

EXPERIMENTAL STUDY ABOUT THERMAL RESISTANCE OF WINDOWS WITH AIR GAP BETWEEN TWO GLASSES USED IN SINGLE HOUSES

by

**Sakthivel PERUMAL^{a*}, Srinivasan RAJENDRIAN^b,
Vijayan VENKATRAMAN^c, Dinesh SUNDARESAN^c,
and Lakshmanan PANDIYAN^c**

^a Department of Mechanical Engineering, Sri Krishna College of Technology,
Coimbatore, India

^b Department of Ancient Science, Faculty of Science, Tamil University,
Thanjavur, Tamilnadu, India

^c Department of Mechanical Engineering, K. Ramakrishnan College of Technology,
Trichy, India

Original scientific paper

<https://doi.org/10.2298/TSCI190411031P>

In this experimental study mainly focused the thermal property such as thermal resistance and heat transfer analysis for the air gap variations provided in between two glasses on window for the domestic purposes. Easily available surrounding air considered as the experimental mater because of its arrangements. Thermal resistance of inside, outside and glasses (both glasses have same thermal conductivity such as 0.78 W/mK) all are maintained as constant throughout the investigation. But only air gap distance increased from 2 mm to 14 mm with gradual increase focused. The thermal conductivity of air considered as 0.026 W/mK. Thermal resistance and heat transfer impact with respect to the air gap between glasses were identify with the help of graphical representations.

Key words: *thermal resistance, heat transfer, air gap,
thermal conductivity, window*

Introduction

Window is the most essential part of each and every house which not only a portion used to cover or open the small part of the wall [1, 2]. It also can be used as an insulator or conductor of heat as well as light, etc. In this investigation focused the heat transfer range impact through increasing the air gap between the window glasses. Normally glasses have higher thermal conductivity than the air in surrounding. The traditional formulae for thermal resistance and heat transfer for the individual portion identified [3-5]. The performance of double-glazed horizontal sliding window was evaluated and verified for its performance to improve the thermal resistance of the glazed edge. An increase of 13% in temperature decrease rate (TDR) was obtained when an insulating spacer was provided [6]. An average increase up to 18% in TDR was encountered when the height of the frame was increased. Double pane heat exchanger was analyzed under two conditions namely constant temperature and natural convection heat transfer [7]. The optimum thickness of boundary-layers was found out of which results at constant

* Corresponding author, e-mail: skt4design@gmail.com

temperature were proven better [8]. Thermal conductivity was measured in order to reduce the coefficient of window of overall heat transfer using aerogel. Single sided window ventilation parameters were identified for optimization of window type [9-11]. Double glazed glass is shown in fig. 1.

Experimental procedure

There are two same glasses with same thermal conductivity (0.78 W/mK) used with air (0.026 W/mK) gap mentioned in fig. 2. The length of the both glasses is 4 mm and area is 1.2 m². So for this total investigation cross-sectional area is 1.2 m². Temperature sensors used to measure inside and outside temperatures. The inside and outside convective heat transfer coefficient, incremental air gap details for the investigations were mentioned clearly in tab. 1. The air gap initially 2 mm used and the corresponding individual resistance and heat transfer rate found through tradition formulae. Then the same operating conditions only air gap increased as 4, 6, 8, 10, 12, and finally 14 mm. Corresponding outcomes identified through the same method.

