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RELIABILITY ASSESSMENT OF INCANDESCENT LIGHT BULBS IN NIGERIA MARKET AND CASE FOR ENERGY SAVING ALTERNATIVE

Ndinechi M. C, Ogungbenro A. Oluwaseyi,
Nwadiuko O. C, and Igboebisi Ikechukwu
Electronics Development Institute, Awka, National Agency
for Science and Engineering Infrastructure,
Federal Ministry of Science and Technology, NIGERIA
mikez4god@yahoo.com, Ogungbenroakin@yahoo.com
onwadiuko@yahoo.com, bigaike@yahoo.com

ABSTRACT

Incandescent lamps have been observed to have low manufacturing cost when compared to other types of light sources. They are the least expensive to buy, but relatively inefficient and burdened with short lifespan hence at the long-run the most expensive to operate. The established fact that about 90 to 95 per cent of the power consumed by an incandescent light bulb is emitted as heat, rather than as visible light implies that just about 5 to 10 per cent of the power is given out as light indicating that only little amount of energy is needed to give intensity large enough for domestic illumination. This research explores the durability of some incandescent bulbs, in the Nigeria market, with response to voltage fluctuations, temperature and mechanical vibrations. The need for low power, efficient, and reliable energy-saving alternative bulb for indoor and outdoor lightning was discussed in this paper.

Keywords: Incandescent, intensity, durability, illumination, energy-saving, voltage fluctuation

INTRODUCTION

Incandescent bulbs are most widely used domestic lighting device in Nigeria. This may be attributed to the viable intensity and low cost of the bulbs [1] despite the fact that ever since its introduction by Edison in 1879, the incandescent lamp has been the object of several drastic innovations which include introduction of a gas-filling by Langmuir in 1912, the utilization of chemical recycling of the filament material with halogen compounds by Zubler and Mosby in 1959, etc [2]. Incandescent bulbs work on the principle of heating a metal filament wire (usually tungsten), in a tube of gas, to a high temperature to which it become white-hot and begins to glow [3]. The incandescent bulbs are widely used in household and industrial lighting [4]. Many Nigerians are not familiar with the name “incandescent”. The common name for incandescent bulb in Nigeria is “yellow bulb”, or “ordinary bulb”, because of the common yellowish colour of the light rays from the bulbs. They are produced in wide range of sizes of light output and voltage ratings, from 1.5 volts to about 300 volts. They are commonly used in household and commercial lighting, for portable lighting such as table lamps, car headlamps, and flashlights, and for decorative and advertising lighting [1].

Only about 5% of total energy used by an incandescent bulb is converted to light energy, the remaining 95% is converted to heat energy [5] meaning waste of energy. Most of the energy supplied to it is converted to heat and this is evident as some applications of the incandescent bulb use the heat generated by the filament, such as incubators, brooding boxes for poultry, and heat light for reptile tanks [6, 7]. Also records have it that incandescent lamps have about 1000 hours life span [1, 8], and has a very low efficacy when compared to energy-saving bulbs which have about 9000 hours or more [9], and higher technology lightings of about 24000 hours [10]. Researches have been done on the inefficacious and durability of incandescent lamps compared to compact fluorescent lamps showing obvious advantage of the use of compact fluorescent lamps (CFLs) [11, 12, 13, 14, 15] and other technologies including light emitting diode (LED) lamps [10]. The CFLs are not problem-free, rather, it has better advantages in energy saving. These problems include the presence of mercury in the bulb or tube which is toxic to man and flocks, and the long time it takes to light up [6, 9, 10, 11].

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Incandescent lamps have none of these problems. LED lamps are mercury free, long life span, warm light colour similar to incandescent lamps and the ability to work with dimming switches in certain lamps [10]. Other technologies have their own problems too which arise ranging from complexity [9] to long starting time of high-intensity discharge lighting technology, which include mercury vapor lamps, metal halide lamps, and high pressure sodium lamps [10].

