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Appropriate assessment of disparity in some electrical parameters of selected bulbs

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Abstract

The complaints, worries and dissatisfactions accrued to bulb users prompted the quest of this research. The objective of the research is to suitably assess few electrical parameters of bulbs available in the market in order to have an experimental proof of the disparity in their ratings. In the research experimental data, incandescent bulbs (100W and 200W), LED bulb (5W) and CFL bulb (40W) (of different powers) were selected for evaluation. The power and lux of the bulbs were measured and compared correspondingly using the incandescent bulbs as reference bulbs for lux comparison. The new double T8 full range & ac/dc power meter with dimmer was instrument used to measure power and other associated electrical parameters (current and voltage) of the bulbs. The measurement results show that incandescent bulb of 100W measured 60.1W and the 200W measured 184.0W. The power of the 5W LED and 40W CFL bulbs measured 7.2W and 22.2W respectively. On this note, it is invariably obvious that there exists disparity in power rating of the bulbs accessible in our present day market. The digital luxmetre was used to measure lux (luminous flux per unit area or lumen per metre square) of the bulbs. In the lux measurement, the luxmetre's sensor was placed 50cm away from the bulb's position to obtain exact or close values to original bulbs' lux. Consequential to the bulbs lux comparisons, the lux value of 5W LED and 40W CFL bulbs have illuminances of 507lm/m2 and 568lm/m2 respectively higher than lux of 100W incandescent bulb. Hence, lux values of the LED and CFL bulbs measurements fall in-between lux values of 100W and 200W incandescent bulbs. Critical evaluation of the results tends to establish that luminosity (luminous flux per area) of bulb does not depend on power.

Keywords: Electrical power; Lux; Bulbs; Disparity; Measurement

1. Introduction

The understanding of the world around us is achieved with the help of information reaching our five sense instruments (organs), namely: eyes, ears, nose, tongue and skin. The sense associated with eyes is known as vision (or sight). Light is the agent which stimulates our sense of sight. The eyes convert the incoming light into electrical signals and convey them to the brain, which after processing the signals causes images or pictures to be created in our mind. According to Isaac Newton in 1675, in a corpuscular theory: a luminous body emits in all directions streams of extremely minute particles called corpuscles. Visible range is part of the spectrum constituted by waves, which can be detected by human eye. It extends from deepest violet to the deepest red. The limiting range of these waves depends in the individual properties of the eye and varies approximately in the interval $\lambda = 4000A^0$ to $\lambda = 7800A^0$ [2].

Perceptions of colour and appearance are multifaceted and psychological phenomena. Light can be defined as electromagnetic radiation with high possibility of affecting the sense of sight. For reliable assurance of a certain visual

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comfort, lighting sources must emit a certain luminous flux. When acquiring a specific source, its nominal data are marked on the box, including the light output [1].

Results of tests conducted on various sources with the same technical features has established that for the acquired light source, the luminous flux value marked on the box do not agree with the measured value. There are situations where the value of the emitted flux by a certain source of lighting is not part of the nominal data and is necessary to be determined. This determination is necessary in order to establish the aging degree of the source and whether it should be replaced. It can be achieved by measuring the flux values issued in different time intervals. Preserving or continuous use of a lighting source that is no longer capable to emit a corresponding visual luminous flux causes discomfort and unnecessary electricity consumption [8]. On this note, therefore, it is deemed fit for certain applications and its necessity to determine the actual value of the light output of the light sources. The lighting energy efficiency increase should be necessarily done from time to time to measure the luminous flux emitted by different sources so that light energy of poor efficiency can be replaced in time.

The sensational effect of light is dependent on the radiation spectrum wavelength, λ, according to the relative visibility. The luminous flux is dependent radiant power (energy flow Φ_e), through the relative visibility curve of the normal eye. The measurement unit of the luminous flux is a radiated watt per 0.555 μm wavelength, called watt light (Wl) [11]. In the international system (IS) the measuring unit for flux is lumen [lm] and one-watt light is equal to 683 lm. The unit of measurement of illumination in the international system is lux [lx] and it is defined as illumination of an area that receives a luminous flux of one lumen having a uniformly distribution over a surface of $1m^2$ [6] [9].

