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Thermal Properties of Alumina Pillar of Vacuum Insulated Glazing Application to 3D Heat-Transfer Analysis

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Abstract: Recently proposed tightening of energy-saving design regulations in buildings, today's windows with conventional double glazing and K-values of 1.0 W/m²K will no longer meet thermal-insulation requirements in a few years. So now vacuum insulated glazing marks an alternative approach. This study focused on identify to thermal properties of supported pillar which carry out as an important element in vacuum insulated glazing. For calculate heat transfer at supported pillar and its peripheral parts using 3D heat transfer which based on finite volume method. As a simulated results, the temperature of center part of supported pillar shows clearing evidence for heat transfer from interior part to exterior is 17.78 °C, 10.34 °C, 10.17 °C, 1.06 °C.

1. Introduction

The double glazing for buildings shows a very poor thermal insulation performance in comparison with the multi-layered insulated wall. Figure 1 shows a stark difference in thermal transmittance (K-value) between living room walls and windows according to the thermal transmittance criteria of the areas around regional buildings presented in Energy-Saving Design Standards of Buildings(MOLIT Standard No. 2014-957. Thus, the vacuum glazing has stood out as an alternative to the double glazing with a low thermal insulation performance. The vacuum glazing shows an excellent thermal insulation performance in comparison with the existing double glazing filled with dry air, but pillars are used to prevent the compression damage of glazing caused by the difference between the atmospheric pressure and the vacuum of under 0.1Pa between glazing and to maintain the gap between glazings [1]. Meanwhile, such materials as alumina and ceramics are applied to the pillar of vacuum glazing, which involves the problem of heat loss due to thermal bridge through pillars [2], [3]. The objective of this research is to investigate the heat transfer characteristics of the pillar applied to the vacuum glazing through the 3-dimensional heat transfer analysis and then understand the effect of the pillar diameter on the thermal characteristics.

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2. Vacuum Glazing Industry and Research Trend

A part of vacuum glazing products have been commercialized and used. For its full-scale application to glazing, however, there have been problems to be solved. The triple glazing developed so far in order to improve the thermal insulation effect has resulted in the over-thickness of window systems and the overweight of glazings. In case of the vacuum glazing, the quality improvement of thermal insulation performance for the double glazing was made by removing the heat conduction phenomenon caused by the gas in the cavity. According to such manufacturing method of the vacuum glazing, the vacuum layer thickness of about 1*mm* shows an excellent thermal insulation value as expressed by the thermal transmittance value of 0.5W/m^2K for the under-10*mm* thick double glazing. The factors affecting the heat transfer characteristics of the vacuum glazing may be classified into such factors as sealing edge, support pillar, glazing surface radiation, and vacuum layer. Out of these factors, the pillar is the important factor to determine the thermal insulation performance of the vacuum glazing. The most of research on the vacuum glazing has been conducted to investigate the thermal insulation performance of pillars by using such 3-dimensional finite volume methods as CFD and FEM.

3. Heat Transfer Analysis and Resultant Analysis of Pillar Parts

In this research, in order to investigate the heat transfer characteristics of pillar parts, established was the analysis target and modeled was the analysis shape. (Table 1, Figure 3) As a tool for the heat transfer analysis, used was TRISCO version 12.0w of PHYSIBEL with application of the finite volume method. The primary analysis was made by modelling the pillar part with a glazing thickness of 4mm, a pillar gap of 25mm, a vacuum layer thickness of 0.12mm, and a pillar diameter of 0.4mm. (Figure 1, 2) The results confirmed the specific patterns displayed in the heat transfer phenomenon of the pillar part (Figure 3). In the secondary analysis, in order to investigate the heat transfer characteristics of the pillar and its peripheral parts, the analysis shape was modelled by expanding 1/4 of the pillar area (Figure 4). The indoor boundary conditions were set, according to KS L 2514, at an indoor temperature of 20 °C and an outdoor temperature of 0 °C. As experimental conditions, the indoor surface heat transfer coefficient was set at 25W/m^2.K, and the outdoor one at 7.7W/m^2.K. In addition, in order to confirm the heat transfer characteristic due to the cross-sectional area change of the pillar, it was analyzed by changing the cross-sectional area of the pillar from 0.1mm to 1.0mm (Figure 5, (a), (b), (c), (d)).

