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Heat Insulation Using Colour Glass

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Abstract

In residential and commercial buildings, heat from the sun can enter by radiation through walls, roof and windows. Radiation refers to the mechanism in which the internal energy of an object is emitted in the form of heat without requiring a transfer medium. Traditionally, curtains and coloured glass have been mainly used for windows to reduce the amount of sunlight that enters the unit. This also helps to reduce the amount of heat that passes through. In this article, windows of different colours are studied for their effectiveness in filtering heat via radiation. As windows made of a certain colour only allow the colour to pass through, selecting windows of appropriate colour will also allow for optimum heat insulation and light penetration.

Keywords— colour windows, solar heating, radiation

I. INTRODUCTION

Heat is a form of energy which travels from a region of higher intensity to lower intensity in three different modes – conduction, convection and radiation. While conduction and convection require a transfer medium, radiation can occur even in a vacuum. An example of radiation is the energy from the sun which can travel across the vast space in between to Earth in the form of electromagnetic waves. In 1800, William Hershcel discovered the presence of infrared waves in sunlight, beside the 7 spectrum of visible light, which is mostly responsible for the heat from the sun (Hershcel, 1800). With many of today's buildings having large windows to improve natural lighting, this can inevitably lead to the warming of the units as well. In fact, due to the spectral transmissivity of the glass, the internal temperature can be even higher than the outside environment, a phenomenon known as the greenhouse effect (Cengel and Ghajar, 2011).

In order to maintain a comfortable living condition of 24 to 28°C (Wahab et. al., 2012), active cooling, through an air conditioning system, is normally practiced. Active cooling refers to any method that requires the use of external energy and is one of the contributing factors to the increase in energy demand. An alternative way of removing the heat is through passive cooling, which is achieved through the design itself by reducing the amount of solar heat entering the building (NREL, 1994). Since the heat from the sunlight is due to the infrared

waves, hence, blocking these waves from passing through a window will cool down the internal environment.

In this paper, the objective is to reduce the amount of heat that penetrates into a building through windows by using various colours of window glasses for energy saving purpose. The working principle is that, the coloured glass will only allow spectrums of the same colour to pass through it. Thus, the further the shade of the colour is from infrared, the more effective the glass is in regulating the interior temperature.

II. EXPERIMENTAL

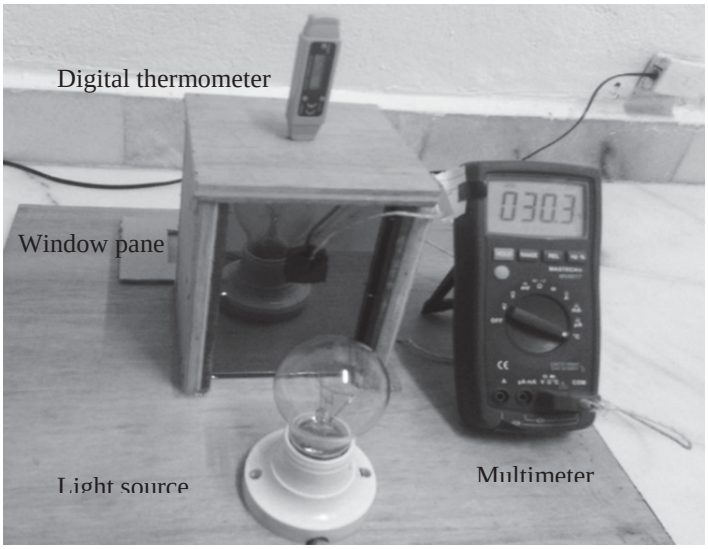

Figure 1. The apparatus for the experiment.

The experimental work was carried out to measure the amount of heating due to glasses of different colours; blue, green, brown and clear, that are available in the market (Figure 1). The colour brown is actually a combination of red and green. A 100-Watt incandescent bulb was used to stimulate the effect given by sunlight to ensure that there is consistent heating. When the light bulb is lit, radiation from the light will heat up the air inside the box which was measured using a digital thermometer. Plywood was used to make the body of the box since it has poor thermal conductivity and low specific heat. The distance between the glass window and the bulb was kept constant at 80 mm. At the same time, a lux meter (Amprobe LM-100) was placed inside the box to measure the amount of visible light entering the box.

III. **RESULTS AND DISCUSSIONS**

The temperature of the surface of the glass was measured and tabulated in Table 1 for all four colours. From the table, it can be seen that the temperature of the glass was almost the same regardless of the colour, indicating that the radiation from the light bulb is consistent throughout the experiment.

From Fig. 2, it can be seen that the temperature difference between the glass surface and the interior was the smallest in clear colour glass and the largest in blue colour glass. This observation suggests that clear glass transmits the highest amount of heat while blue colour glass transmits the least amount of light. The reason being, clear glass transmits light of all spectrums whereas blue only allows the blue spectrum to pass through. And since the colour blue is further away from the infrared in the light spectrum compared to green, hence less heat is being transmitted through the glass. It is also interesting to point out that, when comparing between green and brown colour glasses, brown glass transmits a slightly more amount of heat since it also allows red colour wavelengths to penetrate through it. And because red is adjacent to infrared in the spectrum, hence the interior is hotter.