The light level is measured using an luxmeter. This is based on the action of the light on a photosensitive element. Lumen represented by lm is the SI derived unit of luminous flux that measures the total quantity of visible light emitted by a source per unit of time. Luminous flux differs from power (radiant flux). The radiant flux includes all electromagnetic waves emitted, while luminous flux is weighted according to a model (a luminosity function) of the human eye's sensitivity to various wavelengths. *The 26th General Conference on Weights and Measures (CGPM)* redefined the photometric units in 2018 which took effect on May 20th, 2019 [10]. Based on the new definition, lumens and lux are related in that one lux is one lumen per square metre. But before 2019, the definition was based on Candela (cd) as [7].

1 lm = 1 cd.sr ---------- eqn. 1

Where,

Lm = lumen; cd = candela; and sr = steradian.

In this research, selected and known bulbs/lamps are going to be used in the experiment for clarity and better understanding of the results and further suggestions. Amongst the types of bulb available in the market in our area or location, the three types of bulb that would be applied are the Incandescent, LED, and CFL bulbs/lamps.

An incandescent bulb typically comprises a glass enclosure containing a tungsten filament. When an electric current is passed through the filament, it is heated to a temperature that produces light. The enclosing glass enclosure contains either a vacuum or an inert gas to preserve and protect the filament from evaporating [12] [13].

LED lamp or LED light bulb is an electric light that produces light using light-emitting diodes (LEDs). LED lamps are significantly more energy-efficient than corresponding incandescent lamps and can be significantly more efficient than most fluorescent lamps [3] [5].

A compact fluorescent lamp (CFL), also known as compact fluorescent light, energy-saving light and compact fluorescent tube, is a fluorescent lamp designed to replace an incandescent light bulb. In the intervening time, some types of CFL fit into light fixtures designed for incandescent bulbs. CFLs produce light differently than incandescent bulbs. In a CFL, an electric current is driven through a tube containing argon and a small amount of mercury vapor. This generates invisible ultraviolet light that excites a fluorescent coating (called phosphor) on the inside of the tube, which then emits visible light [4].

Regarding the incandescent bulbs, 100 watts and 200 watts' bulbs would be used as the two extreme (intervals) for comparison with 5 watts LED and 40 watts CFL. Outside the power disparity evaluation, the lux values of 5 watts LED and 40 watts CFL bulbs would be compared to 100 watts and 200 watts' incandescent bulbs.

2. Instruments (Materials) Of Measurement

2.1. Digital Luxmetre

The value of the luminous flux can be measured using the photometer integrator known as Ulbricht lumen meter, which consists of an empty metal or fiberglass sphere, painted in interior with matt, very fine grain white colour, that produces a multiple diffuse reflectance. The white colour used for painting the photometer is characterized by a certain reflection factor *r*.

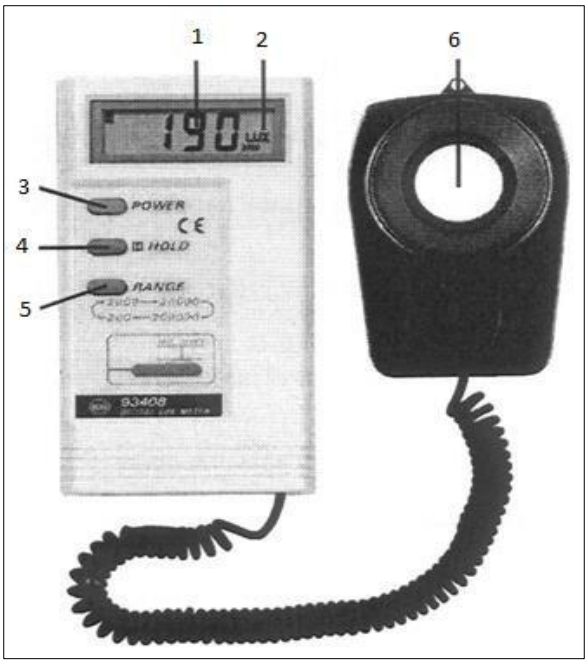

Figure 1 Digital Luxmetre

The luxmetre is composed of the following components

- LCD display
- display measuring range
- start button
- data memory button
- choice button
- Sensor (photodiode with silicon).