Table 1
Properties of Materials of Vacuum Glazing

Materials	*Conductivity* λ*(W/m·K)*	*Emissivity* ε
Low-E coating	1	0.02
Pillar	20	0.9
Vacuum	0	·
Sodalime	0.18	0.84

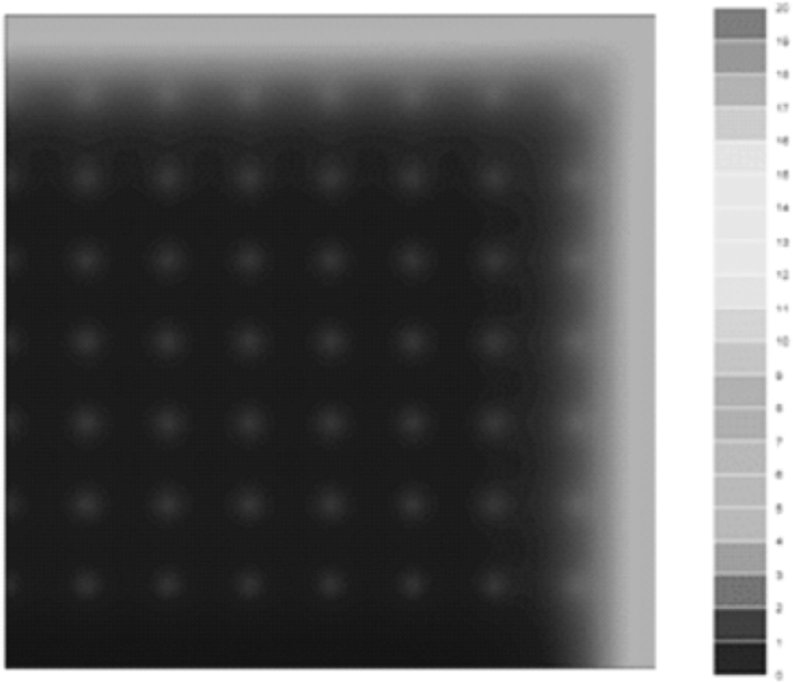


Figure 1: Thermal Distributions of Outer Part of Vacuum Glazing

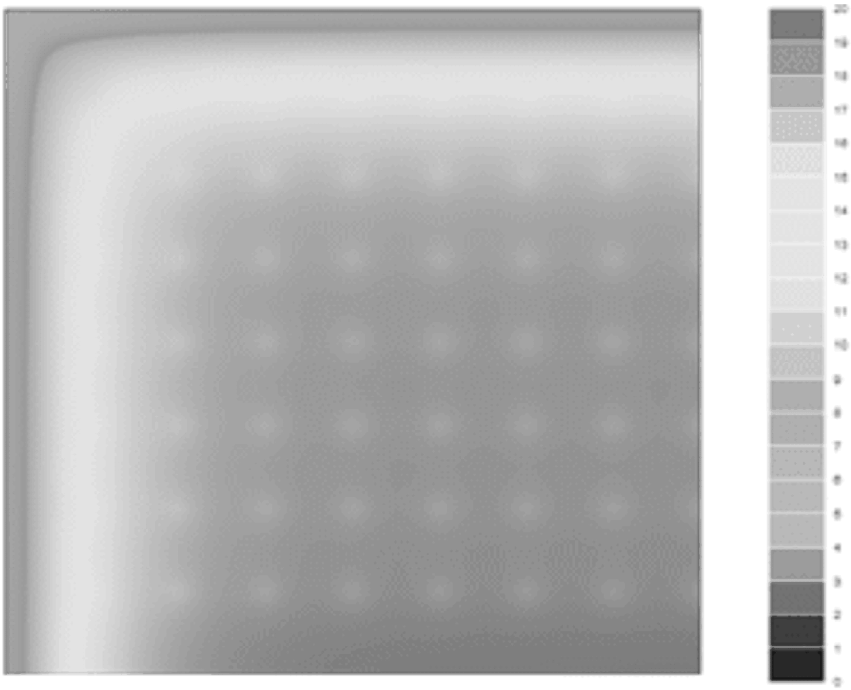
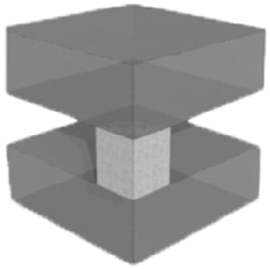
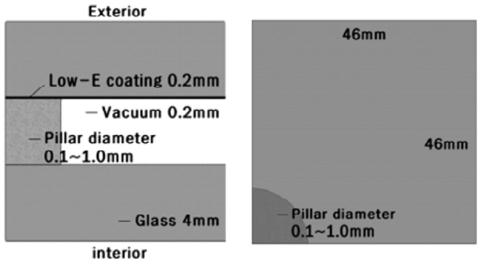