A major factor working against the shift from incandescent bulbs to energy saving bulbs is the cost. Energy-saving bulbs are far more expensive than incandescent bulbs. The cost of energy saving bulb in the Nigerian market ranges between N800 to N1000. However, some substandard energy saving bulbs could be purchase for about N200. On the other hand, the prices of incandescent bulbs range from N30 to N100 [1]. But some suggestions [10] have it that consumers' understanding on the basic lighting principles and terms will help for choices of lighting devices whereby the cost of use of lamp and the quality of light will be most considered.

JUSTIFICATION

Incandescent lamps in Nigeria cost low but burn-out in a very short time thereby calling for more purchase of bulbs. This can be attributed to its lighting efficiency and low manufacturing efficiency. The amount of energy used up by the incandescent bulbs which is major expended as heat instead of light is of major concern to both energy consumer and producer. While it gives the consumer less value for his money, it amplifies energy insufficiency challenge currently being experienced by the country. Energy saving alternative will therefore not only give consumer greater value for his money but curb unnecessary energy waste in homes and industries thereby making more energy available for other purposes while maintaining the same energy generation level.

METHODOLOGY

ExperimentalConsiderations

Nigeria is a country whereby electricity supply is not steady and so there are options of fluctuating voltage or fluctuating current; also there are applications of lighting in areas of spontaneous movements thereby subjecting the lamps to regular and irregular vibrations; the change of energy generation in the country may also arise, and this will introduce change from the normal electric frequency; some environments whereby incandescent lighting are used subject them to high temperatures while some are subjected to low temperatures. The lifespan of energy saving light (bulbs), its good colour rendition, long term cost effectiveness and good light intensity rendering is compared with that of incandescent light in the discussion column below.

Materials

Different lamps were purchased from Awka main market in Anambra State. These include 60W Philips, Tungsram, Pila, Sunlite, Classic, Hana and Osram incandescent bulbs and 100W Tungsram, Pila and Osram bulbs. Also purchased were 12W and 20W compact fluorescent lamps, and 20W light emitting diode energy saving light. Figure 1 shows the arrangement of these lights on the rectangular board. The testing devices are photometer, oscilloscope, thermometer, and multimeter. The other equipments include variac, cabinet, temperature-controlled hot plate, drilling machine attached to a table (as vibrating device), oscillator, bulb holders, wires and wiring equipments.

Method

Accelerated life testing techniques were used to demonstrate the reliability of incandescent light bulbs. Nominal test where bulbs were powered and allowed to naturally go off, simulation of voltage fluctuation with variac, vibration and spike test were carried out. The mean-time failure is estimated in the final model and reliability is estimated.

The bulbs were mounted parallel to each other on a board and controlled by a single switch to ascertain uniform quantity of power is supplied to each bulb at the same time. Subjected to similar conditions, they were left "on" and "off" for same period of time with same type of power supply which is assumed to be steady source. After this set of test, another test was conducted with erratically

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varying voltage. Variable alternating current transformer (Variac) was used for this purpose. Figure 1 shows various brand of electric bulbs arranged side by side on a board.