TABLE 1 TEMPERATURE OF GLASS SURFACE OVER TIME

Time (min)	**Temperature (in °C)**				
	Clear	***Brown***	***Green***	***Blue***	***Std dev***
0	27.1	27.6	26.9	27.6	0.36
1	37.6	37.4	37.5	37.8	0.17
2	39.6	39.1	38.5	39.4	0.48
3	41.2	40.7	39.5	41.2	0.80
4	42.4	41.9	40.1	42.6	1.14
5	43.4	42.8	41.2	43.6	1.09
6	44.2	43.7	42.4	44.7	0.99
7	44.8	44.6	43.7	45.3	0.67
8	45.4	45.1	44.6	47.2	1.13

9	46.5	45.9	45.7	48	1.04
10	47	46.4	46.9	48.7	1.00
11	47.4	47.4	47.2	49	0.84
12	48.1	48	48.1	49.6	0.77
13	48.7	48.8	48.7	49.6	0.44
14	48.8	49	49.2	51.2	1.11
15	49	49.4	49.5	51.4	1.07

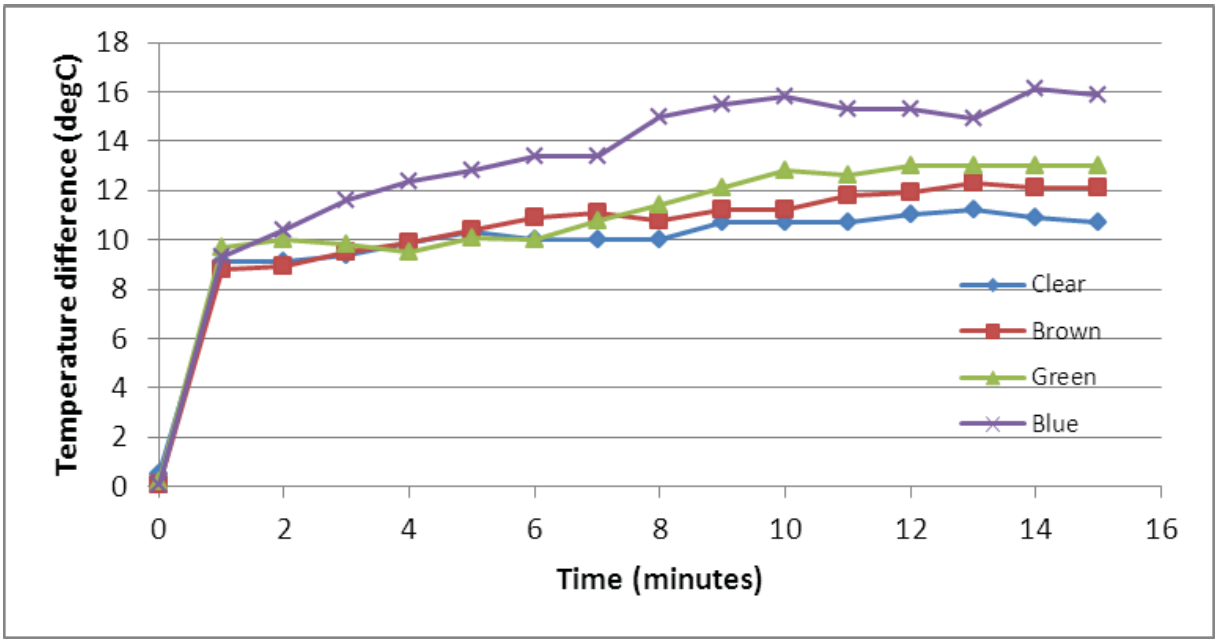

Figure 2 Temperature difference versus time with glass of different colours

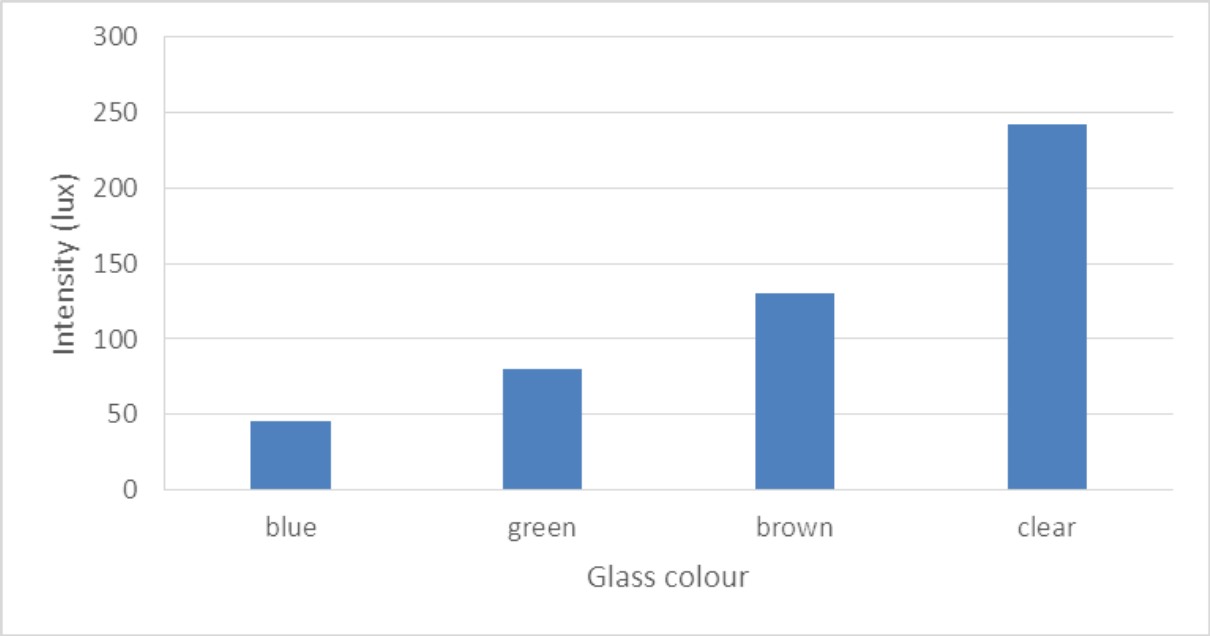

Figure 3 Light intensity measured against different glass colours

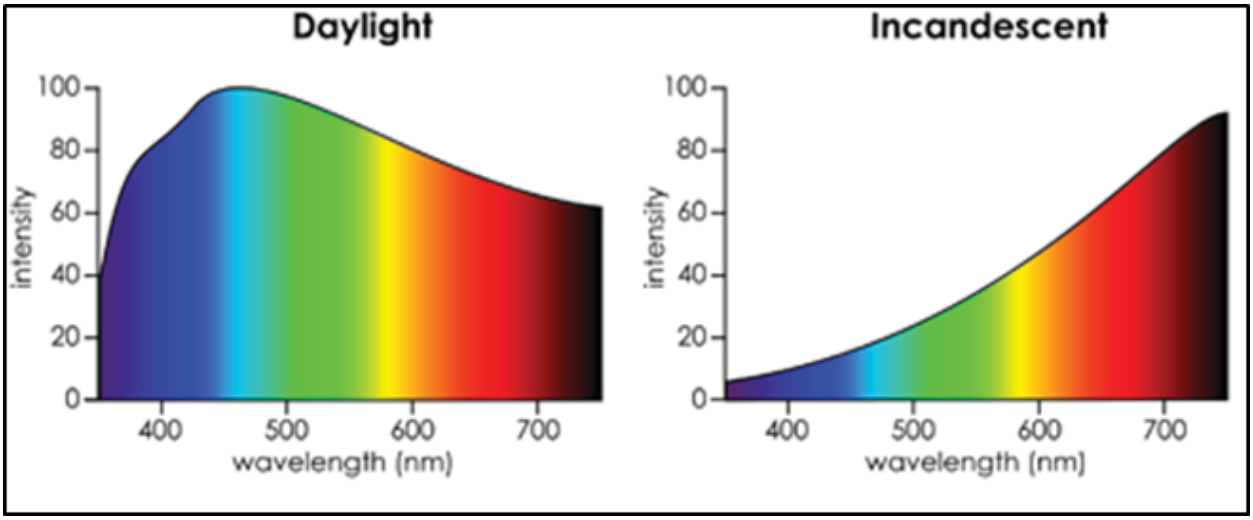

Figure 4 Spectrum of (a) daylight and (b) incandescent light bulb (Geller, 2014)

To further support the argument, the intensity of the light that penetrates these glasses was also measured (Fig. 3). From the graph, the information recorded is matched to that in Fig. 2. It is worth mentioning that in incandescent light bulb, the intensity of the colours across the spectrum is not the same (Fig. 4). It can be seen that it gives out mostly red colour

(wavelength between 610 -700 nm) while only a small portion consists of blue colour (wavelength between 450-500 nm). This also helps to explain the low readings recorded in the lux meter when using blue colour glass.

It should be noted, however, on the other end of the spectrum, the ultraviolet (UV) light is harmful to humans. Too much exposure to UV can be detrimental as it is a known cause for skin cancer. When using blue colour windows, the amount of UV light will be the highest compared to brown and red due to its close proximity.

IV. CONCLUSION

From the current experiment, it can be concluded that the amount of heat and light transmitted through windows can be manipulated using windows of different colours. Based on the findings, use of blue colour windows is the most effective in reducing the amount of heating within the building. But on the other end, due to its close proximity to the colour of ultraviolet rays, which is harmful to us, it is suggested here that green colour windows may be the better choice. Also, the measurement was only taken for a short period of time because continuous heating will eventually lead to a higher interior temperature as a result of heat conduction which would compound the effect of heating.

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