Accurate measurements and comparisons are essential to progress in any technical field. When it comes to fenestration (window) systems, performance regarding the resistance to heat transfer through the window is a very important measurement. Heat transfer through windows leads to higher cooling loads in the summer, and higher heating loads in the winter, directly affecting energy usage.

To give a fair comparison of new window technologies, it is important that they are tested according to standardized methods. This summer research project’s goals involve the design and construction of a testing system used to evaluate the performance of fenestration systems.

The objective was to design and construct a testing system that meets the following criteria:
- Accommodate windows 36 inches by 36 inches
- Achieve ASTM and NFRC designated testing conditions
- 0 F on the cold side
- 70 F on the hot side
- Relatively even temperature distribution on the panel surface
- Steady state conditions to within 1K
- Hot and cold side air circulation simulating indoor and outdoor conditions

Thorough computer design and simulation
We used Autodesk Inventor and Autodesk Simulation Multiphysics extensively to simulate design conditions and help us choose effective materials and designs. Also, transient thermal simulation was performed on the hotbox to help give us a realistic estimate of the time constant for the system.

Cost effective construction
Because of the limited budget at hand, we had to be careful about selecting materials and instrumentation with which to design the hotbox. Based on the simulations we performed, we decided upon a wood and rigid foam construction, where the wood would provide structural rigidity and the foam would provide thermal insulation. In order to cool the cold chamber, a laboratory-grade refrigeration system would be far too expensive. Instead, we bought a chest freezer and designed a circulation system that would direct air through the freezer.

At this stage, we have not been able to achieve the required temperature on the cold side. Increased refrigeration capacity will without a doubt allow the system to reach equilibrium at the required temperature, and will allow successful testing to take place. A freezer with greater capacity is being installed, and will allow for further testing.

Based on calculations using early steady-state analysis values, we estimated the thermal resistance of the test panel (2 sheets of insulating foam, R=10) to be R=12.8. This is a validation of our method, especially at this stage in the project and with rudimentary data.

The larger temperature difference obtained through the addition of a new freezer should help increase precision of measurement of the R-value due to the larger temperature difference.

References