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Evaluation of Energy Performance of Pms Added Polyurethane in Building Heat İnsulation

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Abstract
In this study, two types of insulation materials with different heat transfer coefficients were compared in a building energy performance. Within this comparison, changes in the thermal performance of the building have been examined. The conductive heat transfer coefficient of the polyurethane foam material is 0.02094 W/m.K and the commercial one is 0.035 W/m.K. Within the scope of the analysis, depending on the building material, the thickness of the insulation material was changed at certain rates for both cases. With the aid of EES (Engineering Equations Solver) program, changes in the total energy and fuel costs have been observed. In addition, the analyzes were carried out for Ankara region having continental climate. A sample building with the same dimensions was taken as a reference in the analysis for both cases. As a result of the analyzes, it has been observed that PMS added polyurethane foam shows a better performance of about 3.86% compare to the commercial one in terms of energy saving.

Keywords: Thermal insulation, PMS, Polyurethane, Thermal performance, Fuel cost

INTRODUCTION

Parallel to the developing world, energy needs are increasing day by day. However, the energy resources are decreasing with time and the energy demand is increasing to a great extent. For this reason it is vital to consume energy unconsciously and to use conservative. The vast majority of energy losses in the world stem from buildings. Therefore energy efficiency and energy saving in the buildings have become one of the most important problems in the world. Building energy consumption arising from Turkey and in EU countries constitute about 33% of the total energy consumed. And half of these losses are due to the building surfaces [1]. It is clear from this that the energy losses caused by the buildings are directly related to our economy. It is not possible to destroy these losses. However, it can be downloaded to a minimum. This is possible thanks to thermal insulation. Because of these reasons, thermal insulation is very important. In order to obtain the best possible savings from heat insulation, a suitable thermal insulation material must be selected. Various materials such as calcium silicate, polystyrene, stone wool, glass wool, phenol foam, expanded polystyrene and polyurethane are widely used in heat insulation. The most widely used polyurethane in these. The reason for this is that it has low thermal conductivity [2]. In thermal insulation, it is desirable that the thermal conductivity of the insulation material is low. Because it is possible to provide a better insulation on the same conditions. Many studies have been carried out using various insulation and building materials in order to minimize the losses caused by the buildings.

Ikbal Çetiner et al. have experimentally examined the suitability of natural fiber materials in the form of wood waste as a thermal insulation material in the construction of wooden frame walls. According to the test results, the thermal conductivity of the wood waste ranged from 0.048 to 0.055 W / mK. And as heat insulation material, they are available as a result [3].

L.Bergamonti et al. organic-inorganic hybrid geopolymers prepared polyurethane powders (polyurethane foam and polyisocyanurate foam). Geopolymers produced with polyurethane waste at different rates; chemical, physical and mechanical properties. As a result of the investigations, the thermal conductivity value was found to be in the appropriate range as insulation material in the buildings [4].

In this study, two types of insulation material were used for comparison for a sample building. One of these is the widely used polyurethane with a transmission coefficient of 0.035 W / mK. The other is polyurethane with 3% PMS content and k = 0.02094 W / mK conductivity coefficient. In the scope of the study, annual coal fuel cost and annual total energy requirement of two materials are analyzed and compared. The building mentioned in the analysis belongs to the province of Ankara in the third degree day zone.

MATERIALS AND METHODS

A. The building

In this study, a building with a length of 15,98 m, a width of 8,21 m and a height of 12,32 m was taken as a reference. This building has been examined separately for Ankara region.

B. Polyurethane

To produce of polyurethane matrix composites, PMS at different amounts (1%, 2% and 3% w/w) was added to the 20 mL of polyol solution, then stirred by mechanical mixer at 3000 rpm for 1 min. to ensure homogeneity. Finally, TDI as foaming agent was quickly added to the prepared solutions and stirred at 3000 rpm for 5 seconds then poured into the prepared molds. After the polymerization reactions were completed, the obtained polyurethane foam material was removed from mold and dry for 24 hours. Also, the PMS additive contains 59.45% cellulose, 31.01% hemicellulose, 22.70% volatile matter (at 950°C), 12.65% ash (at 950°C), 9.54% lignin and 1.35%moisture (at 105°C), respectively.

Table 1. Results of thermal conductivity measurement of produced polyurethane foams.

Sample	Thermal conductivity coefficient k (W/mK)	R (mK/W)
Pure	0.02432	41.123
1% PMS additive	0.02316	43.176
2% PMS additive	0.02195	45.556
3% PMS additive	0.02094	47.754

C. Calculation Methods

Since a large majority of the heat losses in the building originate from the wall surfaces, the loss of energy can be reduced by reducing these losses. In this study, besides the effect of heat insulation on the thermal comfort, energy and cost analysis for energy saving and efficient usage are emphasized. Annual energy and cost analyzes were carried out with the help of the Engineering Equations Solver (EES) program. Analysis included analysis of heat losses caused by building walls, reinforced concrete, ceilings, floors and windows and doors as well as solar radiation gains. All these studies were carried out on the selected sample building. This building, which is considered as a reference, has been analyzed and compared with each other for a four day region. Finally, for the three concrete with different heat transfer coefficients used in the analysis, the calculations were made by changing the polyurethane thickness d = 0.035 m - 0.085 m. Here, the reason why the polyurethane thickness is taken as these values is the values of the bottom and top polyurethane thickness used in the market.

