

A Review Paper on Comparative Study and Analysis of Illuminating Lamps

*¹Rahul Pansare, ²Gauri Nambiar, ³Prof. Sharmila M., ⁴Prof. Shraddha Vinchurkar

^{1,2}UG Student, Department of Electrical Engineering, Sandip Institute of Engineering & Management, Sandip Foundation, Maharashtra, India

^{3,4}Assistant Professor, Department of Electrical Engineering, Sandip Institute of Engineering & Management, Sandip Foundation, Maharashtra, India

ABSTRACT: The latest technologies are introduced and adopted in the electrical sector very rapidly nowadays. Consequent developments were observed in the studies related to Illumination which led to emerging technology of Light emitting Diodes (LED) instead of Compact Fluorescent Lamp (CFL) and the Incandescent lamps. This paper explains the comparable aspects of the different types of lamps and their related technology on various parameters like size, constructional details, ratings, power consumption, and cost aspect etc.. Thus, justifying the technology of LED to be better than CFL, and reduction in the per capita energy consumption.

KEYWORDS: LED, CFL, Incandescent Lamps, Bulb, Lumens, Power, Watts, Light, Electrical Energy.

I. INTRODUCTION

In earlier days people used Carbon Arc lamps in which they use to bring two similar electrodes near to each other with some space in between and the AC supply was given to it. The positive part of battery is connecting to the rod having size twice of that the negative side. Supply is given and due to which arc is produced having very less efficiency of 12lm/watt. Then time came of Incandescent or Filament lamps in which a carbon filament or tungsten filament was used to produce the light. The filament is kept in the glass cover and either evacuated or filled with inert gases like nitrogen and argon which help to increase the temperature. As ac supply is give to the filament, the temperature rises and heat is generated due to which light is produced or illumination takes place. The simple principle is to pass electricity through a resistive material and energy is produced in the form of light. This lamps are 20% more efficient than carbon arc lamps but consumes more energy and having power rating of 60-150 watts.

After all this technologies, Fluorescent tube and CFL came in the Market and replaced the incandescent lamps and Now LEDs are taking over it.

II. COMPARATIVE STUDY

A. Incandescent Lamps:-Incandescent lamps consist of a wire filament heated to a high temperature to produce visible light. It works on the principle of incandescence and so called incandescent lamp[1]. It consists of a coil filament placed between two electrodes connected to the supply. This circuit is enclosed in a glass or quartz bulb that is will with inert gas (argon with a small amount of nitrogen at low pressure) or evacuated. Carbon filaments were used n early days which could attain a temperature of about 1700 degree Celsius as above this temperature the carbon starts vaporizing. Also carbon being a brittle material, it was difficult was to be used as filament. The overall efficiency of the bulb was also thus less. So taking the disadvantages into consideration, carbon filaments were replaced by tungsten metal which can attain more temperature of about 2000 degree Celsius making it more efficient to use. Also the tungsten filament has more life and is less brittle.The filament may be made in two ways; either a stretch of zigzag thread or coiling. A coiled filament is made by winding tungsten wire on a fine iron wire to form a spiral which is again wound on a thick iron wire to form a coiled coil. The iron is later dissolved in acid.

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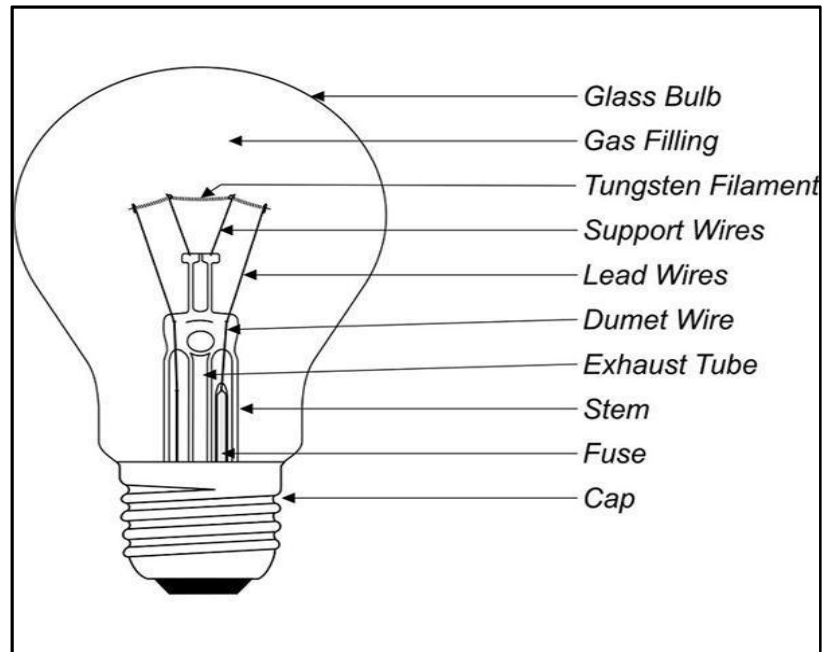