This digital lux meter used in this experiment has four measuring ranges of lux: 0 – 20, 0 – 200, 0 – 2000 and 0 – 20000, with the corresponding errors to the four areas being 0.01, 0.1, 1.0 and 10.0.

2.2. New Double T8 Full Range & AC/DC Power Meter with Dimmer (Model No.: LT-1396F)

The input voltage of this power meter Is AC 90V-265V/DC 12V. The output voltage is the same as input voltage. The power meter could test any electric appliance among AC 90V-265V/DC 12V. The tester could test not only the lighting products (LED lamps, CFL energy saving lamps, halogen lamps) but also the other electric appliance. Maximum testing wattage: AC 300W, DC 60W. Testing parameters include voltage, current, wattage, power factor, annual power consumption and annual bill. It is convenient to use with multi-use sockets, and could test the appliance with power plug of different countries. It is no need to connect the wire in addition.

With different base: AC part contains 2pcs E27, 2pcs B22, 2pcs G24, 2pcs E14, 2pcs GU10, 2pcs B15, 2pcs G9, 2pcs AC multi-use sockets, 2 sets of terminal holder and 2 sets of tube connectors. DC part contains 2pcs MR16, and 2 sets terminal holder, so it could test different lamps with different bases. Having 2 dimmers on tester, it tests the dimmable lamps also.

It compares 2 lamps or 2 tubes at same time with 2 sets display windows to show the data. The appliance could be tested by connecting the wires with terminal holder on the tester. With fuse in power sockets, it could protect load short circuit.

Figure 2 New double T8 full range & ac/dc power meter with dimmer

2.3. Acquisition of bulb

The bulbs used in the research were acquired from the electrical appliance shop in the market. They are not supplied direct from the manufacturer. Different bulb types were acquired and hence, 100 watts and 200 watts incandescent, 5 watts LED and 40 watts CFL were selected based on their comparable flux values.

2.4. Images (Samples) Of Used Bulbs

Figure 3 Commonest Led tube light bulb

Figure 4 Commonest Incandescent Bulb

Figure 5 The three common Compact Fluorescent Lamps

2.5. Technique of experiment

2.5.1. Step 1

The digital luxmetre was used here to measure lux of all the bulbs acquired from the market. In the process of the measurement, the sensor cap was opened before taking reading. For accurate values the luxmetre's sensor was placed 50cm away from the light source (the bulb) for all the bulbs. When the bulb was fixed or connected in the power metre and the metre switched on, a metre rule was used to measure a 50cm distance from the light source while the digital luxmetre was applied to record the lux of the bulbs in luminous flux (lumen) per m^2.

2.5.2. Step 2

The 100 wats and 200 watts incandescent bulbs were picked and compared. The two bulbs were connected to the power metre at band A and B and the metre was switched on as their different electrical parameters such as power, voltage and current were recorded directly from the power metre. Afterwards, the measurements were conducted for 5 watts LED and 40 watts CFL in same power metre.

3. Experimental results and discussions

The following are results of the experiments recorded of 100 watts and 200 watts' incandescent bulbs, 5 watts LED bulb and 40 watts CFL bulb.

3.1. Results on the bulbs' electrical parameters

Voltage of source = 219.5V

Table 1 Results of some electrical parameters of 100W and 200W incandescent (reference) bulbs

Normal (original) Values	Measured Values			
Power (Watts)	**Lux (lm/m²)**	**Power (Watts)**	**Voltage (V)**	**Current (A)**
100	308	60.1	219.2	0.268
200	867	184.0	218.7	0.841

Table 2 Results of some electrical parameters of 5W LED and 40W CFL bulbs

Bulb Type	Normal (original) Values	Measured Values			
	Power (Watts)	**Lux (lm/m²)**	**Power (Watts)**	**Voltage (V)**	**Current (A)**
LED	5	507	7.2	219.4	0.120
CFL	40	568	22.2	219.4	0.325

3.2. Discussion of power disparity of the selected bulbs

From the data representation of table 1 above, it could be grasped that power of 100W incandescent bulb measured 60.1W which is about 39.9W lower than the actual (normal) or manufacturer claimed power and the power of 200W incandescent bulb measured 184.0W which lacks the actual value by 16.0W against the claim of the manufacturer.

