# An Intensity Comparison of Light Bulbs Using Spectroscopy Method

S. Nurulain[1], N. O. Sharif[1], F. Siddiq[1], M. R. Salim[2], H. Manap[1]

[1]Faculty of Engineering Technology, University Malaysia Pahang, UMP, Malaysia.
[2]University of Technology Malaysia (UTM), Malaysia.
*Corresponding author: hadi@ump.edu.my*

***Abstract*—This paper describes the differences between light intensity of light bulbs from different working principle. A Maya2000 spectrometer from Ocean Optics is used as a light detector. The intensity of light is taken within the visible wavelength between 390 nm to 700 nm. It is observed that light intensity from different type of light bulbs forms different spectral power distribution. The light emitting diode (LED) lamp shown to be the most efficient light bulbs with the highest average light intensity compared to incandescent and fluorescent lamps.**

***Keywords*— optical sensor, bulb intensity.**

## I. INTRODUCTION

Light transmission is an electromagnetic radiation. It can be created by making an electron oscillates which emits an oscillating electric and magnetic field thus producing light in the form of energy packet called photon. Light can be broken up into different types, some of them can be seen by human eyes and others cannot, but all of them are still under electromagnetic spectrum. The human eyes can perceive light in between approximately 400 to 700 nm that give off colors ranging from violet to red [1].

Light intensity as used in this experiment is the number of photons per unit area per time. In this research, the main purpose is to study the comparison between the intensity of light coming from light bulbs with different working principle. Besides that, the differences in average intensity of light between the same working principle light bulbs but of different watt are also observed. The types of light bulb that were used in the experiment are incandescent, fluorescent, and light emitting diode (LED) light bulbs. The intensity of light emitted by these three light bulbs is expected to give different spectral power distribution graph.

## II. THEORY

This experiment used three sets of light bulb. Each set comprises of three light bulbs of different working principle which are incandescent lamp, fluorescent lamp, and LED lamp. The three sets of lamps which are selected are 5watt, 15watt, and 20watt. For each set, the type of light bulbs is set as the manipulative variable while the power input is fixed. The power input values are obtained using the formula below:

$$P = V. I \qquad (1)$$

Where P is power, V is voltage, and I is current input.

Briefly, incandescent light bulb works by heating up a thin tungsten filament. The result upon heating creates an "incandescence" which is light produced by heat [2]. Meanwhile, a fluorescent lamp basically built using a long glass gas discharge tube. Firstly, electrode filaments will preheat the tube to initiate a rapid conduction of electrons which then collide with the gaseous mercury atoms, increasing the amount of energy. The ultraviolet light is emitted as electrons return to their original energy level which causes the phosphorous coating on the tube to give off visible light [3]. As for LED lamp, it uses two lead semiconductors that emit light when electrons pass through it. The transfer of the electrons from the conduction band to an empty space in the valence causes energy difference in the band gap. The energy is being released and emitted as photon [4].

The differences in how each light bulb works affect the pattern of the spectral power distribution and the average intensity of light given off by the light bulbs.

## III. EXPERIMENTAL SET UP

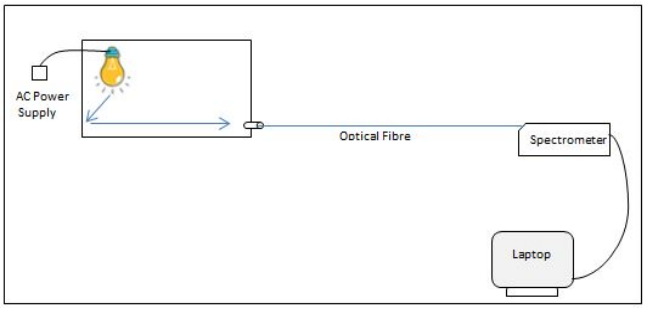


Figure 1: Generic design of a light detector tools used in this experiment

The experimental setup is shown in Figure 1 and Figure 2. Light bulbs of different kind were used as the light source. The power supply used in this experiment is AC voltage of 236V. The light bulb was put in a full covered by a wooden black box with dimension 28cm x 30cm x 41cm. The box was made by using plywood sprayed with a matte black paint to reduce the chances of light from coming from outside and to set the environment inside the box to be as dark as possible when the lamp is turned off. A collimating lens was placed on one side of the box and it was directed to the point inside the box where the light from the lamp was reflected.


