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Measurement of Temperature Gradient of Walls as a Means of Controlling the Inner Temperature of Buildings

Akpan, O.P., Etim, I.G., Akpan, E. F., Ekwere, A.E. & Jimmy, E.E
Department of Science Technology
Akwa Ibom State Polytechnic, Ikot Osurua

ABSTRACT

In this study, wall temperature gradient was investigated as means of controlling the inner room temperature. The temperature data were collected in ten buildings in Akwa Ibom State Polytechnic, Ikot Osurua. The result shows that the temperature gradient for 10 buildings ranges from 13.1 ℃/m to 30.8 ℃/m, the highest value was for building ten(30.8 ℃/m) and the least was for building nine (13.1 ℃/m). The building with higher temperature gradient was seen to have low inner temperature. The result also shows that the inner temperature is proportional to the outer temperature while temperature gradient is inversely proportional to the thermal conductivity that aids the radiation of the heat within the room. Thermal mathematical model were developed for the various variables. The equations generated from the graph are good input parameters that can be used by building designers to regulate the internal temperature of the enclosure to a tolerable degree. The result shows that to regulate the room temperature, the inner and outer temperature of walls together with the temperature gradients have to be considered.

Keywords: *Temperature, Temperature gradient, Thermal conductivity, Radiation.*

INTRODUCTION

Temperature is a physical property of matter that quantitatively expressed the common notions of hot and cold (Bede *et al.*, 2006), as distinct from a quantity of heat, temperature may be viewed as a measure of a quantity of a body, (Bryan e*t al*., 1907) or of heat, (Bailyn,1994). In our homes, indoor thermal discomfort has been very challenging and it depends on one or more of the materials used either as ceiling board; rock used as walling materials; wood used in making doors; wood sample used in making roofing support or combination of all of them (Berkeley, 2000). One of the special concerns of the trained builders is to design a building that the indoor environmental condition is thermally tolerable and conducive to the occupants of the building (Ajibola & Ohabenjo, 1995, Van Straaten, 1967). Besides the door, roofing and ceiling materials, the wall also generate heat thereby contributing in no small measure to the thermal discomfort of a building. Object with high temperature is referred to as warm or hot. When two objects of the same material are placed together the object with the higher temperature cools while the cooler object becomes warmer until a point is reached after which no more changes occurs. When the thermal changes have stopped, we say that the two objects are in thermal equilibrium. So, temperature of a system can now be defined as that quantity which is the same for system when they are in thermal equilibrium, (Quinn, 1990). As such, temperature gradient is a physical quantity that describes in which direction and at what rate the temperature changes the most rapidly around a particulars location. The temperature gradient is also the dimensional quantity expressed in units of degrees (on a particular temperature scale) per unit length. Temperature is one of the principal properties studied in the field of thermodynamics, particularly important in the field are the difference in temperature between regions of matter. This is because such differences are the driving force for heat, which is the transfer of thermal energy, (Adkins, 1987). Spontaneously, heat flow only from regions of higher temperature to region of lower temperature. If no heat is transferred between two objects it means the object has the same temperature, temperature of an object varies with the speed of the particles it contains. Temperature is an intensive variable because it is independent of the bulk amount of elementary entities contained within atoms, molecules or electrons. Many physical properties of materials including the phase (solid, liquid, gaseous or plasma) density, solubility, vapor pressure and electrical conductivity depend on the temperature. Temperature plays a vital role in determining the rate and extent to which chemical reactions occur. This is one reason why the human body has several elaborate mechanisms for maintaining the temperature at 310k, since few degrees higher can result in harmful reaction with serious consequences. Temperature also controls the thermal radiation emitted from a surface (Herzfeld, 1962). The aim of this paper is to study temperature gradient using the outer and inner temperature of walls with the thickness in order to generate a mathematical model that can be used to predict and regulate the temperature of these buildings.

METHOD

Ten selected buildings in Akwa Ibom State Polytechnic, Ikot Osurua, Ikot Ekpene, Nigeria were used for the study. For each day, out of the ten the wall thickness (L) of the building was measured with the help of a long meter rule and recorded. The temperatures of the outside (Tout) walls were also measured using mercury in glass thermometer withheld to the walls with the help of a paper tape. The thermometer was left on the outside and inside walls for six complete hours. At exact six hours, the temperature of the outside (Tout) and the temperature of the inside (Tin) walls were read and recorded before removing the thermometer from the wall. The temperature gradient of each of the walls was gotten from the equation below

$$\Delta T_g = \frac{T_{out} - T_{in}}{\Delta L} \qquad 1$$

Where Δ Tg = Temperature gradient Tout = Temperature of the outside wall

Tin = Temperature of the inside wall

Δ L = Wall Thickness

RESULTS AND DISCUSSION

The result obtained from ten different buildings is as shown in the Table 1

Table1. Measured wall thickness, temperatures and calculated temperature gradient

