Integration of Transparent Insulation Materials into Solar Collection Devices

Sam Yang, Philibert Girurugwiro, Alejandro Rivera, Juan Ordonez

Transparent Insulation Material (TIM)

"A layer with high thermal resistance and radiation transmittance."

Previous Studies

1. Advanced glazing materials such as silica aerogel insulations [1-2].

2. Mathematical models and thermal performance of solar collector equipped with different arrangements of square-cell honeycomb materials [3].

3. A status report on solar TIM covering a survey of the literature, different physical and material properties of TIM devices: classifications, applications, fabrication procedures, availability, and cost trends [4].

[1] Baetens, R. et al., 2010. Aerogel insulation for building applications: A state-of-the-art review.
[2] Buratti, C. and Moretti, E., 2012. Glazing systems with silica aerogel for energy savings in buildings.
[3] Ghoneim, A. A., 2004. Performance optimization of solar collector equipped with different arrangements of square-celled honeycomb.
[4] Kaushika, N.D. and Sumathy, K., 2003. Solar transparent insulation materials: a review.

This study

1. Mathematical model for a transparent insulation material (TIM) is derived, analyzed, and validated for application purposes (i.e. solar collection devices where insulations with high radiation transmittance and low thermal conductivity are desired).

2. TIM is integrated into flat-plate and parabolic trough solar collectors and evaluated.

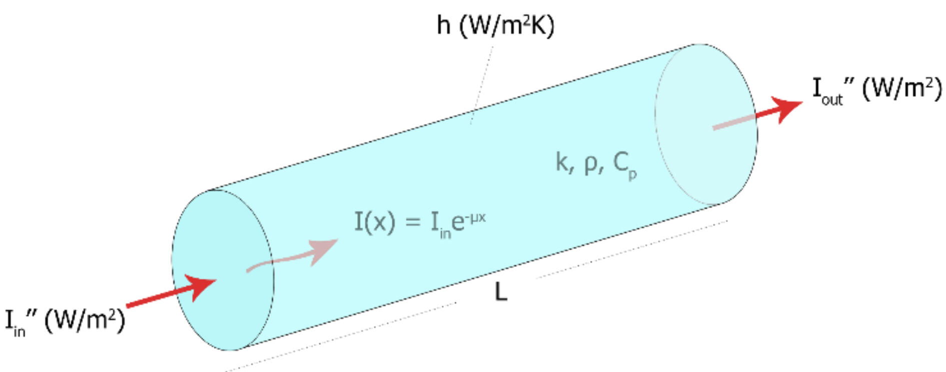

Fig. 1 – Physical model of a TIM.

Beer-Lambert law:

$$dI = -\mu I_{in} dx$$

First law (Energy Balance):

$$\frac{d^2T}{dx^2} + \frac{I_{in}\mu}{k} e^{-\mu x} - \frac{hP}{k\,A_T}(T - T_\infty) = \frac{1}{\alpha}\frac{dT}{dt}$$

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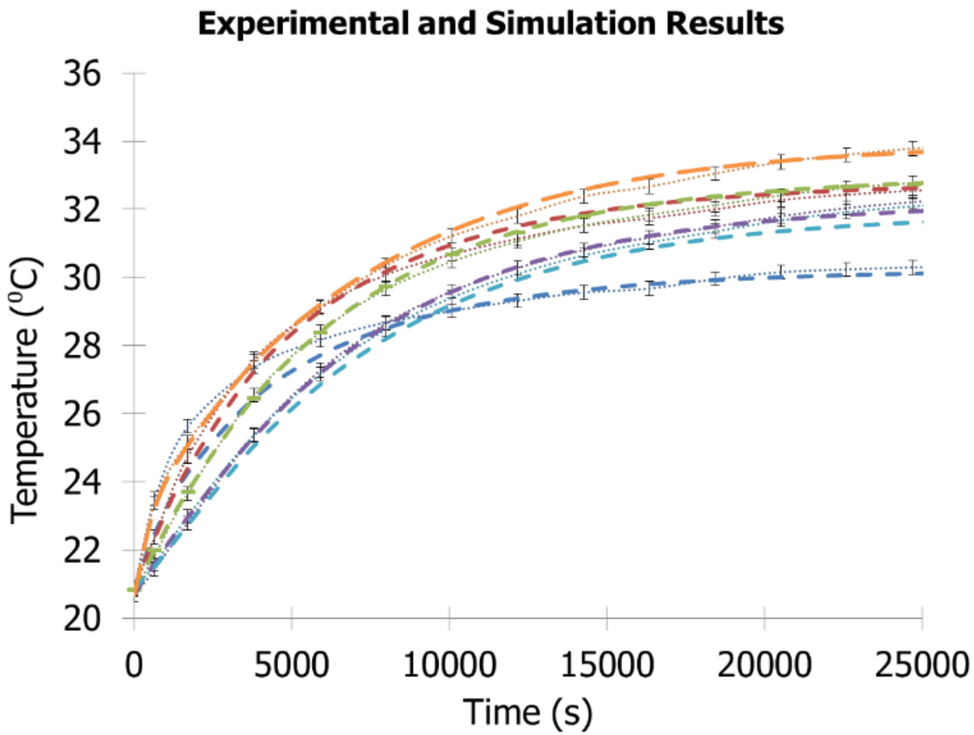
Simulation and Experimental Validation

1. Finite difference method is employed to numerically solve the governing equation.
2. Experiment is performed to validate the accuracy of the derived mathematical model.



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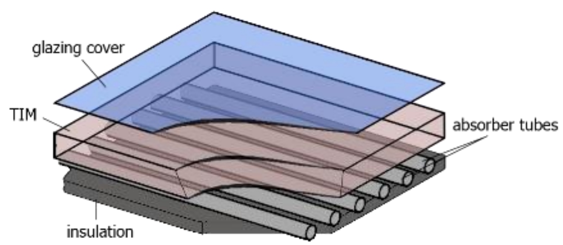
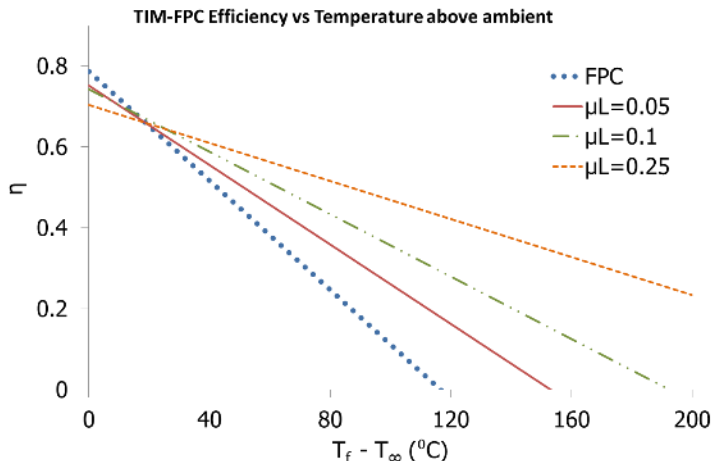
Integration

1. Flat-Plate Solar Collector





2. Parabolic Trough Solar Collector