Effect of Thermal Barrier and Insulation Material Properties on Thermal Performance of the Windows Systems

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Architectural systems use finite element analysis programs to detect weak points in thermal transmittance during the design phase. Therm, Bisco, Window, Flixo, and FrameSimulator are some of the examples of these programs which are frequently used by experts. Thus, it is possible to improve the thermal performance at the design stage. The thermal transmittance calculations made in this study was made with FLIXO finite element analysis program. The thermal conductivity of air spaces can be calculated automatically according to the TS EN ISO 10077-2 standard by the FLIXO. To calculate the thermal transmittance of the frame section, an insulating panel with thermal conductivity of λ= 0.035 W/mK replaces the opaque panel in bg thickness of existing glass. The insulated panel bg length must be greater than 190 mm, and the height equal to 1000 mm (Figure 4). The panel's surface is considered an adiabatic boundary. The dimensions to be considered in the thermal transmittance of the architectural system can be seen in Figure 4. The calculation cannot be performed if the specified dimensions are lower than the given values in Figure 4.

[illegible]

These three strategies are achieved by frame optimization to reduce the thermal conductivity coefficient.

The first strategy is to increase the width of the frame material and create the maximum number of closed chambers during the design of the plan/section detail of the aluminum frame material.

The second strategy is to choose the insulation barrier material used to prevent heat conduction with a low thermal conductivity coefficient and to keep the barrier as high as possible since aluminum has a high thermal conductivity coefficient.

The third strategy is to fill the gaps between the barriers with insulation materials with a low thermal conductivity coefficient to reduce the convection effect of air through the window.

Optimization work should also be carried out on the EPDM gasket, which is highly preferred in the industry for air and water tightness used between aluminum window profiles. The number of chambers and decrease between the gasket and the thermal barrier is necessary. Although the EPDM materials already provide a low thermal conductivity, a two-component gasket is being used to further reduce the heat coefficient.

While EPDM material is used to provide strength in the area that provides sealing with the contact of the gasket to the thermal barrier, the EPDM foam material is preferred in areas that do not need strength.

According to ISO and CEN standards, if the material's thermal conductivity value (λ- lambda) is less than 0.065 W/m.K, thus, it can be called a thermal insulation material according to ISO and CEN standards. If it is higher than this value, it is then called a building material. The thermal conductivity values of the insulation materials used for this study are shown in Table 1.

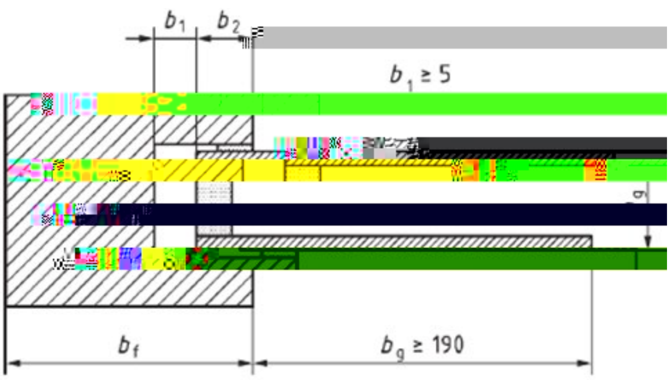

Figure 4: Measures to be considered in thermal transmittance.

The study examines the effect of U_f (Thermal transmittance of the frame) on the insulation materials by considering the third strategy. U_f value can be improved by optimizing several parameters in the window section detail. Only some parameters were kept constant to examine the insulation material's effect, which are;

- T e height of the heat barrier is 54mm,
- Narrow Frame and sash
- T e width of the insulation panel is 36mm

Phenolic foam is a closed-cell rigid foam containing phenolic resin and other additives. Phenolic foam is the best insulation material due to its excellent fire resistance performance, low smoke emission, high-temperature resistance, stability, superior thermal performance, and extremely robust insulation property. The operating temperature range of the foam is -180°C - +180°C (Table 2) .

Polyurethane is produced from two materials, isocyanate and polyol, obtained from crude oil. Polyurethane foam shows good thermal properties. The operating temperature range is –200°C to +135°C (Table 2). The average thermal conductivity coefficient of polyurethane foam is 0.025 W/m.K. The most significant advantage of polyurethane foam is its excellent thermal insulation properties. Due to this feature, one of the most frequently preferred materials for all kinds of construction and renovation works, such as welded assembly and sealing. The disadvantages of the material are its relative flammability and low resistance to UV radiation.

When the best insulation material for a climate zone is investigated according to the minimum life cycle cost and initial cost recovery time criteria; Although the aerogel insulation material has a higher initial cost, the initial cost recovery time of Aerogel insulated walls in a colder climate was found to be less than three years due to its high heat resistance properties. Although the initial cost is high, it can be classified as an economically beneficial type of material [19].

Table 1:

Materials	Thermal conductivity ə(W/m.K)
Aluminum	160
Polyamide (PA66GF25)	0.3
Low lambda polyamide (LLPA66GF25)	0.21
Phenolic foam	0.023
Polyethylene foam (PE)	0.049
Polyurethane foam (PU)	0.025
Aerogel	0.014
Insulation panel	0.035
EPDM	0.25
EPDM foam	0.06

Value	Phenolic foam	Polyethylene foam	Polyurethane foam	Aerogel
Density (kg/m³)	56	40	70	20 – 120
Durability	-180 to +180°C	-100 to +80°C	-200 to +135°C	-180 to +180°C
(J/kgK)	-	-	1,500	990 (J/kgK)

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other possibilities, more than one parameter is determined to improve