The general equations that form the basis of the analysis can be described as Eqs. 1- 2[5], Eqs. 3-4[6]. The amount of specific heat loss from unit time can be calculated by the following equation:

$$Q = \frac{A.\Delta T}{R} \quad (1)$$

where, Q is the heat transfer velocity (Watt), A is the surface area through which heat is passed (m2) and ΔT is the temperature difference (oC or K), respectively. R is the thermal resistance (m2K/W) and can be defined as:

$$R = \frac{1}{h_{in}} + \frac{d_1}{k_1} + \frac{d_2}{k_2} + \frac{d_3}{k_3} + \cdots + \frac{1}{h_{out}} \quad (2)$$

where, hin and hout are surface heat transfer coefficient on inner and outer surfaces (W/m2K), respectively. d1-2-3 are represent the thickness of the structural component (m) and k is the thermal conductivity coefficient (W/m2K).

$$H = H_T + H_V \quad (3)$$

where, H, HT , HV are , total specific heat loss (W/K), heat loss through conduction and convection (W/K) and heat loss through ventilation (W/K), respectively.

$$H_V = \rho.c.V' \quad (4)$$

where ρ is unit volume of air (kg/m3), c is specific heat of the air (J/kgK) and V' is volumetric air change (m3/h).

RESULTS AND DISCUSSION

In this section, the results of the analysis are presented. The analyzes were performed with the help of EES (Engineering Equations Solver) program.

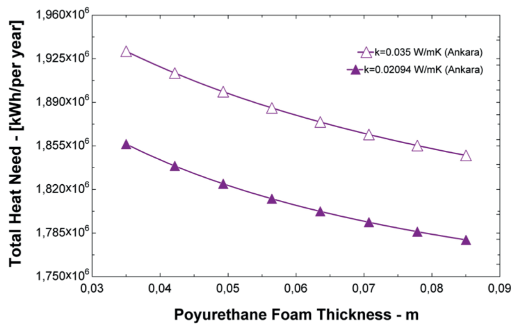

Figure 1. Change in total heat need due to polyurethane foam thickness

The change in the one year total heat need for Ankara province is shown in Figure 1. As can be seen from the figure, when 3% PMS additive polyurethane was used as insulation material in the building, the annual total heat need decreased by 3.88%.

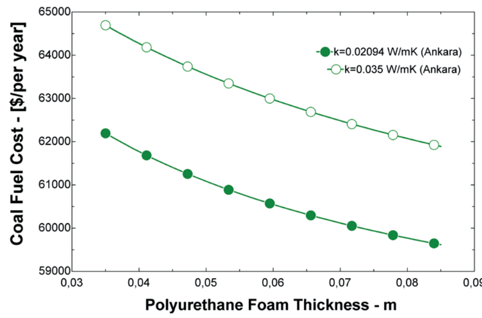

Figure 2. Change in coal fuel cost due to polyurethane foam thickness

Fig.2 shows the change in the cost of one year coal fuel for the province of Ankara. As the insulation material in the building, when 3% PMS added polyurethane is preferred, it is seen that all thickness values are more economical than standard polyurethane. And an annual saving of 3.86% is achieved. Since Ankara is in a cold climate with a continental climate, the savings of 3.86% are very important.

CONCLUSION

In this study, the importance of thermal insulation materials used in construction was emphasized and energy and fuel cost analysis for Ankara region was carried out. The main results of the study can be summarized as follows:

❖ First of all, considering that the vast majority of energy losses in the world originate from the buildings, the most to lose is to take a big step towards energy saving around the world. This can only be achieved by using healthy thermal insulation techniques.

❖ Insulation materials are very important used in thermal insulation. Because a healthy thermal insulation is possible only if the insulation and building materials are correctly selected.

❖ If appropriate building and insulation materials built by incorporating waste into beneficial products in buildings are preferred, wastes can be destroyed in large quantities. This is a great proposition for a sustainable world. Because by-products can be used as raw materials in another industry.

❖ Thermal insulation applications are important in cold climate zones as well as in hot climate zones. The heat insulation, which is important to ensure that the cold or hot air in the interior is at temperature, has important consequences for energy and cost analysis. The polyurethane foam used in the study was used as insulation material for a building in the third degree day zone. And as a result, important results have been obtained in terms of maintaining the ambient temperature.

❖ Finally, in this study, when the use of polyurethane used as insulating material is preferred, it will contribute to both heat insulation and energy saving. Polyurethane is a material suitable for recycling. For this reason, it will contribute to the recycling of waste and energy saving will be provided in a great sense.

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