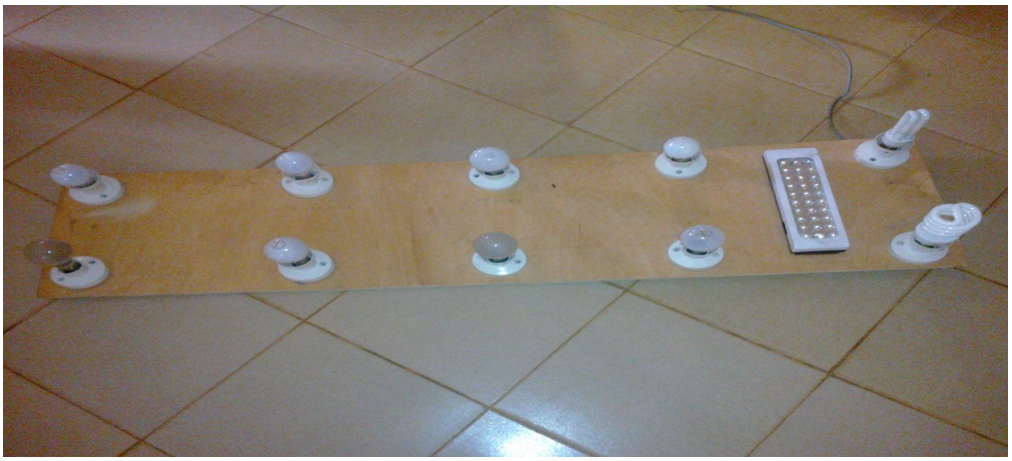

Figure1.Different Bulbs arranged on rectangular board

The variac was used to alter the voltage and current inputs to the bulbs. The board of bulbs were kept on the table with the drilling machine speed adjusted to create different degrees of vibrations. The oscillator was used to supply varied frequency to the bulbs. A 2000 watts hot plate was kept in the cabinet to supply heat at different temperatures to the bulb board for environmental temperature variation test.

RESULT AND DISCUSSION

Confined to the limit of experimental result as earlier discussed the summary of the result is shown in figure 2. Philips brand of incandescent bulb is more durable than others engaged in the experiment while Osram brand is found to be least reliable.

The light bulbs were found to have variable burn-out periods with the minimum of 758hours for the 100W Osram bulb, and a maximum of 1665 hours for the Philips product, a 60Watts bulb. Below is the bar chart representing the time of burn-out for the different bulbs.

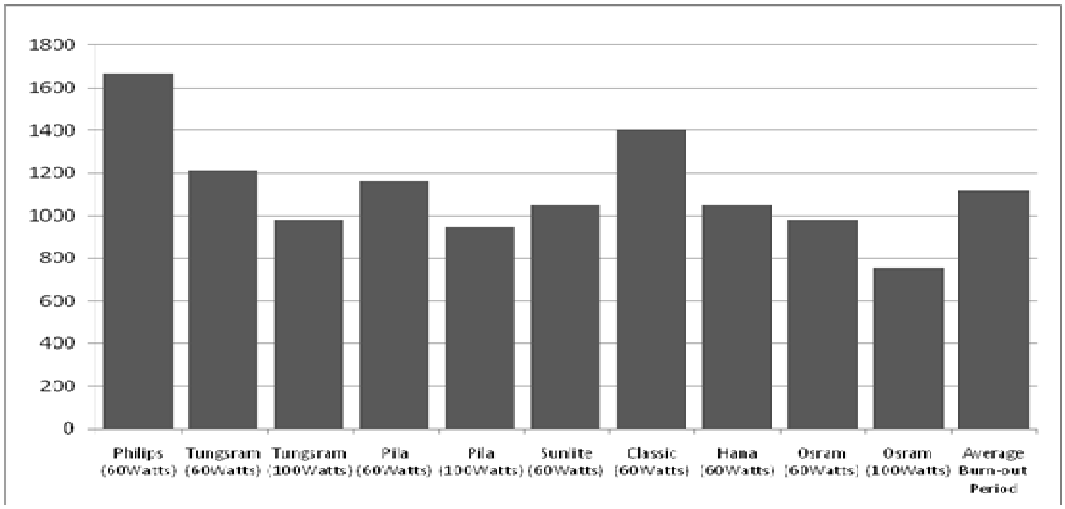

Figure 2.Burn-out period for some incandescent bulbs in Nigeria market

The experiment using the incandescent bulbs showed that the incandescent lights last for about 1120hours.

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The table below contains the characteristics of different types of incandescent lamps, including the efficacy, lifetime, and colour temperature, indoor and outdoor usage.