Building no.	L (m)	(Tout) °C	(Tin) °C	(ΔTg) °C/m
1	0.26	36	32	15.4
2	0.17	37	34	17.7
3	0.24	35	31	16.7
4	0.15	38	35	20.0
5	0.17	36	34	11.8
6	0.26	37	33	15.4
7	0.14	39	35	28.6
8	0.17	38	35	17.7
9	0.23	35	32	13.1
10	0.13	38	34	30.8

Table1 shows the wall thickness (ΔL) in meters, outside (Tout) and inside (Tin) walls temperature in degree Celsius and the calculated thermal gradient (ΔTg) in degree Celsius/meter for the ten different buildings considered in the research

DISCUSSION

The aim of this work was primarily to investigate the dependence of temperature gradient with the wall thickness as a means of controlling the thermal flow or transport within residential houses. The result as seen in fig.1 shows variation in the temperature gradient as per buildings. Building number 10 has the highest thermal gradient but the least wall thickness, building number 7 has a higher temperature gradient while building number 5 records the lowest temperature gradient. Again the inverse relationship between wall thickness and temperature gradient could also be observed in Table 1.0

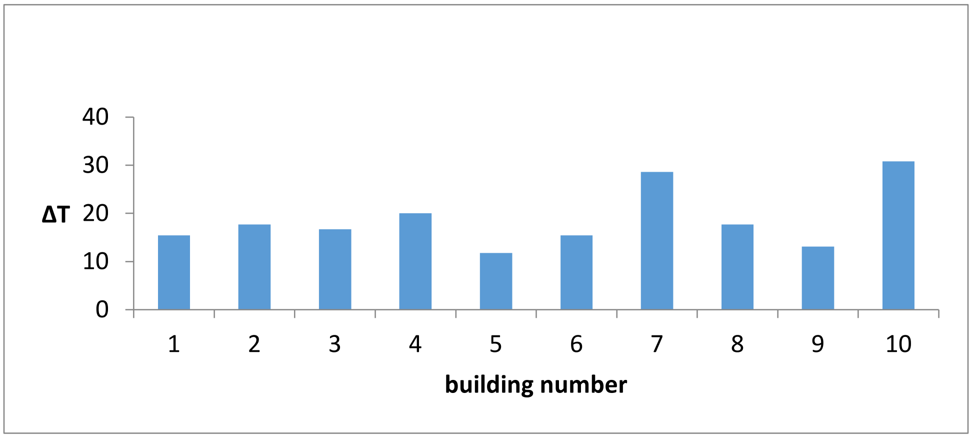


FIG. 1 Temperature gradient per building no.

Figures 1-3 shows the various graph and a chart that explain the relationship between the various parameter that can be used in regulating the walls temperture thereby installing coolness within the room

