Investigation of Thermal Energy Storage In Residential AC Systems

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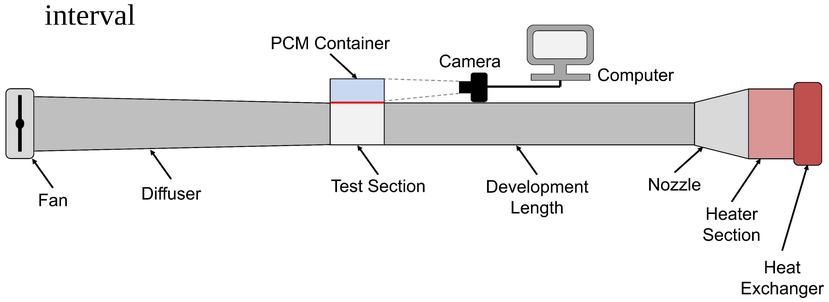
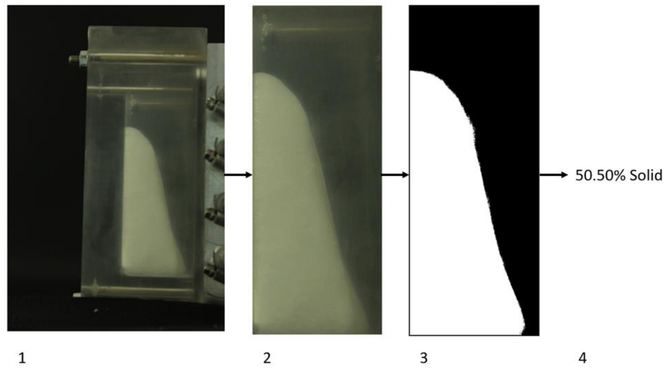
Experimental Methodology – Melt Front Analysis

- The Heat Exchanger Test Loop (HXTL) is shown below, with temperature control via the heat exchanger at the inlet, and velocity control via the fan at the outlet
- Selected test section temperatures and velocity will be chosen based on the tested PCM
- A camera will be used to track the melt front development through images taken at a side profile of the PCM container. Images will be collected and saved on a computer at a set time interval



Data Collection

- The raw image will be imported into MATLAB, cropped to the desire size, and then converted into black-and-white to define the areas of the image that represent the solid and liquid PCM
- From this developed image a liquid fraction will be determined by comparing the number of cells that are black versus the number of cells that are white



- When completed for all the collected images of a given melt, a melt fraction versus time graph will be created to study the phase change and create a benchmark to be used for potential future numerical simulations

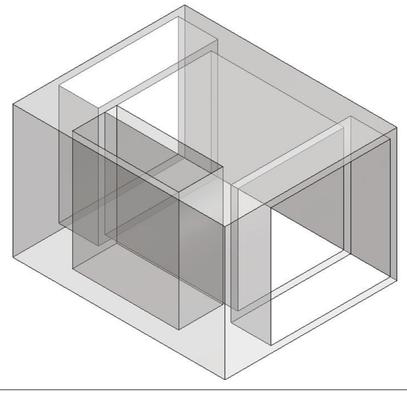
Background

Extensive work has been completed to investigate various PCMs with respect to their melting characteristics under different system variations, including adjustments into the enclosure's aspect ratio, new additions to the internal geometry using fins, alterations to the enclosure's orientation with respect to the heated boundary condition, and variations of the boundary condition.

Published works investigating the melting of PCM in rectangular enclosures use either isothermal or constant heat flux boundary conditions. This current modeled system will use a convective boundary condition to evaluate a more realistic performance of how a TES system could be incorporated into a residential air-conditioning system.

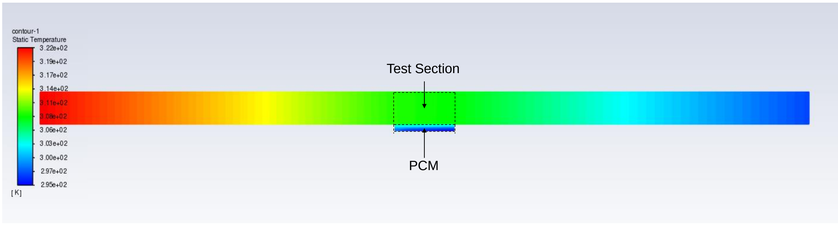
Test Section Design

- Either end of the test section is designed larger than the internal dimensions of the HXTL to allow the part to be press fit onto the development length and diffuser
- The PCM container will be cut out of the acrylic with interior dimensions selected based on a scaled down version of a separate rectangular enclosure experiment
- A resin-printed cap will be attached to the top of the container to minimize heat loss to the environment
- A thin wall will be used at the interface between the PCM container and the internal flow of the test loop to ensure a convective boundary condition can be assumed

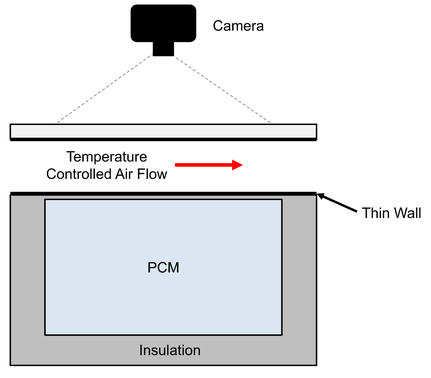


Liquid Crystal Thermography

- Liquid crystal thermography (LCT) is a useful, non-invasive and non-destructive tool to visualize temperature measurements on a surface for fluid flow experiments
- LCT uses thermochromic liquid crystal (TLC), temperature sensitive material that changes the reflected light from the visual spectrum based on the temperature of the material it is applied to
- The test section is modeled and simulated in ANSYS Fluent to determine the sufficient test section length to observe melting
- An example of a simulation run is shown in the image below. Initially, the test section was modeled as a 2-D parallel plate channel, however after further investigation, the system should be modeled as a 3-D square duct



- A second test section will be created with the newly selected length for the PCM container
- Data collection will be completed with a camera to photograph the LCT sheet on the thin interface wall throughout the duration of the melt.



- Setup of imaging will need to remain constant, with negligible changes in ambient lighting after calibration
- Temperature data can be collected from the images, and this could later be compared to numerical simulations as another form of validation