Table 1.characteristics of different types of incandescent bulbs

Types of Incandescent Lamps	*Efficacy (lumen/Watt)*	*Lifetime (hour)*	*Colour Rendition*	*Colour Temperature (K)*	*Indoor/Outdoor*
Standard Incandescent Lamps	10-17	750-2500	98-100	2700-2800	Indoor/Outdoor
Tungsten Halogen lamps	12-22	2000-4000	98-100	2900-3200 warm to neutral	Indoor/Outdoor
Reflector Lamps	12-19	2000-3000	98-100	2800 Warm	Indoor/Outdoor
Energy saving (CFL)	60-82	6000-8000	98-100	2700-5000	Indoor/outdoor
Led Energy Saving Light	60-131	10,000-50,000	90-100	4000k-6500k	Indoor/outdoor

It was however discovered that all the bulb brands respond to vibration the same way. While minor vibration was found to be harmless to the bulbs, major vibration affected the bulb filament proportionately.

Energy consumed in Nigeria can be drastically reduced if Nigerians replace their incandescent bulbs with energy efficiency bulbs. The energy saving bulbs we found in the market were those of 20W, 26W and 36W. If a particular household using 20 incandescent bulbs of 60W decides to replace them with energy saving bulbs of 20W, instead of consuming 1200W/h (20 x 60W) for lighting, they will be consuming 400 watts per hour (20 x 20W), this will equally reduce consumers cost by saving approximately 67% of energy for lighting alone. At the same time more grid energy is saved. This is a huge saving. On a larger scale, if Nigeria as a country phase out one million incandescent bulbs and replace them with energy saving bulbs, the country will be saving about 40MW of electricity. This is enough to provide electricity to many communities in Nigeria. If each of the 36 states and the FCT replace one million incandescent bulbs each, we can save up to 1480MW of electricity [1]. Incandescent bulbs are less efficient compared to the energy saving bulbs. Nigerian bulb consumers should be enlightened on the cost effectiveness nature of the energy-saving bulb. The cost of incandescent bulbs can be low, but considering the fact that one would use more than ten (10) incandescent bulbs while one energy saving bulb is still functional.

Awareness creation is needed to change the attitude of Nigerians on the need to save energy by using the right technology [1]. Some countries like Brazil have their own policy and this has reduced waste of energy by electric gadgets [4]. Policy option for Nigeria will include phase out of incandescent bulbs from the Nigerian system and putting a ban on the importation and production of incandescent bulbs. Policy to encourage the importation and production of energy efficiency light bulbs will enhance the efficient use of energy. Government should put in place strategies to reduce the cost of energy saving bulbs.

Also the need to control the use of incandescent lamps for adverts in the day should be discouraged. Some fast food centers, snack sellers and electrical materials dealers are faulting on this some even have more than 20 incandescent bulbs lit at the same time for the purpose of displaying their products. They light incandescent lamps in the day to attract the attention of people to their goods. This is a waste of energy by purpose, where there is an available natural source of light.

It has been found also that many Nigerians, at domestics and commercial environments, do not put off their outdoor lightings as well as street light during the day. This reduces the amount of energy

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available to offices and industries which need energy for operation in the day. Good energy management policy, appropriate pricing and metering will go a long way curbing this energy wastage problem.

CONCLUSION

Reliability test of incandescent bulbs based on normal life span test, voltage fluctuation and response to vibration has been carried out. While all the bulbs have similar response to vibration, the response to voltage fluctuation and normal life span test varies from bulb to bulb as summarized in figure 2. While Philips brand of bulb recorded longest life span of 1665 hours Osram brand has 758 light hours. Equally the analysis of energy lost due to the use of incandescent bulb and their average short life span of 1120 hours has greatly justified the need to switch to energy saving equivalents especially the light emitting diode (led) type which has up to 10,000 hour life span.

RECOMMENDATION

Haven gone through this work I will like to recommend that Government policy and legislation should be put in place to regulate the type of lighting bulb been used in the country. Energy saving alternative remains the best for long term cost effectiveness and regulatory energy management.

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