According to data of table 2 as represented above, the power of 5W LED bulb/tube measured 7.2W as contrary to the manufacturer's claimed power value of the bulb which differed by 2.2W. On the other hand, the power of 40W CFL measured 22.2W against the prerogative value of the bulb with difference of 17.8W.

The two experimental results revealed that lots of bulbs in the market today are mendacities of the manufacturers' designated worth or values. These falsified specifications had made the users to encounter difficulties in balancing the power input and output of their household power sources and appliances, especially people that generate their energy from clean energy (renewable energy) or mechanical/chemical effects (such as in generator set). The danger of this falsehood affects the energy consumers of national grid (for example, EEDC in Nigeria) whose monthly energy consumption bills are mostly charged by estimations and not energy meter reading based and, also it could affect the EEDC revenue. Therefore, the most users of illuminating source (bulb) are being skeptical about reliability of bulb in the market.

3.3. Discussion of comparative nature of the selected bulbs' lux

Lux of the selected three bulb types as measured will be compared here to ascertain the factors of its depictions. The two incandescent bulbs of powers 100W and 200W were measured as reference bulbs to compare their brightness, known as the luminous flux (measured in lumen), with 5W LED and the 40W CFL. Measurement of flux is unswervingly an understanding of the brightness of a bulb.

Considering the measured lux of the bulbs, we can see that 100W incandescent bulb measured 307lm/m^2 and the 200W incandescent bulb measured 887lm/m^2. Let the lux results of the incandescent bulbs be considered to establish a comparison. The lux value of 5W LED bulb measured 507lm/m^2 which is greater than value of 100W incandescent bulb (307lm/m^2) and below value of 200W incandescent bulb (887lm/m^2). This result shows that the lux of 5W LED bulb falls in-between the lux values of 100W and the 200W incandescent bulbs. However, it is clearly evident that the brightness or illuminance of 5W LED bulb is greater than 100W incandescent bulb despite its lesser power value. Therefore, luminous flux (brightness) is not power dependent since a 5W LED could produce more a visible light than a 100W incandescent bulb.

The lux value of 40W CFL bulb measured 568lm/m^2 which is of greater value to 100W incandescent bulb. Despite the difference in power of the two bulbs, yet, the lux value of CFL out-measured the incandescent bulb. This is convenient evidence to receive that lux (luminous flux per unit area) of bulb is not power dependent.

The outcomes of the experiment had shown that in general concept, power is not a determinant of values of luminous flux. The only condition when power is a factor of bulb's lux is when it concerns a bulb manufacturing company in whose bulb's illuminance differs by their powers

4. Conclusion

The bulbs available in today's market are insufficiently having their claimed power rating. In fact, bulb manufacturers are playing pranks in bulb manufacturing. They defraud money from their bulbs users by manufacturing bulbs whose power rating are below their claimed values.

On the other hand, LED and CFL bulbs have greater lux values than the incandescent bulb and that is why their brightness (visible light emission) is far beyond what incandescent bulbs could emit. The outcomes of the experiments displayed a glaring fact that lux does not depend on power, though manufacturers use power to differentiate their products (bulbs) lux.

Suggestion

The bulb manufacturers should change their manufacturing pattern of ratings to accommodate and address the shortfalls in values of the bulbs' electrical parameters. In other words, it is suggested that bulb manufacturers instead of been exact in their ratings should rather have a range of values as specifications. For example, a bulb of power rating of 100W could be specified with a rating of 60W-100W attributed to the bulbs that were used in the experiment.

However, LED and CFL bulbs should be considered for areas (households, event centres, etc.) that need more illuminance because they conserve more energy notwithstanding their high illumination.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest.

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