Figure 2: Thermal Distributions of Inner Part of Vacuum Glazing

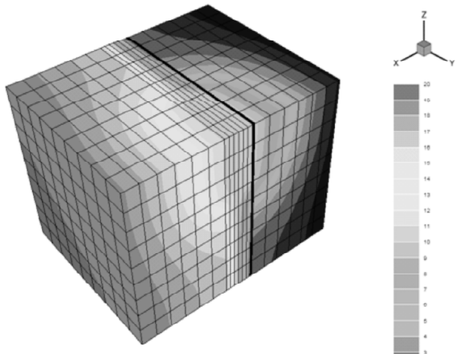


(a) Perspective of Pillar Part

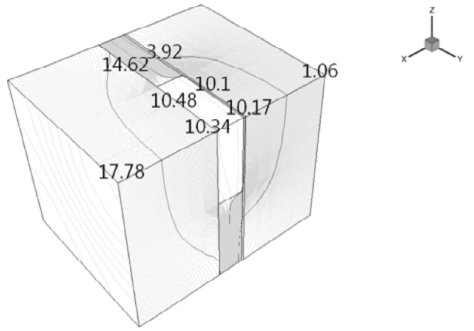


(b) Section (c) Plan

Figure 3: Pillar Parts Detail of Vacuum Glazing

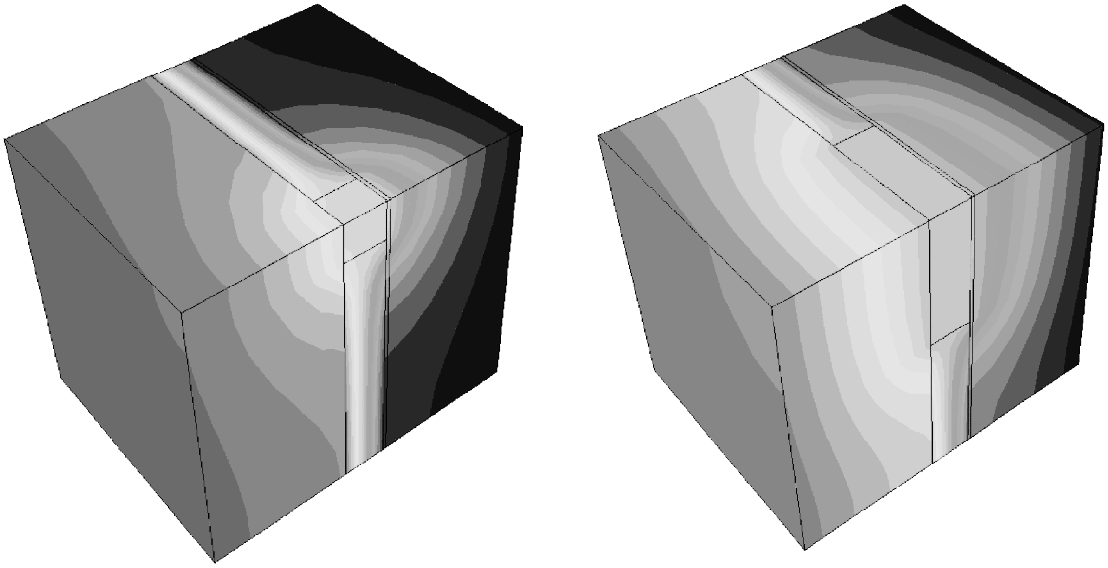


a) Grid Modelling in Finite Volume Method

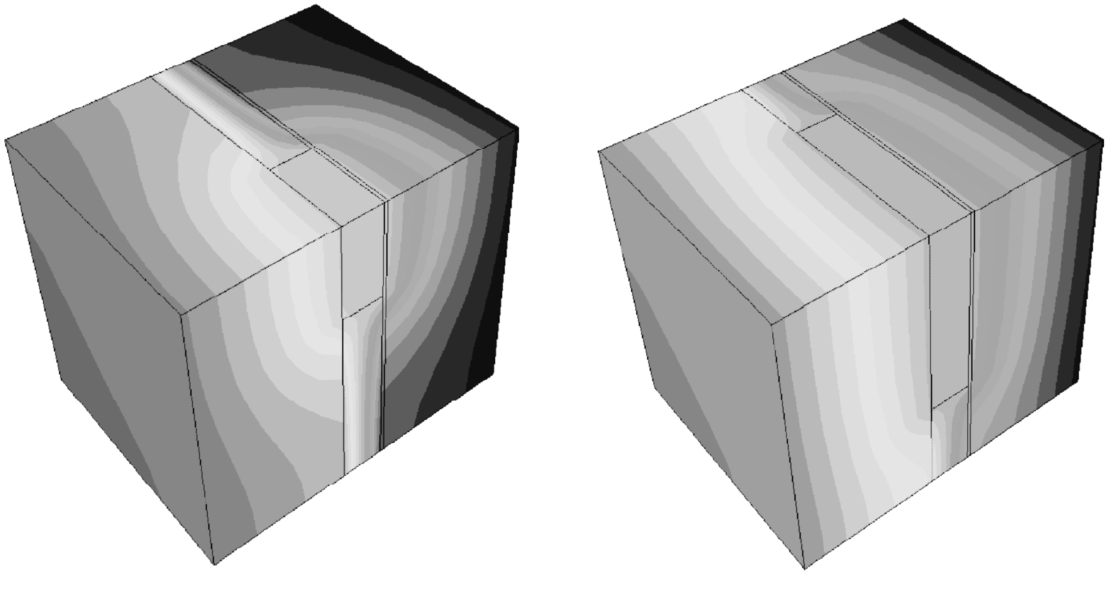


b) Isothermal Lines

Figure 4: Temperature Distribution and Isothermal Lines of Pillar Part



(a) Pillar Diameter : 0.2mm (b) Pillar Diameter : 0.5mm



(c) Pillar Diameter : 0.7mm (d) Pillar Diameter : 1.0mm

Figure 5: Heat Transfer Properties as Sectional Diameter Change of Pillar

4. Result Analysis and Conclusions

On the basis of the results of this research, made are the following conclusions: First of all, the indoor-side glazing temperature and pillar boundary temperature at the center part of the pillar were 10.34 °C and the surface temperature of the indoor-side glazing vacuum part was 14.62 °C, showing a temperature difference of 4.28 °C. The outdoor-side glazing temperature and pillar boundary temperature at the same point were 10.17! and the surface temperature of the outdoor-side glazing vacuum part was 3.92 °C. The thermal insulation effect due to vacuum is 10.7 °C, as shown by the difference between the surface temperature of the indoor-side glazing vacuum part and the surface temperature of the outdoor-side glazing vacuum part.

Reference

[1] Yueping Fang, Low emittance coating and the thermal performance of vacuum glazing, *Solar energy*. 81(2007), 8-12.

[2] R. E. Collins. Vacuum glazing-a new component for insulating windows, Building and Environment, Vol. 30 ,No. 4 .pp. 459-452, 1995.

[3] Jeon E. S., “The Strength Simulation and Test of Glass According to Array Separation of Pillars to Maintain Vacuum Gap”, Proceedings of The Society Air-Conditioning and Refrigerating Engineering of Korea, SAREK, pp. 133-135, 2013.