Fig.1 Construction of Incandescent lamp/Bulb

When any material is heated to a very high temperature below its melting point, it starts radiating electromagnetic waves which are having light and heat energy."When a substance is heated, if the temperature is not sufficient to melt it, the electrons in the outer orbit of the substance gets excited and jumps to a higher energy level, but since they are not stable, they again fall back to lower energy level. During this process of falling back, photons are released in the form of electromagnetic radiation. Incandescent bulbs are manufactured in wide ranges having different voltage ratings from 1.5V to about 300V.[2] They require no external regulating equipment and hence low cost. Also, it works well on both AC and DC. But, it is less efficient and convert hardly 5% of the energy they use, remaining energy is converted to heat and thus, have a short life span of 1000hrs.

Since Incandescent bulbs have low cost and compact size, they were used widely in household and commercial lightings, for portable lightings such as table lamps, car headlamps, flashlights and for decorative and advertising lightings.As these bulbs were proven very inefficient, they are now replaced by CFLs and LEDs. Even if these lamps have disadvantages, the heat and light together is smartly use for other purposes where both light and heat energy is essential. Such application includes incubators, brooding boxes for poultry[3], heat lights for reptile tanks[4], infrared heating for industrial heating and drying processes, lava lamps and easy bake oven toys.

B. Compact Fluorescent Lamps(CFLs):-These are also known as compact fluorescent light or energy saving light. These lamps are designed to replace an incandescent bulb. CFLs are fluorescent tubes which are folded or curved to get fit into the size of an incandescent bulb. Both CFL and incandescent lamp gives same amount of light but having different ratings and lumens per watt. Also CFLs saves 10 times more energy than the incandescent bulbs and last 5 to 15 times longer. The price of CFLs compared to incandescent lamps is 10 to 15 times higher but it saves 15 times purchase price in electricity bill over his entire life. so CFLs are not only energy saving devices but also but also price or cost saving.CFLs have the most biggest drawback of disposal. CFL contains toxic mercury[5] which is difficult to dispose off.

CFL radiates different light spectrum compared to incandescent lamps. CFL uses phosphor tubes which improve the colour of light emitted by CFL and so we receive standard warm white light. CFLs typically have a rated service life of 6,000–15,000 hours, whereas standard incandescent lamps have a service life of 750 or 1000 hours[6][7][8].

CFL has two parts 1. Gas filled tube,2. Magnetic or electronic ballast. The tube is coated with a phosphor coating and is bended in different compact shapes. Electronic ballast contains a circuit board with a bridge rectifier which converts

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AC current into DC and a filter capacitor is connected to give pure DC as shown in figure 2. Two switching transistors are provided which are often insulated gate polar transistors. AC current is rectified to DC, and then converted to high frequency AC by the transistors, connected as series DC to AC inverter. The component not only converts but also stabilizes lamp current over a range of input voltages. When AC supply is given to CFL tube, a ballast flows through gas (mercury), which emits or produce ultraviolet rays which excites the phosphor coating of tubes and produce light which is in the spectrum of visibility.