Figure 2: Experimental set up in the laboratory

An optical fibre (Optran UVNS, Ultra Violet Non Solarising) with 600 µm core is connected to the box via collimating lens. The collimating lens was used to gather the light coming from light source then channel it to the optical fiber to be directed to the light detector. The light detector used in this experiment was Maya2000 spectrometer from Ocean Optics. The spectrometer can capture the light of wavelength from 190 to 1100 nm and has resolution up to 0.65 nm (FWHM). The spectrometer was connected to the computer via Spectra suite software installed beforehand. Spectra suite is a program specifically designed and developed by Ocean Optics to acquire data from the spectrometer. It also has some data processing function so that the average reading of intensity of the light source within the range of wavelength of interest can be displayed to the user.

## IV. Results and Analysis

Initially, the box was covered properly as not to allow any light to come in and affects the intensity reading. When the light bulb was switched on, the lights were gathered by the lens on the collimating lens. The light then travelled via fiber optic cable to the spectrometer. The fiber optic cables were used as they are a convenient way to channel light from one point to another. When the light as photons reached the spectrometer, they will be transmitted through a grating to be diffracted according to their respective wavelength [5]. The pixel of the detector collected the photon in the form of energy. In this experiment the integration time was set to100ms. After each integration time, the charge levels from all the pixels were read and converted into a specific number of "counts". The amount of photon is being translated into data, where the higher the number of counts indicates the higher the number of photons. The higher number of photons means higher intensity of light in this context.

The reading was taken for 20 minutes to make sure the light coming from the light bulbs had stabilized. After the end of 20 minutes, the data to compare the pattern of spectral power distribution was taken. The value of current input was also measured by using a handheld digital clamp multi-meter. The voltage value was fixed at 236V. The power input values were calculated using equation (1). The results from the experiment are shown in Table 1. The precision of the handheld digital clamp multi-meter is up to two decimal places for current reading and zero decimal place for voltage reading. Hence the readings shown in this paper are only an approximation.

Table 1: The measurement of current, voltage, and power input of each light bulb.

| Type of Light Bulb | Current Input (A) | Voltage (V) | Power (W) |
|---|---|---|---|
| | | | |
| Philips LED 5W | 0.02±0.01 | 236±1 | 4.72±2.38 |
| FF Lighting LED 15W | 0.06±0.01 | 236±1 | 14.16±2.42 |
| Aletko LED 20W | 0.09±0.01 | 236±1 | 21.24±2.45 |
| | | | |
| Philips F 5W | 0.02±0.01 | 236±1 | 4.72±2.38 |
| Osram F 15W | 0.07±0.01 | 236±1 | 16.52±2.43 |
| Osram F 20W | 0.09±0.01 | 236±1 | 21.24±2.45 |
| | | | |
| Chiyoda ID 5W | 0.03±0.01 | 236±1 | 7.08±2.39 |
| Osram Halogen ID 15W | 0.06±0.01 | 236±1 | 14.16±2.42 |
| Chiyoda ID 20W | 0.08±0.01 | 236±1 | 18.88±2.44 |

The intensity of the light emitted by each light bulb of different working principle with the same power input of approximated 5Watt is as shown in the Figure 3. As can be seen, for the LED light bulb reading, the peak is at wavelength 448.88nm with 590 counts. The intensity then reduces until it reaches wavelength at 479.04 with 169 counts.

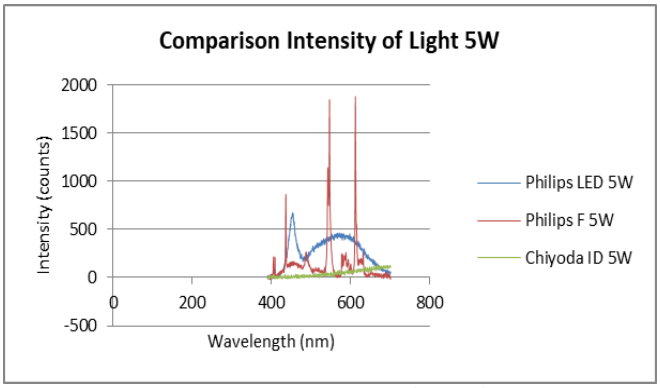


Figure 3: Comparison between the intensity of light of 5Watt light bulbs

Then, it increases until wavelength 567.91nm with 428 counts before decreasing again. The distribution of the spectrum gives bluish light due to the higher amount of blue light compared to other colors.

Meanwhile, the fluorescent light bulb graph has several peaks. The four highest peaks are at wavelengths 436.51, 542.17, 546.7, and 611.96 nm with 818, 1142, 1842, and 1879 counts respectively. This kind of pattern creates white light as a result. The downside is that when the light is reflected on a surface, it will not show the true color of the surface because of the lack of variety color spectrum in the light. When illuminated by the light source, only the spikes of the color spectrum present will be emphasized in the rendering of color for objects [6]. Next, for incandescent light bulb, the amount of the photons increases as the wavelength increases. The highest count reading is at wavelength 690.86 nm with 106 counts. Within the visible light range, the intensity is higher at the yellow to red spectrum region compared to violet to blue color spectrum which makes the light appears orange. The experiment was repeated using light bulbs with different watts. The results using light bulbs of power input 15Watt and 20Watt are shown below.

