Thermal Performance Test of Cellulose Insulation Imbedded with Phase Change Material

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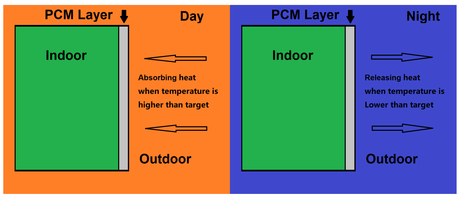
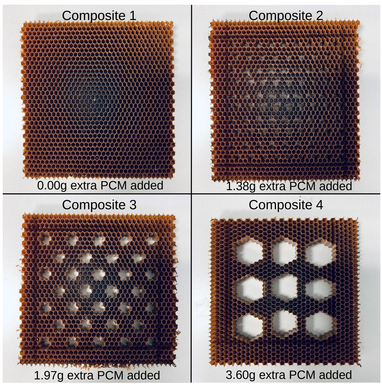
Introduction

Over the past decades, phase change material (PCM) has become one of the main topics of energy efficiency enhancement due to its latent heat storage capability.

Phase change materials are substances which absorb or release latent heat when changing their physical state. Imbedding PCMs into building walls has been an effective method to reduce the energy consumption and enhance the feeling comfort in the building.



Materials and Methods

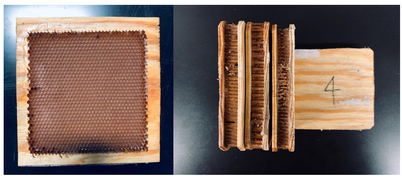


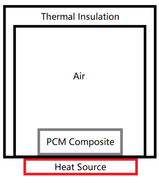
- Top and bottom surfaces: southern yellow pine veneer.
- Mid-layer honeycomb: 4.5*4.5*0.5 inch, standard 1/8 inch cell.
- Phase change material: paraffin wax, melting point at 55°C (similar thermal properties with paraffin wax melting point at 25°C) .
- Glue: epoxy resin.

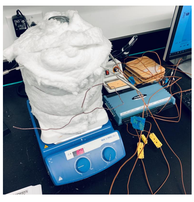
The PCM composites were prepared by filling and sealing the PCM into veneer honeycomb sandwich structure with several different cut opening sizes on the honeycomb mid-layers.

Different sizes of holes were cut on the honeycomb layers showing on the left. By calculating the volume of honeycomb structure loss, the weight of extra PCM added could be calculated.

The honeycomb layers were glued on the bottom surface veneers first. As the epoxy cured, the melting PCM was precisely filled into the honeycomb showing on the right. The top surface veneers were glued on the honeycomb layers after the PCM had been in solid state.
A control group of veneer-honeycomb composite was fabricated without PCM filled in.



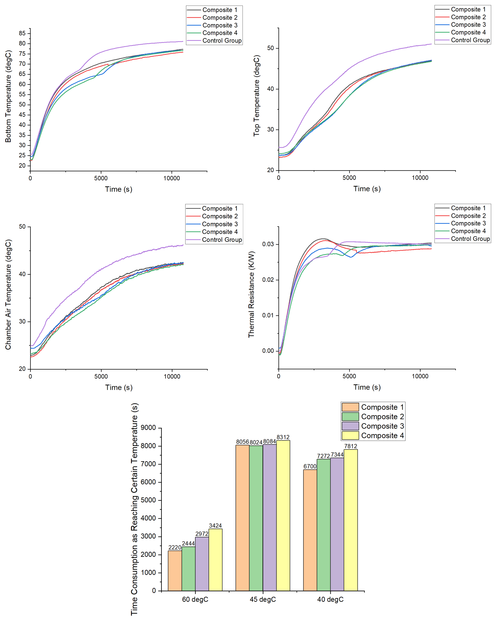




The PCM composite was placed into a glass chamber. Two thermocouples were taped on both bottom and top surfaces, the other thermocouple was set at the center of the chamber to monitor the air temperature.
The chamber was evenly covered with thermal insulation materials and placed on a heat source with constant temperature of 80°C and power of 1000W.
The temperature data collected was converted and transferred to the computer by the device of Omega Engineering OMB-DAQ-2416.

Results and Discussion

- These charts on the right show that PCM composite with greater extra weight value, has the lower bottom, top, and air temperature profiles during the period of phase changing process.
- This chart at the bottom right shows the relationship between thermal resistance and time. During the phase changing period, the volume of honeycomb structure decreasing causes the thermal resistance reduced, at 3600s, comparing with composite 1, thermal resistance of composite 2, 3, and 4 reduced 0.76%, 0.716%, and 1.224%.
- Comparing with composite 1, the time consumptions of bottom surface and chamber center air increased as reaching certain temperature, no significant difference observed of the time consumption of top surface.
- The volume of phase change material increasing causes the time consumption added, at the moment that air temperature reached 40°C, the time consumption of Composite 2,3, and 4 increased 8.54%, 9.61%, and 16.60%.



Conclusion

With replacing honeycomb structure of 1.54cm^3, 2.19cm^3, and 4.00cm^3 instead of same volume of PCM:

- The thermal resistance at the time of 3600s (phase changing process), reduced 0.76%, 0.716%, and 1.224%;
- The time consumption of chamber center air temperature reaching 40°C increased 8.54%, 9.61%, and 16.60%.