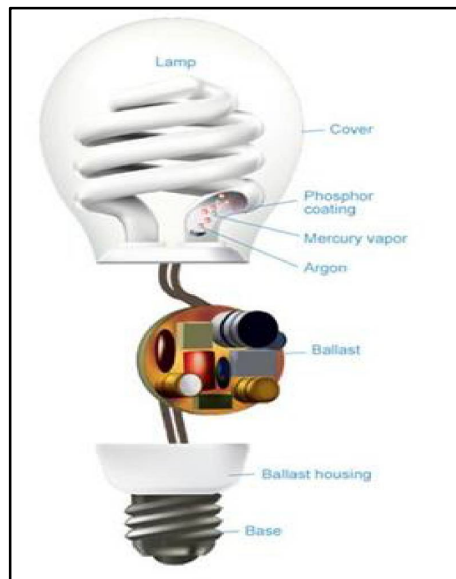


Fig.2 Compact Fluorescent Lamp

Magnetic ballast are nowadays replaced by electronic ballast as electronic ballast removes most of the flickering and slow starting of fluorescent lights. At the end of its life period CFL produce 70-80% brightness of its actual one[9]. Lumen efficiency of CFLs is 50-70lm/W[10], whereas incandescent lamps have only 10-17lm/W. If incandescent lamps are replaced by CFLs it would save 409 Terawatt hour energy which is 2-5% of world energy consumption. Also the CO₂ emissions would be much less like 230 million tonnes CO₂ will be reduced per year. PF as the input part of CFL is of rectified, so it can cause harmonic distortion in the current drawn by the supply. In home applications it has no effect on power quality. PF of CFL does not affect energy saving benefits significantly.

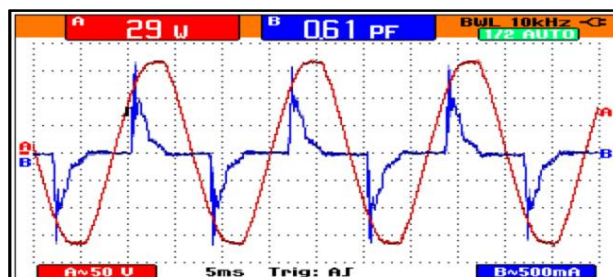


Fig.3 PF distortion in CFL

The devices operated by infrared remote control can interrupt the infrared light emitted by CFL as a signal; so CFL must be placed away from TV, radios and remote controls. Incandescent lamps reaches to full brightness within a fraction of seconds after being switched[11], but in case of CFLs it reaches to 40-60% of its full brightness in the same time[12]. Due to use of mercury amalgam it take minutes to reach to its full output. The SCENIHR in 2008 states that UV and blue light emitted by CFLs aggravate symptoms in people who have already suffers from skin disease[13]. A

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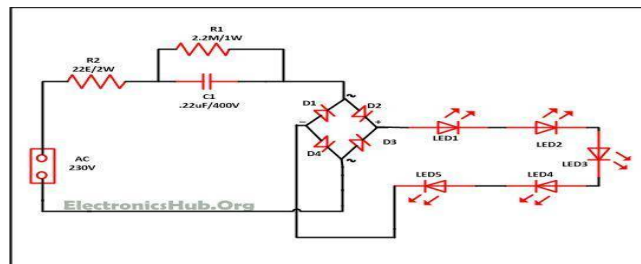
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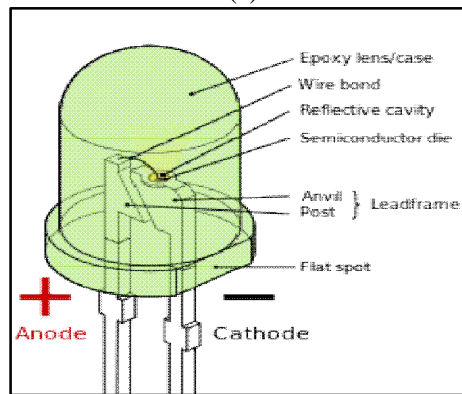
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safe distance of 20 cm should be kept between the light emitted and skin; distance less than this can cause skin problems and retinal damage. Each CFL contains about 3-5mg of Hg which is toxic for the environment[14][15].

C. *Light Emitting Diode (LEDs)*:- LED is nothing but the a semiconductor which convert the electrical energy into light. Basically in solar semiconductor converts the solar energy into electrical and here reverse action is takes place.



(a)



(b)

Fig.3 (a) LED circuit diagram (b) LED Construction

So above two figures show the construction and circuit diagram of LEDS. In fig.3 it is clearly shows the Ac is first convert into dc and capacitor is there to make pulsating DC into pure DC and then the DC supply is given to LED series.