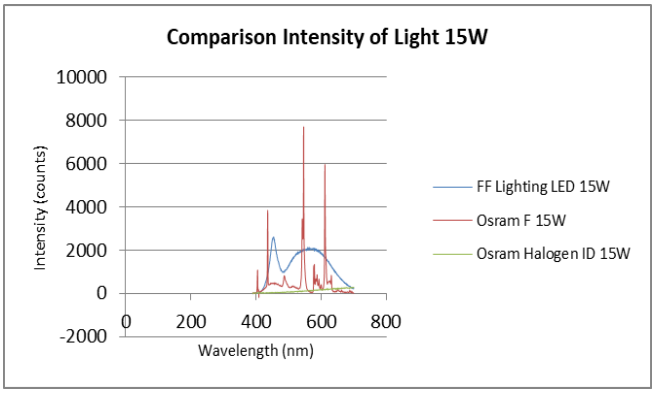


Figure 4: Comparison between the intensity of light of 15Watt light bulbs

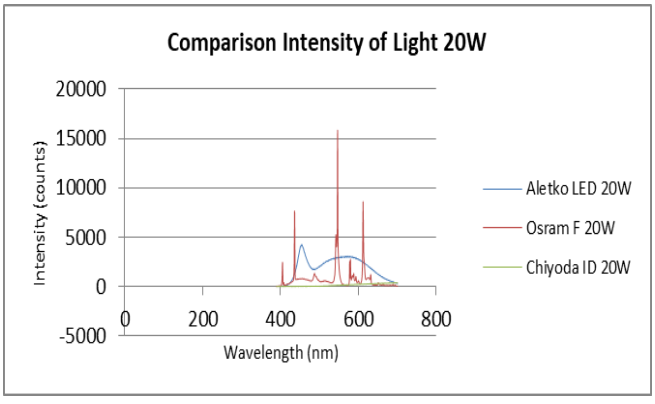


Figure 5: Comparison between the intensity of light of 20Watt light bulbs

Figure 4 and Figure 5 show the spectrum pattern for 15Watt and 20Watt respectively. It can be observed that the general patterns of the spectrum of 15Watt and 20Watt LED light bulbs are similar with that of 5Watt LED light bulb. The same goes to 15Watt and 20Watt fluorescent lamp. The pattern is similar to

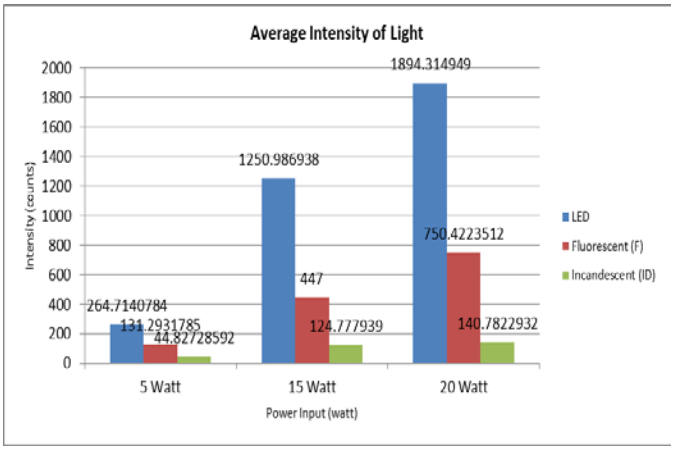


Figure 6: Comparison of the average intensity of light of all light bulbs used

5Watt fluorescent lamp. It can be observed for incandescent lamp as well whereby the 15Watt and 20Watt spectral pattern is similar to 5Watt incandescent lamp. The difference is only in the average intensity of lights.

As can be seen from Figure 6, the highest reading at approximated 20Watt power input is LED, then fluorescent and lastly incandescent lamps at 1894.31, 750.24, and 140.78 counts respectively. The 15Watt and 5Watt light bulbs also show the same pattern where the average intensity of light of LED lamp is the highest. Other than that, within the same type of light bulbs, it is shown that the higher the number of watt consumed by the light bulbs the higher the average light intensity is being emitted.

