Passive Thermal Control for Window Insulation

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Introduction: Window's are a thermal weak point in the building envelope. Roughly 40% of all building energy use in climates with a defined heating season is for space and water heating [1]. There are energy (and thus environmental), and financial consequences associated with relying on active systems to meet the dynamic heating and cooling loads of the Canadian climate.

Operable (movable) insulation is a viable solution to this problem, particularly overnight, when views and solar radiation are unavailable.

The main drawback, is that these systems are often in static configurations and require manual user operation (see figure 1). This can lead to a number of problems, including window overheating - a cause for potential damage [2], and more importantly; it can form a restriction to passive building heating from potential solar heat gains through the glazing.

A superior control scheme could solve these problems

Figure 1. *Experimental setup with a static operable insulation system and thermocouples*

Computational Methods: Conjugate heat transfer with radiation, and the moving mesh (ALE) modules were used to model the problem.

The model geometry consists of 2 meter wide sections of the wall construction surrounding the windows, spanning the height of the first and second floors (see figure 2).

Figure 2. *Geometry and plot of iso-thermal contours through the construction*

Model Highlights include; use of spectral bands to account for behaviour of modern glazing, accurate solar positioning, and component couplings to inform the displacement of movable components.

Results: The simulation is compared with the collected data (see figure 4), which was measured at four surfaces throughout the window /insulation assembly. The COMSOL results (grey) were taken from the same location as the insulation thermocouple (orange).

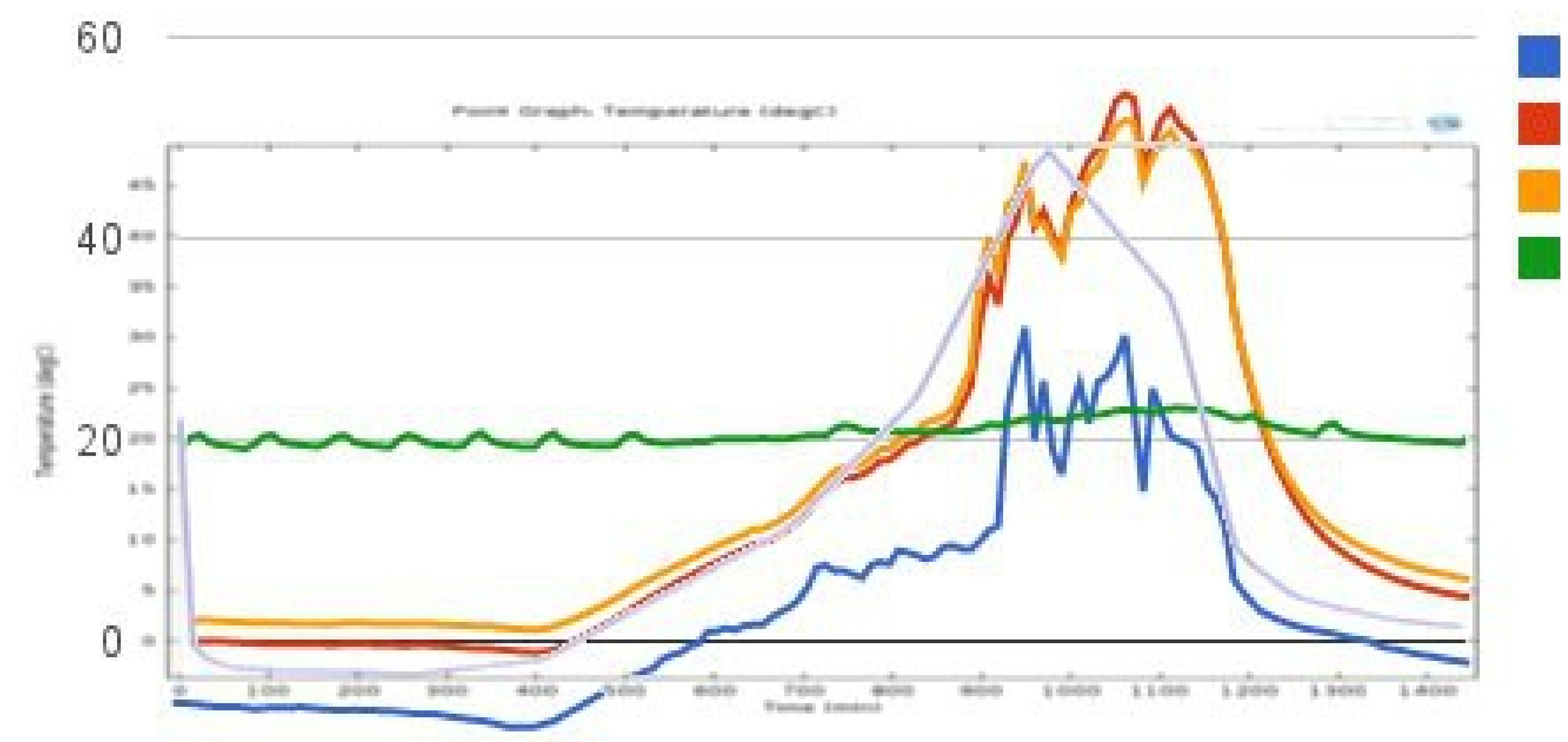

Figure 3. *Overlay of COMSOL temperature results (grey) with experimental data (April 16)*

Implementing the control scheme yields a change in heat flux at the 'room-window plane' (see figures 4 and 5) of about 28% during the high solar-gain period.

