Issues of modelling PCM: A case study in EnergyPlus Simulation

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The Mark Group
1. Phase Change Materials
   – Definitions,
   – Applications,

2. Energy Plus
   – Simulation process,
   – Systems currently utilising the software,
   – Layout & options,
   – PCM incorporation

3. Case Study
   – PCMs in a simple Solid Brick building

4. Q & A
Phase Change Materials

‘Unique materials that store/release heat in latent form as they change phase from solid to liquid and vice versa’
PCM Applications

Clothing, Air Conditioning, Building Materials............

Any overheating control system
PCMs in Action

PCM -23 melting point reached

Indoor Environment

Wall
PCM Thermal Properties

Thermal Conductivity / $k$-Value (W/m.K)

Density / $\rho$-Value (kg/m$^3$)

Specific Heat Capacity / $C$-Value (J/kg.K)

Enthalpy and Heat of Fusion (J/kg)
Octadecane (26°C MP)
EnergyPlus – Simulation Process

Graphical Interface

Compiler

Results Viewer

Plug-in

Autodesk Ecotect

NREL

Tas

Dynamo

DesignBuilder

Bentley HEC

ACOMP
EnergyPlus – Simulation Process

1. Manual
2. Automatic
3. Combination
EnergyPlus - PCM Incorporation

Graphical Interface

Google SketchUp

ONREL

Compiler

Individual Data File (IDF)

PCM Enthalpy (J/kg)

DSC

Guassian Equation
EnergyPlus - PCM Incorporation

\[ C_{eff} = C_{Sensible} + C_{Latent} \]

\[ C_{Latent} = Ae \]

\[ A = \text{Enthalpy Coefficient (~ half PCM Heat of Fusion)} \]

\[ B = \text{Melting Width Coefficient (Purity ~ 0.1 – 1.0)} \]
EnergyPlus - PCM Incorporation

Graphical Interface

Compiler

Individual Data File (IDF)

Guassian Equation

PCM Enthalpy Values (J/kg)
Case Study – Building Simulation Parameters

1. Simple (225mm) solid brick building (*Constructions & materials*)
   - Roof and Floor: insulated to Building Regulation standard U-Values
   - Ventilation and Air tightness: Openstudio Defaults
   - Walls insulated internally with *Mineral Fibre*, U-Values:
     • Before: \(3.0 \text{ W/m}^2\cdot\text{K}\)
     • After: \(0.3 \text{ W/m}^2\cdot\text{K}\)

2. PCM Parameters
   - Thermal \((k, C_s, \rho, \text{ etc})\): based on BASF Micronal PCM
   - Incorporated into 12.5mm of Finishing Plaster
   - Simulated at 3 separate melting points: \(18^\circ\text{C}, 22^\circ\text{C}, 26^\circ\text{C}\)
Case Study – Building Simulation Parameters

3. Location: London (Climate)

4. Hot Period: 1\textsuperscript{st} – 15\textsuperscript{th} July (Weather conditions)

5. Occupied: Day time (Openstudio default Schedules)

Case Study – Building Simulation
Case Study Conclusions

1. Under the simulations limitations, PCMs reduced the impact of overheating, provided that:
   - The melting point is set to an appropriate value, i.e. In the centre of the comfort zone
   - A suitable quantity of PCM is used

2. If available results from a Differential Scanning Calorimeter (DSC) should be used in the simulation to improve accuracy

3. PCMs should not be considered as a full solution to overheating, in certain circumstances alternative cooling would be required
QUESTIONS???

Software Sources:
http://openstudio.nrel.gov/
(Note: ensure you follow the user documentation)

http://sketchup.google.com/
http://apps1.eere.energy.gov/buildings/energyplus/

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