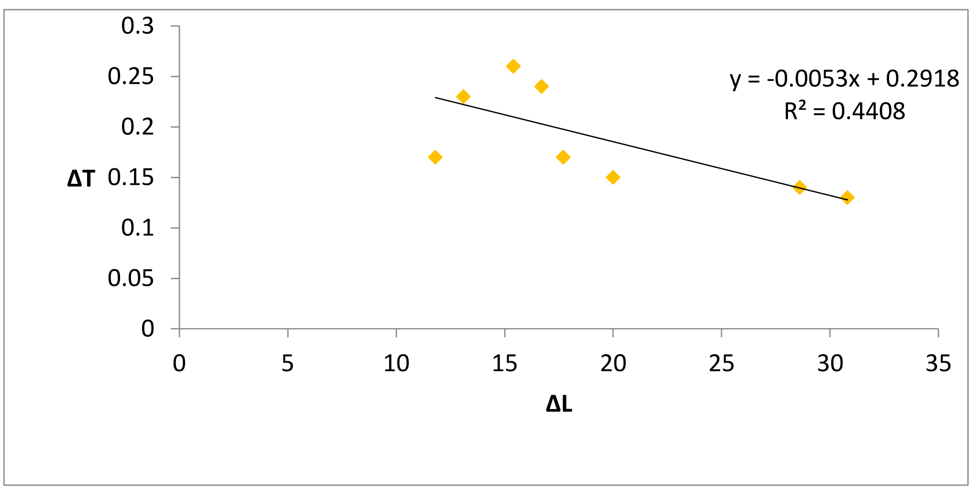


FIG.2 Plot of temperature gradient against wall thickness

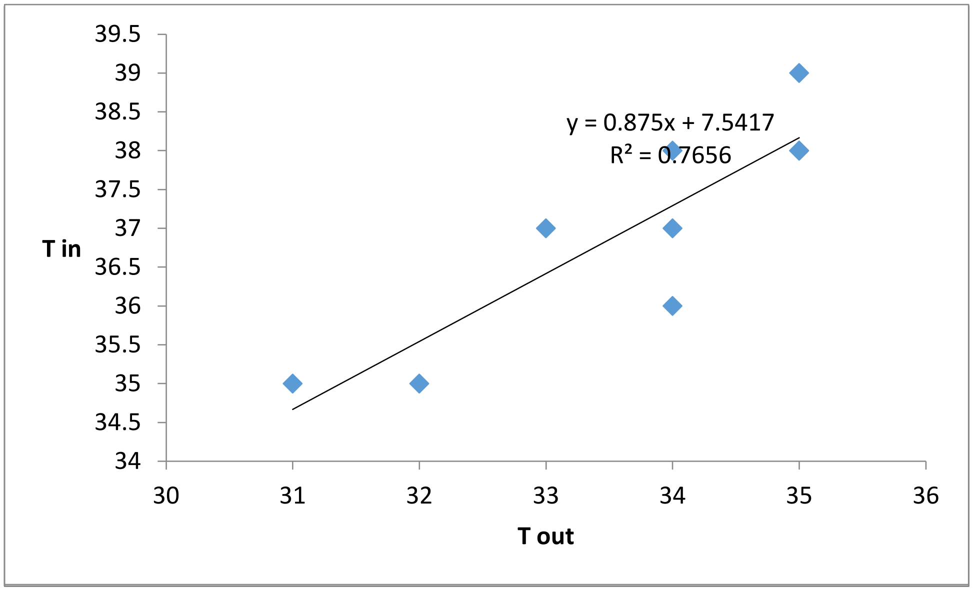
Figure 2 is a plot of temperature gradient against the Wall thickness. The graph indicates that, the higher the wall thickness the lower the thermal gradient of a building according to the trendline equation 2

$$\Delta T = -0.005\Delta L + 0.291 \qquad 2$$

ΔT given in equation 2 is similar to that obtained in a similar investigations elswhere and reproduced in equation 3 (George et al, 2010) . When the building has a higher wall thickness , the room temperature of the building is bound to be hot, and will lead to high thermal conductivity.

ΔT=-82.66L+34.59 3

To reduce the thermal conductivity within the building that will heat up the building, the wall thickness has to be reduced so that the temperature gradient will be high.



3 Plot of inner temperature against the outer temperature

Figure 3 is a plot of inner temperature against the outer temperature. The graph shows proportional increase between the two variables. This means that increase in outer temperature leads to increase in inner temperature as well as increase in temperature gradient. Thus, the thermal conductivity is inversely proportional to the temperature gradient. Hence, to reduce the heat content of the house, the wall thickness must be sufficiently larger so that the temperature gradient will be higher. The wall temperature can be regulated between the inner temperature and the outer temperature of the walls using the generating function or equation 4

$Tin = 0.875\,Tout + 7.541$ 4

A similar equation to equation 4 was obtained in a similar investigation elsewhere and represented in equation 5 (George et al, 2010)

Tin=0.917outer–0.343 5

Figure 3 shows the comparison between the outer and the inner temperature as explained in Figure 2 for the ten buildings used. The correlation shown in the variable also goes a long way to prove that outer temperature is proportional to the inner temperature that is when the inside temperature increases the outer also increases

In addition it could be observed in this study that room temperature of any building depends on the wall thickness used in the construction of the walls. This also means that the inner temperature of any building is inversely proportional to the wall thickness of the building. (i.e. the wall thickness of any building determines the inner temperature of that building). Again the temperature of the inner is further found to be increasing proportionally with the outer temperatures. The above explanation shows that the wall temperature (outer and inner) and temperature gradients can be used as scientific tools for controlling room temperature. By considering the wall thickness, the temperature of the building can be conveniently regulated.

CONCLUSION

The wall temperature gradient of ten different buildings use in this work shows that the outer temperature of any wall in a building is greater than the inner temperature and as the Tout increases the Tin also increase which resulted in high temperature gradient and thereby giving a low thermal conductivity in buildings

The generated parameters from the work can help to regulate the inner room temperature of any building to a suitable standard required if put into consideration when constructing a wall in buildings.

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