Investigation of Thermal Energy Storage In Residential AC Systems

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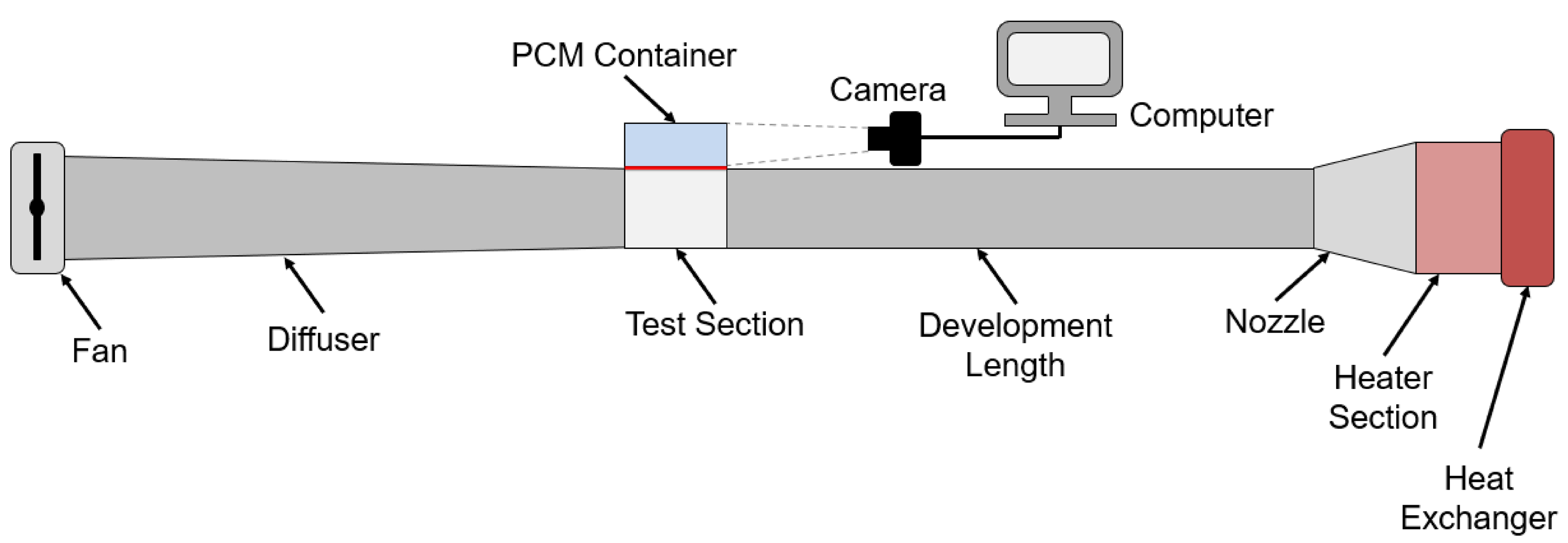
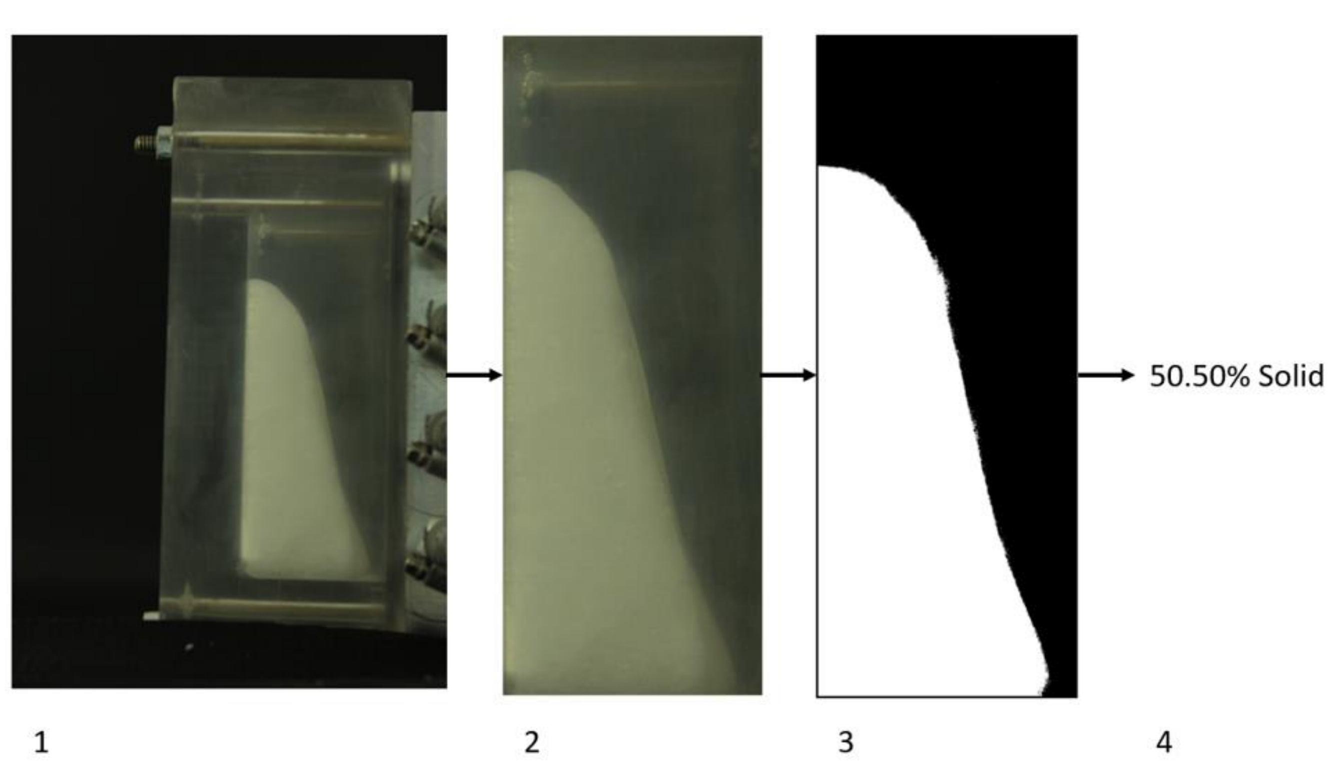
Experimental Methodology – Melt Front Analysis