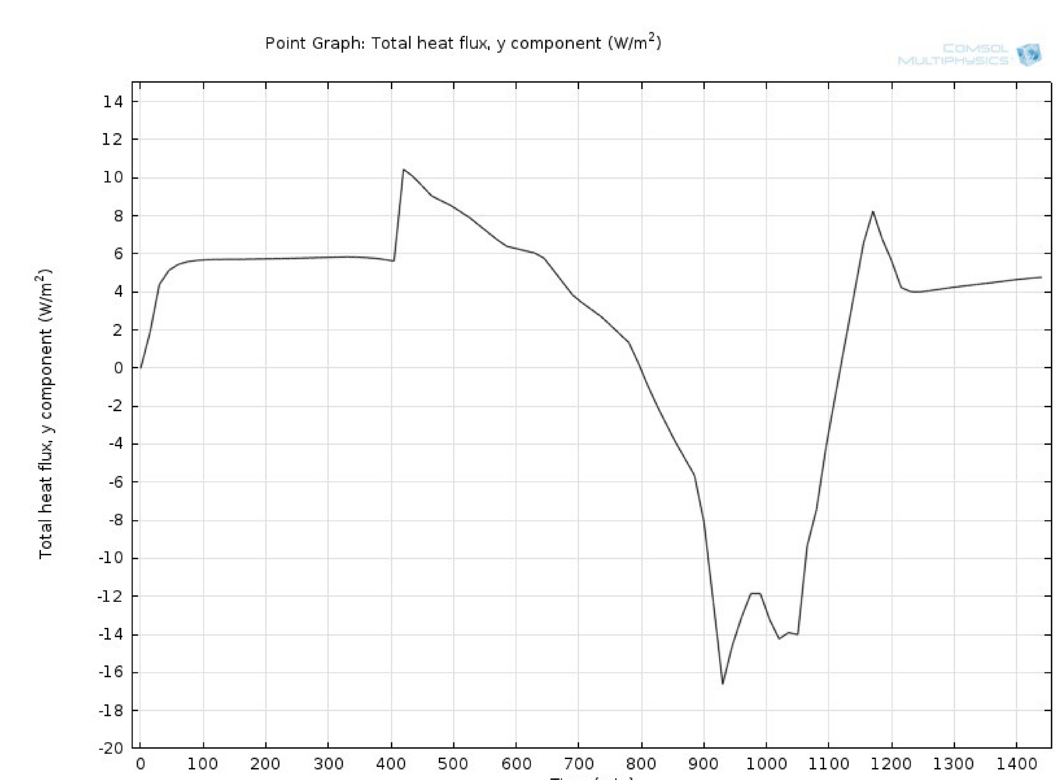

Figure 4. *Heat Flux (y) – night-control system*

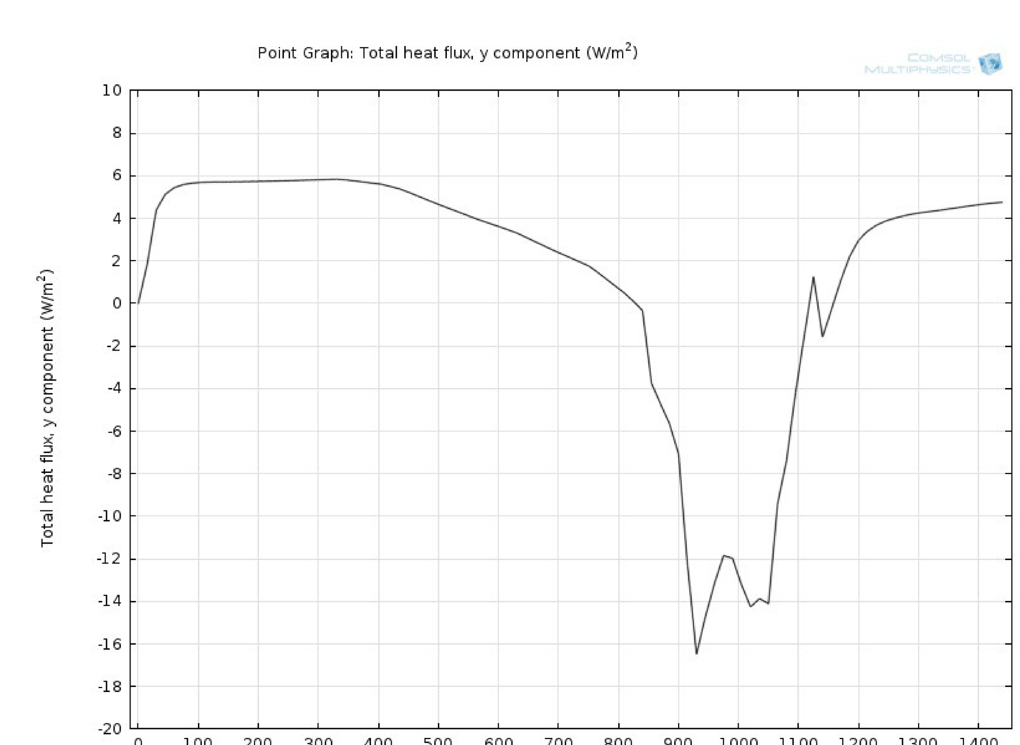

Figure 5. *Heat Flux (y) – passive-control system*

Conclusions: This work supports the hypothesis that a quick-response control can improve upon heat flux values of both a static, and night-time operable insulation system. It does so by mitigating losses against gains from direct solar radiation. This simulation is in the shoulder season of April and simulation in a heating season month is underway where values are expected to be more significant over a longer time period.

References:

1. IEA, Key World Energy Statistics, IEA/OECD Ch. 1 (2012)
2. CCHRC, Evaluating Window Insulation, Cold Climate Housing Research Centre (2011)

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