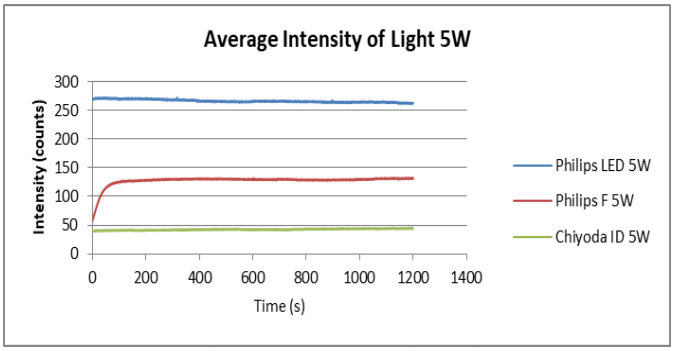


Figure 7: Comparison of the average intensity of light of 5Watt light bulbs over 20 minutes.

Next, Figure 7 shows the average intensity of light within the visible light range (300nm-700nm) taken in duration of 20 minutes. The data shows that for LED light bulb, the intensity of the light decreases linearly before it reaches a stable intensity. However, the intensity for fluorescent and incandescent light bulbs increases over time until they reach their maximum intensity. Fluorescent light shows a rapid rise within the first 2 minutes compared to incandescent light that has linear increase over 20 minutes time. It is shown that with the same consumption of power, the LED light bulb gave off a higher average intensity of light followed by fluorescent lamp, and finally incandescent lamp. Incandescent lamp is the least

efficient lamp among the three light bulbs because the energy is mostly wasted on heat rather than on the light since it creates light through heating.

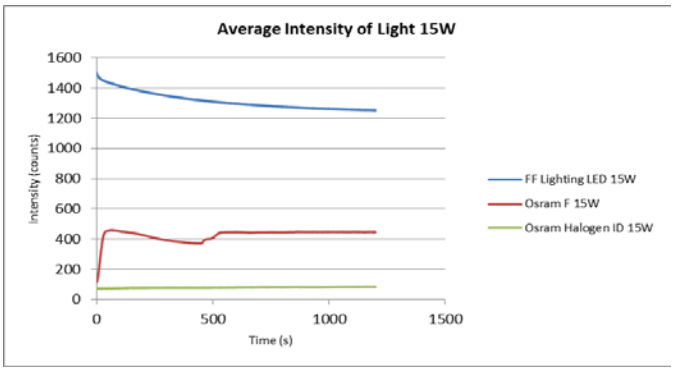


Figure 8: Comparison of the average intensity of light of 15Watt light bulbs over 20 minutes.

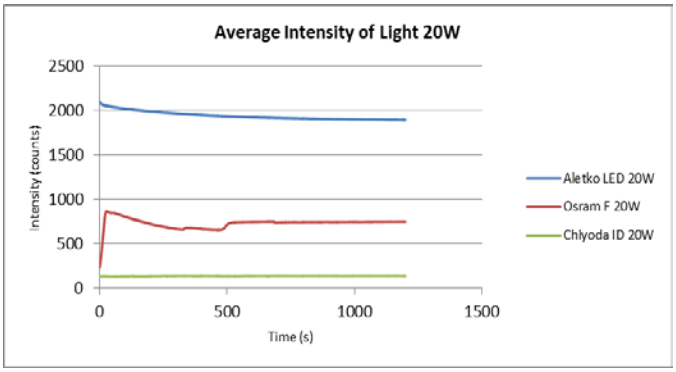


Figure 9: Comparison of the average intensity of light of 20Watt light bulbs over 20 minutes.

Based on Figure 8 and Figure 9, it can be observed that the patterns for the average intensity of light of LED 15W and LED 20W are the same with LED 5W. The same goes to incandescent lamp 15W and incandescent lamp 20W when compared with incandescent lamp 5W. For fluorescent lamp that uses 15W and 20W of power, there is some drop after the average intensity reaches maximum value. This could be because of the flickering of the light bulb. Nevertheless, the values increases again and then stabilizes after 8 minutes. All three sets show that the average light intensity of LED light is the highest while the average intensity of incandescent light is the lowest.

## V. Conclusion and Future Work

The comparison between the intensity of light from light bulbs of different working principle but the same power consumption has been described in this paper. It can be concluded that light bulbs that work with different operating principle will emit light intensity with different pattern of spectral power distribution. Furthermore, the average intensity of light of LED lamp is shown to be the highest followed by fluorescent and lastly incandescent lamps even though the amount of power consumptions is the same for each light bulb. Other than that, within the same type, the light bulb that consumed more energy to function will give off a higher average intensity of light. Future work can focus on how the operating principle of the lamp produces the pattern of the light intensity on spectral power distribution. This will contribute in the improvement of the light bulb to be more efficient.

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