C (131 ° F)	25 ° C (77 ° F)
Latent heat release	50 ° C (122 ° F)	20 ° C (68 ° F)
Latent heat storage capacity	450 kJ/m² (355 Btu/yd²)	300 kJ/m² (237 Btu/yd²)
Weight	1.3 kg/m²(2.4 lb/yd²)	1.1 kg/m² (2 lb/yd²)
Thickness	2 mm (0.08 in.)	1.5 mm (0.06 in.)

Thermal Effects

- Latent heat absorption of the PCM A on hot days reduces heat flux **into** the building (passive cooling system).
- Latent heat release of the PCM B in cold nights reduces the heat flux **out of** the building (decreased heating demands).
- PCM therefore controls the heat flux through the roof, adapting the roof's thermal insulation to prevailing needs.
- Adding PCM creates "smart" building materials.

Benefits

The PCM's heat flux control feature leads to

- Enhanced comfort,
- Decreased heating and cooling loads on the building,
- Improved energy efficiency.

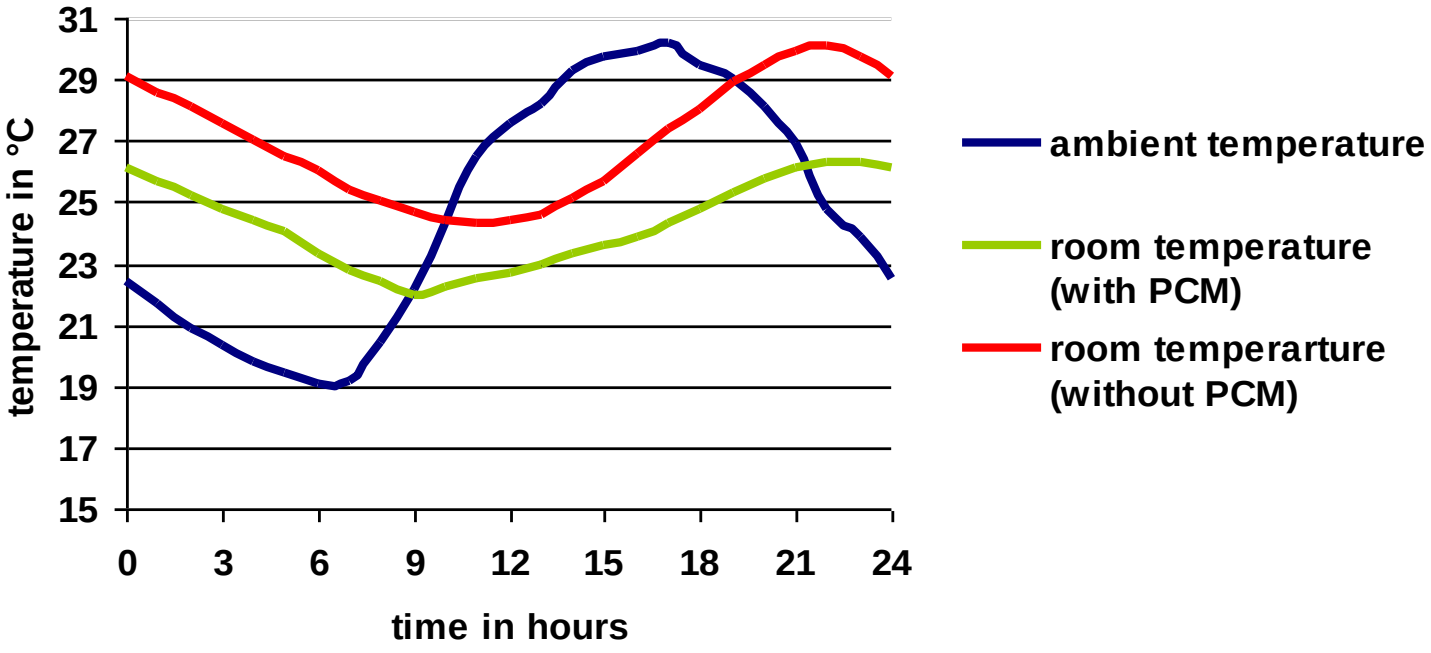
Specifically, the PCM application in the roof eliminates peak energy demands.

Studies

Temperature measurements and computer simulation carried out on a residential building located in Germany.

PCM application in the entire roof with a size of 130 m^2 (1,400 ft^2) leads to a latent heat storage capacity of about 97,500 kJ (92,412Btu).

Temperature Measurements



Energy and Cost Savings

Energy savings:

- **Decreased heating demand: up to 25 %,**
- **Decreased cooling demand: up to 40 %.**

Cost savings for residential building in Germany:

- Annual heating demand: 13,500 kWh
  (heating costs of about € 1000),
- Annual savings in heating energy: 3,300 kWh
  (cost savings of about € 250),
- Annual reduction of CO_2-emissions: 0.9 tons (1800 lb),
- Investment payoff in about 5 years.

Conclusions

Newly-developed PCM-based building materials offer substantial improvements in the thermal management of buildings which, in turn,

- leads to enhanced thermal comfort,
- reduces the building's heating and air-conditioning demands,
- improves the energy efficiency of the structures.