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Energy Saving in Power Consumption by Using Double Glazing Windows in Iraq

Abstract*- It is generally accepted that the summer in Iraq is relatively hot season, where the temperature sometimes reaches 60 C°. Accordingly, most of the Iraqi houses are characterized as having a large area of windows with a single glass, which could be resulted in a significant loss in cooling energy. Hence, the present research concern is to examine the effect of using double glass windows (as an alternative to single glass) on the saving in which energy normally used in houses and buildings at July and August for different hours 3, 6, 9, 12, 15, 18, 21 and 24 P.m. A practical and realistic study was conducted. Three values of aspect ratio are used 30, 15 and 10 for the presence of air between the panels and in the presence of the argon gas for aspect ratio, 10 were practically investigated. The experimental results confirmed that using of the double glass with the presence of air as a medium for heat transfer between the two panels could be reduced the amount of heat transferred compared to that of single glass between (45-78), (54-85) and(58-88)%, while for argon it was (60-91)%.*

Key words: *Energy saving, Power consumption, Double glazing.*

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1. Introduction

It is well known that the thermal performance of windows has a great influence on the energy consumption in a building either for heating or in cooling. The energy transferred from the buildings is large through windows, which means increasing the use of energy for heating in order to compensate for the heat lost in the cold climate. Meanwhile, there is a large amount of energy could be transmitted into the buildings through windows, due to the solar radiation. Therefore careful selection of window components is necessary in order to get the appropriate windows with the required properties [1] studied the air temperature distribution of an air-conditioned a room equipped with a double-glazed window in a desert climate using (CFD) simulation program. It was found that using double glass could reduce the emission of sunlight and heat in desert buildings. Peng et al. [2], examined the thermal behavior of a novel ventilated photovoltaic (PV) double-skin façade (DSF) system experimentally. The results exhibited that the ventilated PV-DSF gives the best performance in terms of solar head gain compared with a tinted-glass DSF with low-e coating. Sharda and Kumar [3], inspected a heat transfer for various glass systems especially those with shading devices in India. They concluded that there was an urgent need to explore the potential of double glazed windows with curtains in the Indian climate .Marjanovic et al. [4], examined a numerical study of convective and radiative heat transfer rate from a window surface with adjacent aluminum venetian blind using CFD software. It was found that the heat transfer between window and indoor air was extremely affected on the convective heat transfer from the window surface this effect only be fully recognized and analyzed in three dimensions. Sala [5], investigated the influence of a louvered blind in a double-glazed unit during night-time conditions. Differences observed in both speed profiles, and temperature distributions were critically discussed according to the type of material. Crlos et al. [6],concentrated on the design aspects of a ventilated double window as a system to pre-heat the ventilation air system as a function of airflow pattern generated by the stack and wind effect. Experimental measurements of the thermal performance of the ventilated double window were carried out in an outdoor environment in the winter season. It was found that the above system could be reduced the global heating energy that lead to a substantial reduction in the energy heat through ventilation in winter season.A numerical study of natural convective in a cavity of double glazing system with the integration of semi-transparent PV cells examined by Jun Han et al. [7]. Results showed that both the convection flow strength as well as heat transfer increased with increasing Rayliegh number. On the other hand, Khoukhi and Maruyama [8], used a radiation model to simulate the single and double glazing window system. Thermal flow and temperature distribution were examined in case of stability of single and double glass exposed to solar radiation during the winter period. Results revealed that the behavior of temperature distribution within the glass layers was linear. The above literature has shown a significant work on the effect of using double glass windows as an alternative to single glass either by experimental or theoretical work by using CFD software. Accordingly, present study pay more attention to the effect of using double glass windows as an alternative to single glass on the saving in the cooling energy used in houses and buildings in Iraq during July and August for different hours 3, 6, 9, 12, 15, 18, 21 and 24 P.m. Three values of aspect ratio are used 30, 15 and 10 with presence of air between the panels and in the presence of argon gas, the aspect ratio was 10.