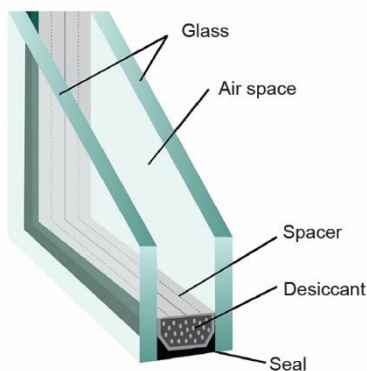


Figure 1. Double glazed glass

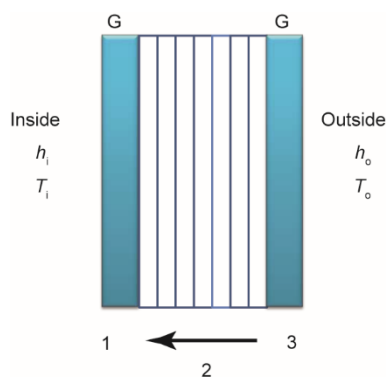


Figure 2. Experimental arrangement

Table 1. Experimental values for the investigation

Inside Convective heat transfer coefficient [Wm ⁻² K ⁻¹]	1 (glass)		2 (air gap)		3 (glass)		Outer Convective heat transfer coefficient [Wm ⁻² K ⁻¹]
	Length [m]	Thermal conductivity [Wm ⁻¹ K ⁻¹]	Length [m]	Thermal conductivity [Wm ⁻¹ K ⁻¹]	Length [m]	Thermal conductivity [Wm ⁻¹ K ⁻¹]	
10	0.004	0.78	0.002	0.026	0.004	0.78	20
10	0.004	0.78	0.004	0.026	0.004	0.78	20
10	0.004	0.78	0.006	0.026	0.004	0.78	20
10	0.004	0.78	0.008	0.026	0.004	0.78	20
10	0.004	0.78	0.01	0.026	0.004	0.78	20
10	0.004	0.78	0.012	0.026	0.004	0.78	20
10	0.004	0.78	0.014	0.026	0.004	0.78	20

Result and discussion

The calculated thermal resistance values related to air gap and sum of all resistances termed as total resistance and relative heat transfers were mentioned in tab. 2. Figure 3 showed are the individual calculated inner, R_i , glasses, R_1 , R_3 , and outer thermal resistances with respect to air gap thickness but there is no change in the mentioned resistance throughout the testing.

Table 2. Calculated resistance and heat transfers

Air gap [mm]	Thermal resistance of air gap, R_{air} , [KW ⁻¹]	Sum of all thermal resistance R_{total} , [KW ⁻¹]	Heat transfer Q , [W]
2	0.064	0.1976496	101.2
4	0.128	0.2617521	72.59
6	0.192	0.3258547	55.24
8	0.256	0.3899573	43.59
10	0.321	0.4540598	35.24
12	0.385	0.5181624	28.95
14	0.449	0.582265	24.04

Here R_1 also equals to R_3 because of same material with same dimensions. Figure 4 clearly showed calculated air gap thermal resistances with respect to different air gap thickness and cumulative total resistance as sum of all the calculated individual resistances, R_i , R_1 , R_2 , R_3 , and R_o , as a graphical representation. Inside temperature and outside temperature differences with respect to air gap thickness mentioned in fig. 5. Similarly heat transfers with respect to air gap thickness and total resistance found through traditional formulae mentioned in fig. 6.

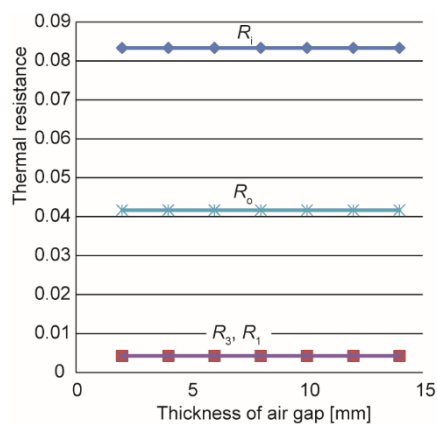


Figure 3. Individual thermal resistances with respect to air gap thickness

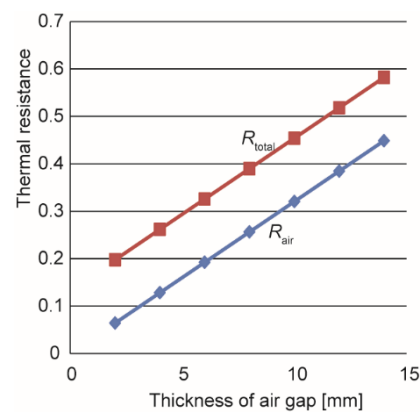


Figure 4. Air gap and sum of thermal resistances with respect to air gap thickness

Conclusion

In this experimental investigation about thermal resistance and heat transfer analysis regarding air gap between two glasses on window for the domestic use conclude the following.