- 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

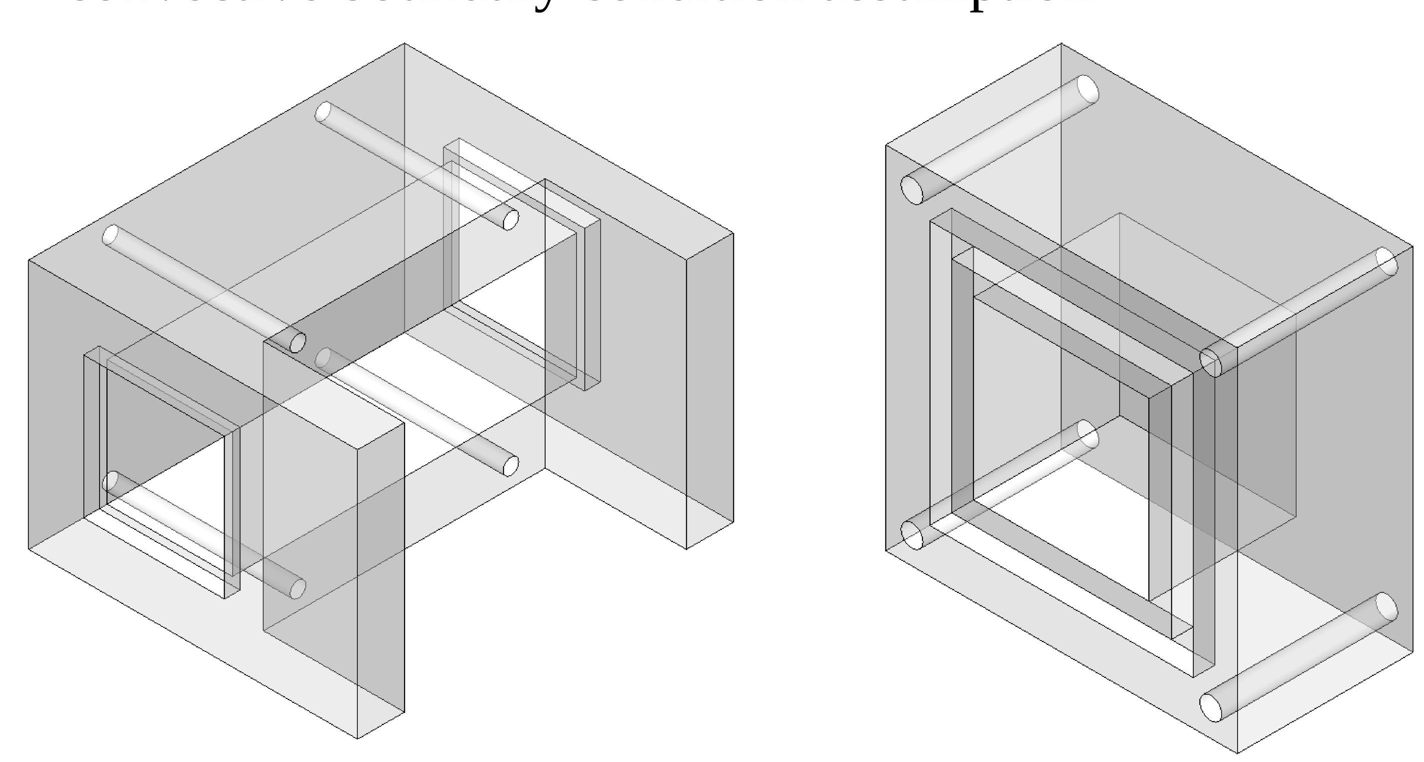
Background

Extensive work has been completed to investigate various PCMs with respect to their melting characteristics under different system variations such as alterations to PCM container aspect ratio and studied boundary conditions.

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.

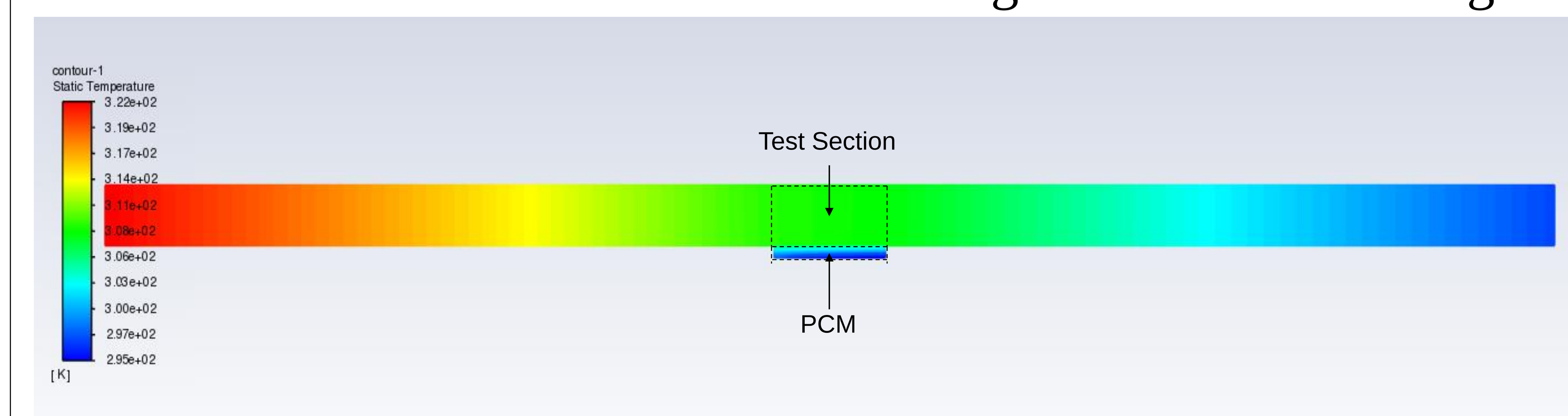
Test Section Design

- The initial design was to be 3D resin printed, and would contain a preselected size for the PCM container
- Issues arose with clarity of the part as well as whether the thin printed wall could be considered as a convective boundary condition
- The design was changed to a modular system containing, allowing for future investigations into PCM containers of differing aspect ratios
- Shown below is the new acrylic test section and PCM container, respectively. The system will be secured with four bolts, and an o-ring will be used to prevent leakage. The new design for the thin wall will be a piece of aluminum, which should allow for the convective boundary condition assumption



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), a 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



- Data collection will be completed with a camera to photograph the LCT sheet on the thin interface wall throughout the duration of the melt.
- Temperature data can be collected from the images, and this could later be compared to numerical simulations as another form of validation

HXTL Benchmarking

- Benchmarking has been carried out and will continue as the project progresses
- As part of checking for leaks, pressure drop through the new test section will be validated utilizing pressure taps
- The mean velocity will be checked for magnitude and unsteadiness using a pitot tube rake for mean velocity as well as a hot wire anemometer for unsteadiness to pair with Reynold's number calculations
- An example of previous benchmarking can be seen below