2. Nomenclature

A Windows area (m^2),
AR Aspect ratio (m),
d Distance between the two panes of glass (m),
H High of window (m),
h_i Convective heat transfer coefficient for inside surface of window ($W/m^2.K$),
h_o Convective heat transfer coefficient for outside surface of window($W/m^2.K$),
h_{cp} Convective heat transfer coefficient between two window pane($W/m^2.K$)s,
h_{rp} Radiation heat transfer coefficient between two window panes($W/m^2.K$),
k Air thermal conductivity(W/m.K),
k_g Glass thermal conductivity(W/m.K),
Nu Nusselt number,
Nu_a First Nusselt number between glass convective equations,
Nu_b Second Nusselt number between glass convective equations,
Nu_c Third Nusselt number between glass convective equations,
Q Heat transfer rate through window (W),
Ra Rayliegh number,
To Outside air temperature (K),
T_1 Temperature of inside surface of window(K),
T_2 Temperature of outer surface of inner window pane(K),
T_3 Temperature of inner surface of outer window pane(K),
T_4 Temperature of outside surface of window(K),
U_t Overall heat transfer coefficient between in and outside($W/m^2.K$),
U_P Overall heat transfer coefficient between pane s ($W/m^2.K$),
W_g Glass thickness (m),
B Bulk expansion coefficient,
N Kinematic viscosity of gas between panes (m^2/s).

3.Experimental Set-Up

Figures 1 and 2 illustrate a photograph picture and schematic diagram of the testing rig. It consists of two-part, the first comprises a wooden structure with dimensions of 70, 50 and 40 cm encased in perspex material for five sides. The sixth side consists of a wooden frame with dimensions 50 and 40 cm containing two glasses with dimensions of 40, 30 cm and thickness of 4 mm. In this frame, there are three positions to change the glass location 1, 2 and 3 cm as shown in the Figure 3 and 4. The outer surface of this part was isolated by thermal insulation to prevent the heat transfer with surrounding and allowed it through the glass only. The second part, represents a cooling system to provide the required temperature inside box which is controlled by a thermostat. This part is composed of a reservoir of cool water and fan coil shown in Figure 5. To measure the required temperature four-thermo couple type-T were used which were installed to the four glass surfaces (inside and outside) as shown in the Figure 6. Correspondingly, two digital thermometers were used to measure the temperature inside the box and the atmosphere.

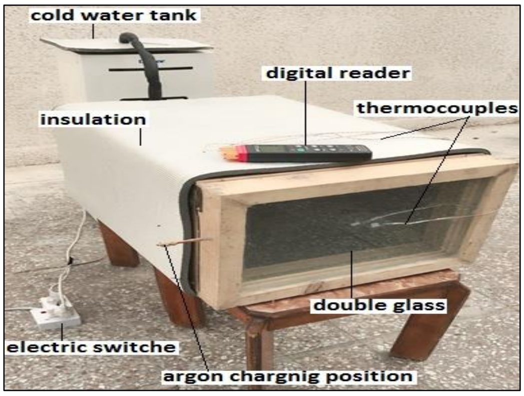

Figure 1: Experimental setup

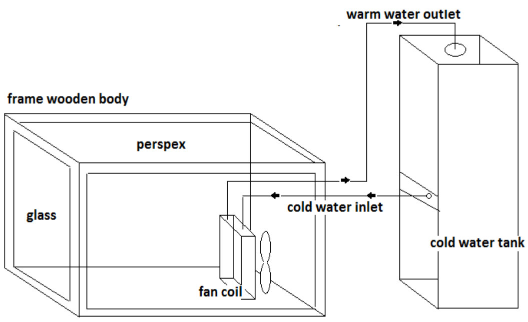

Figure 2: Schematic diagram of the experimental rig

Figure 3: Wooden structures with frame of glasses

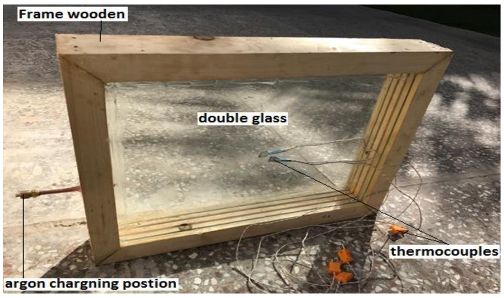

Figure 4: Test section frame of glasses

Figure 5: Fan and cooling coil unit

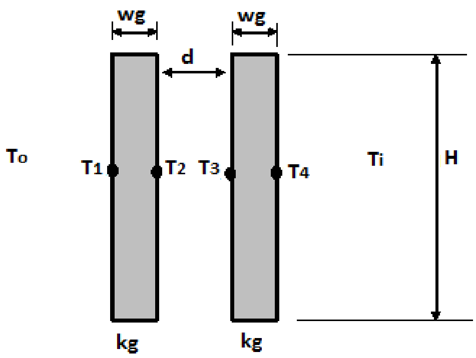

Figure 6: Schematic diagrams of temperatures locations and distribution

I. Experimental Procedures

First, a single glass was used and the cooling system was activated until a constant temperature of 24 ° C was obtained inside the box. After reaching the steady state conditions, the required temperatures were recorded. The temperatures of the inside and outside, in addition to the temperature of the glass surfaces were regularly repeated every three hours for a single day. The above procedure was repeated using a double glass with 1, 2 and 3 cm spaces between them with air gap between the two glass plates. It should be noted that argon gas was used instated of air in the gap of the two glasses are 3 cm apart.