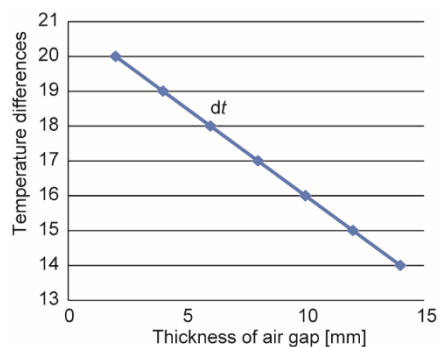


Figure 5. Individual inside and outside temperature differences with respect to air gap thickness

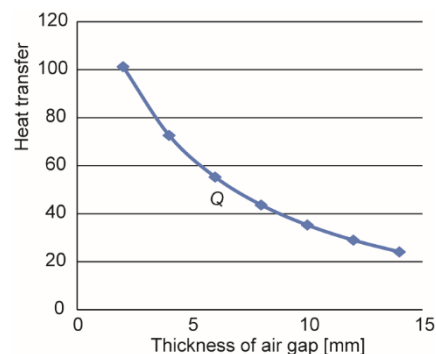


Figure 6. Individual heat transfers with respect to air gap thickness

- The normal air gaps thickness between two glasses generate significant impact on the thermal resistance and heat transfer when the remaining parameters are same.
- Thermal resistance increased with increment on air gap thickness.
- Similarly heat transfer rate also decreased with increase in air gap thickness.
- So the maximum air gap is recommended in between glass for the domestic usage with respect to heat reduction from outside of the window when compared to inside.

References

- [1] Coillot, M., et al., Heating, Ventilating and Cooling Impacts of Double Windows on Historic Buildings in Mediterranean Area, *Energy Procedia*, 133 (2017), Oct., pp. 28-41
- [2] Park, S., Song, S.-Y., Evaluation of Alternatives for Improving the Thermal Resistance of Window Glazing Edges, *Energies* 12 (2019), 2, pp 244 -271
- [3] Aydin, O., Conjugate Heat Transfer Analysis of Double Pane Windows, *Building and Environment*, 41 (2006), 2, pp. 109-116
- [4] Arici, M., Karabay, H., Determination of Optimum Thickness of Double-Glazed Windows for the Climatic Regions of Turkey, *Energy and Buildings*, 42 (2010), 10, pp. 1773-1778
- [5] Koo, S. Y., et al., Effect of Surface Thermal Resistance on the Simulation Accuracy of the Condensation Risk Assessment for a High-Performance Window, *Energies* 11 (2018), 2, pp. 382-393
- [6] Kumar, P. M. K., et al., Computational Analysis and Optimization of Spiral Plate Heat Exchanger, *J. of Applied Fluid Mechanics*, 11 (2018), Special Issue, pp. 121-128
- [7] Lenin, V. R., et al., Optimization of Window Type and Vent Parameters on Single-Sided Natural Ventilation Buildings, *J. Therm. Anal. Calorim.*, 136 (2019), 1, pp 367-379
- [8] Avudaiappan, T., et al., Potential Flow Simulation through Lagrangian Interpolation Meshless Method Coding, *J. of Applied Fluid Mechanics*, 11 (2018), Special Issue, pp. 129-134
- [9] Sivakumar, V., et al., Analysis of Ventilation Rate in Cross Ventilated Rooms by Varying Aperture Shape of Windows using CFD, *J. of Applied Fluid Mechanics*, 10 (2018), Special Issue, pp. 61-68
- [10] Cha, J., et al., Improvement of Window Thermal Performance Using Aerogel Insulation Film for Building Energy Saving, *J. Therm. Anal. Calorim.*, 116 (2014), 1, pp. 219-224
- [11] Sudhagarm, S., et al., Performance Analysis of Fin Tube Evaporator Using Various Refrigerants, *Thermal Science*, 24 (2019), 1B, pp. 609-612