Experimental Study on the Thermal Performance of a PCM Panel with Mach-Zehnder Interferometry

Fabio Almeida[1,*], Wey H. Leong[2] and Alan S. Fung[2]

[1]Morrison Hershfield, 4321 Still Creek Dr #310, Burnaby V5C 6S7, Canada.
[2]Ryerson University, 350 Victoria Street, Toronto M5B 2K3, Canada.
[*]Corresponding Author: Fabio Almeida. Email: falmeida@morrisonhershfield.com.

Abstract: An experimental study was performed to measure the convective heat transfer and thermal decay of a vertical PCM (Phase Change Material) panel. The PCM (soy wax) was enclosed in a thin acrylic shell with an insulated perimeter. The panel was heated to 70°C and allowed to cool by natural convection to room temperature. The experiment captured the transient thermal behaviour of the panel in free convection during liquid and solid phases, and during phase change. Near temperature field visualization and convective heat transfer measurements were obtained using Mach Zehnder Interferometry at one-minute intervals. Finite fringe interferograms were used to obtain surface temperatures and used for heat transfer analysis along with embedded temperature sensors in the panel. Convective heat transfer coefficients were obtained from optically measured surface temperatures and near-wall temperature gradients and where compared to Nusselt number correlations. During solidification, significant sub-cooling was observed resulting in a temperature jump of approximately 4.2°C. This temperature jump occurred initially at the bottom of the panel and propagated upwards before returning to free convective cooling. During the sensible heat transfer portions of the experiment, the measured heat transfer coefficients were within ±1% and ±4% of Nusselt number correlations for the liquid and solid phase portions respectively. During the phase change portion, the Nusselt number correlations over predicted the convective heat transfer coefficient up to 14% over the optically measured convective heat transfer coefficients. This is partially a consequence of the variation of surface temperature during phase change. The largest deviation in the convective heat transfer coefficient coincided with the onset of the averaged temperature jump.

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