4. Theoretical Analysis

The following assumptions were applied to carry out the theoretical analysis:

1. Heat transfer in one dimension.
2. Heat transfer is steady.
3. The effect of solar radiation was ignored.
4. The effect of the window frame was ignored too.

The conduction heat transfer between surface 1 and surface 2 as shown in figure (6) gives [9]

$$\frac{Q}{A}=\frac{T_1-T_2}{w_g/k_g}=-\frac{T_1-T_2}{R_g} \quad (1)$$

The conduction heat transfer between surface 1 and 2 through the widow may be given by:

$$\frac{Q}{A}=U_t(Ti-To) \quad (2)$$

Where$U_t=\frac{1}{R_t}$ and $R_t=R_i+R_g+R_p+R_g+R_o$

$$R_g=\frac{w_g}{k_g}, R_i=\frac{1}{h_{ci}}, R_o=\frac{1}{h_{co}}$$

i = inside, g =glass, p =pane, o = outside

The heat transfer rate is assumed to be expressed in term of Ralyieh number and AR for the gap between surface 2 and surface 3 and given by:

$$Ra=\frac{\beta g d^3\,(T_2-T_3)}{\gamma^2} \quad (3)$$

Where:

$$\beta=\frac{1}{T_{film}}=\frac{2}{T_2+T_3} \quad (4)$$

The aspect ratio of the window is given by

$$AR=\frac{H}{d} \quad (5)$$

The radiation coefficient is interpreted as:

$$h_{rp}=\frac{\sigma(T_2^2+T_3^2)(T_2+T_3)}{\frac{2}{\epsilon}-1} \quad (6)$$

The following three Nusselt numbers are then defined and the Nu for the heat transfer in the gap is taken as the largest of these values[10]

$$Nu_a=o.o605Ra^{1/3} \quad (7)$$

$$Nu_b=[1+\{\frac{0.104Ra^{0.293}}{1+(\frac{6310}{Ra})^{1.36}}\}^{3}]^{1/3} \quad (8)$$

$$Nu_c=0.242(\frac{Ra}{AR})^{0,272} \quad (9)$$

And ;

$$h_{cp}=\frac{Nu.k}{d} \quad (10)$$

And ;

$$\frac{Q}{A}=U_p(T2-T3) \quad (11)$$

Where $U_p=\frac{1}{R_p}$ & $R_p=\frac{1}{h_{cp}+h_{rp}}$

5. Results and Discussion

Four cases were used for experimental tests single, and double glass with air as a medium for heat transfer and three values for the aspect ratio (AR) 30, 15 and 10, and with argon gas as a medium for AR equal 10. Figures 7 and 8 show the change in overall heat transfer coefficient with different times per day, eight times were used in the measurement from 3:00 to 24:00 at a rate of three hours. The value of the overall heat transfer coefficient is generally increased from 3:00 am and reaches its maximum value at 15:00 pm due to the increase in the temperature difference between inside and outside and then starts to decrease due to low temperature difference between inside and outside. It is also observed that the overall heat transfer coefficient is reduced when using double glazing as an alternative to single glass and the value of U is reduced with decreased aspect ratio using the air as a medium heat transfer between the two panels. The value of U is reduced by using Argon as a heat transfer medium as an alternative to air for aspect ratio equal 10 because the thermal conductivity of Argon is low. The highest value recorded for single glass is 0.5 $W/m^2.c^o$ at 3 pm because the glass is good conductor of heat so the window without double glass makes the heat move directly from outside into the space inside. Figure 8 reveals in the double glass the value of overall heat transfer coefficient U decreasing with decreasing aspect ratio because the distance between the glasses is considered as an insulator and lead to the determination the transfer of heat from the outside to the inside and the greater distance is the best insulation so the value of U was reduced. For a double glass window at AR equals 10, 15 and 30 the maximum value are 0.16, 0.13, and 0.1 $W/m^2.C^O$ in the time 3, 12 and 6 respectively while for argon at nine o'clock and equal to 0.07 $W/m^2.C^O$. Minimum values are obtained for single and double glassing (air and argon) for three AR 30, 15 and 10 are 0.19, 0.13, 0.1 and 0.08 at the time 9, 12, 6 and 24, respectively. However, Figure 9 demonstrates the amount of heat transfer by using the above four cases where the highest heat transfer was achieved using single glass while the lower heat was transferred into double glass and AR equal 10 with the Argon as a medium for heat transfer between the two plates due to the low overall heat transfer coefficient. It seems that the maximum amount of heat transfer in single glass and double glassing with air and AR 30 and 15 also with air and argon as a medium with AR 10 are 95, 94, 30.4, 16.3, 14, 3 and 12.04 W for a time 15, 18 and 9, respectively. Figure 10 illustrates the comparison between three AR values 30, 15 and 10 in the presence of air as the medium of heat transfer between the two panels where it is clearly noted that increase distance between the two panels decreases the amount of heat transferred due to the increases in thermal conductivity resistance is higher than increases in conviction heat transfer coefficient (increase Nusselt number equations 7, 8 and 9). The maximum amount of heat transfer is 30.4W at AR=30 in 15 pm while minimum amount is 6.7 W at AR=10 at 3 a.m. Figure 11 on the other hand, displays is the relation between the amount of heat transfer with time at constant AR=10 with air once and argon gas, where the amount of heat transferred through the argon gas is clearly shown lower value than that of air. The maximum difference in the amount of heat transferred recorded at 6 pm is equal 80.4 W. Figures 12, 13, 14 and 15 clarify the difference between actual and theoretical quantities of overall heat transfer coefficient in the space between the two panels using air for AR 30, 15 and 10 air and argon. It's clear that the difference between experimental and theoretical results is may be attributed to the following reasons:

1. Ignoring the frame heat transfer.
2. Using one dimension assumption.
3. Calculating of kinematic viscosity at an average temperature of the two surfaces.

For AR 30, 15 with air and 10 with air and argon the difference between experimental and theoretical results are0.08, 0.1, 0.09 and 0.04 $W/m^2.C^O$ in time 15, 18, 21 and 24 hrs, respectively. Figure.16 obviously shows the percentage reduction for heat transferred from the outside to the inside using double glass as an alternative to single glass thus reducing the cooling load. The maximum values obtained for AR 30 and 15 with air and 10 with air and argon are (45-78) %, (54-85) %, (58-88) % and (60-91) %, respectively. The reason is the greater the distance the lower the amount of heat transferred through the glass that the large distance means a great resistance in the facing the heat transfer. The low conductivity of argon is another reason for these values.

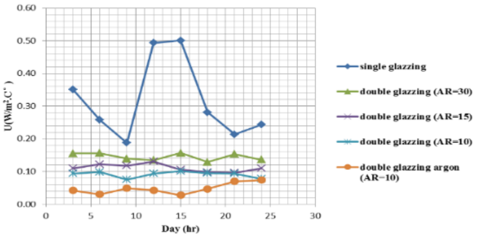

Figure7: Change of overall heat transfer coefficient with time

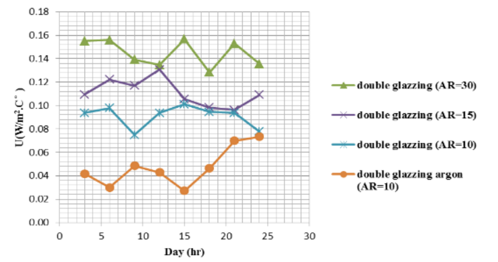

Figure 8: Change of overall heat transfer coefficient with time

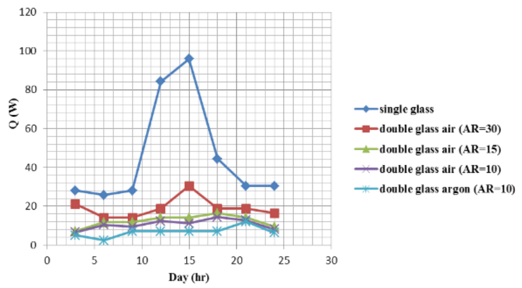

Figure 9: Change of heat transfer rate with time

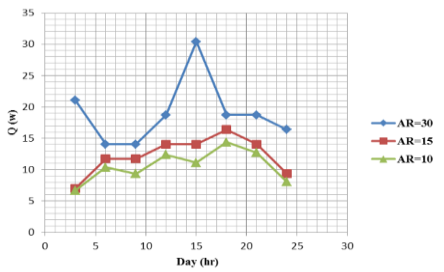

Figure 10: Change of heat transfer rate with time

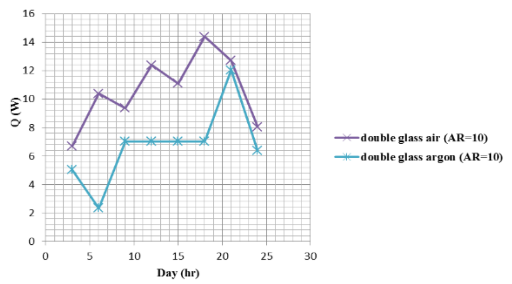

Figure 11: Change of heat transfer rate with time at constant AR

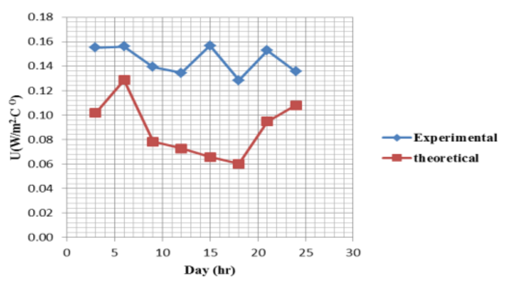

Figure 12: Variation of actual and theoretical of heat transfer coefficient with time for AR=30

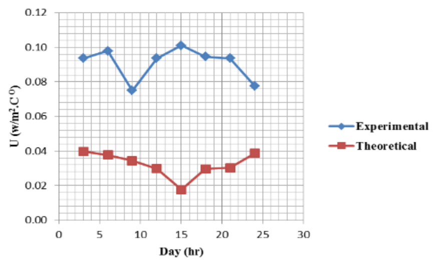

Figure 13: Variation of actual and theoretical of heat transfer coefficient with time for AR=15

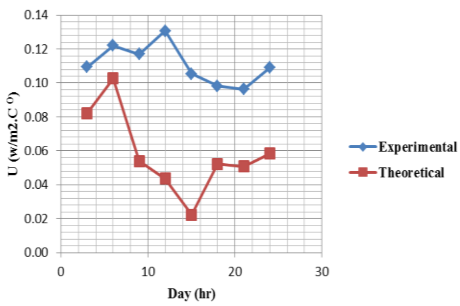

Figure 14: Variation of actual and theoretical of heat transfer coefficient with time for AR=10

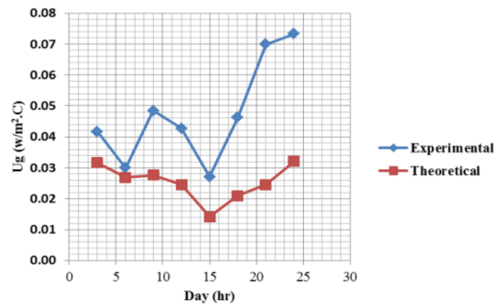

Figure 15: Variation of actual and theoretical of heat transfer coefficient with time for AR=10 argon

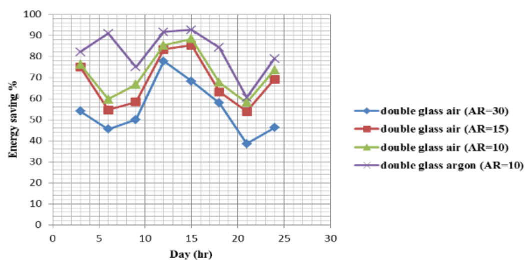

Figure 16: Energy saving of the heat transfer with time

4. Conclusions

The effect of using double glass windows as an alternative to single glass and its effect on the energy saving used in the cooling of houses and buildings in Iraq during the period of July and August for a different daytime 3, 6, 9, 12, 15, 18, 21 and 24, were examined. A practical study was successfully conducted for a three values of aspect ratio 30, 15 and 10 in the presence of air between the panels and in the presence of the argon gas for an aspect ratio 10. The e:rimental results confirmed that the use of double glass with the presence of air as a medium for the transfer of heat between the two panels reduced the amount of heat transferred compared to that in single glass between (45%-78%) , (54%-85%) and (58%-88%) for three aspect ratio respectively. While, for argon, it was observed (60%-91%).

Appendix

Table.1 sample calculation at hour 3 am

case	T_{in} c°	T_{out} c°	T_1 c°	T_2 c°	T_3 c°	T_4 c°	Q (W)	U_{total} (w/m2.c)	saving%
Single glass	24	33.6	27.6	26.4	-	-	28.08	0.35	-
Double glass AR=10 (air)	24	39	30.3	29.6	25.6	25.1	6.7	0.09	76
Double glass AR=15 (air)	24	31.7	29.5	28.1	26.3	26	6.7	0.09	75
Double glass AR=30 (air)	24	40.3	28.3	27.5	27.1	26.2	7.02	0.11	54
Double glass AR=10 (argon)	24	44.2	31.1	30.3	25.2	24.9	5.02	0.04	82

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