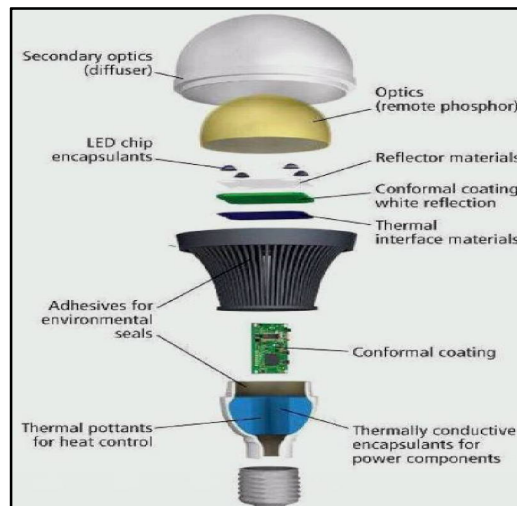


Fig. LED bulb Construction

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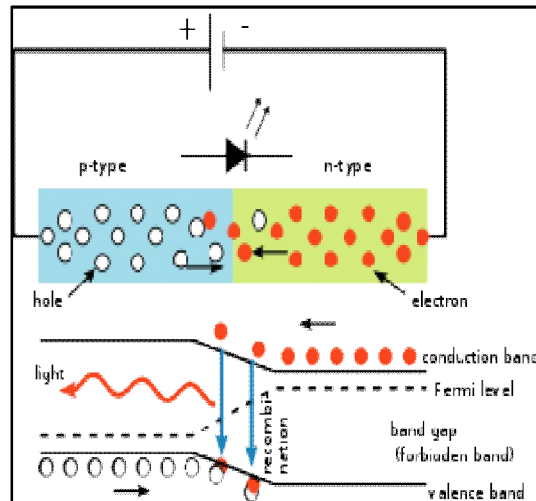


Fig.5 Working principle of pn-junction

LED contains a semiconductor p-n junction which is connected through a wire and has a reflective cavity. This all things are covered by a epoxy lens or case as shown in Fig.4. One side is anode and other side is cathode. Anode is positive and cathode is negative. The working of led is so simple, when a p layer fills of holes and n layer fills with electron are combine together and due to combining some electrons combines with holes and forms a depletion layer as shown in Fig 5. When a dc voltage is applied to it then up to suitable voltage the depletion layer will not vanish or we can say we stand. After a certain limit say 1.8-2V the electrons get so excited that they cross the depletion regions and combines with holes. The electrons have the energy as they were in conduction band whereas holes are in valance band, so due to combination of electrons and holes energy is produce in the form of photon/light.

The combination of LEDs it for a series and then connect to a rectifier circuit which convert 230 V ac supply to 3-12 V dc supply as shown in Fig.3. The maximum current LED can handle is 30mA. So all the combination of above is from LED Bulb. There is some voltage range of LED for different colour which is shown below

TABLE I Forward voltage of LED

| Colour | Voltage |
|--------|---------|
| Red | 2 |
| Yellow | 2.1 |
| Green | 2.2 |
| White | 3.2 |
| Blue | 3.5 |

LED has better lumens efficiency than CFL and incandescent lamps. Lumen efficiency of Led is 80 lm/W and for 9.2 watt energy it emits 1000 lumens. It generates less greenhouse gases. LEDs has longer life which may be in 40000-100000 if temperature and current remains constant or less[16]. The lifetime is not shortened by power usage patterns. Compare to CFLs the life span is 4 to 5 times greater. So fewer bulbs are required resulting in less electricity bills, less landfills. Led contains no toxic mercury. Carbon dioxide emission of LEDs is very much less, almost half of LED (4.4 kg/yrs). It has very low radiations. LEDs are more robust and can turn on instantly having no light flickering and emit very less heat (3 btus/hr). LEDs can save almost twice the cost of electricity as compared to CFLs, as CFL takes Rs.526 per year and LEDs takes Rs.223 per year. LEDs can be used indoor and even in outdoor if it is kept away from moisture whereas CFL can use for indoor applications because for outdoor applications it has problem from the cold temperature and for rating more than 20W can cause harmonics. LED are having a white light in the wavelength of broad spectrum. The white light doesn't irritate the human eyes like incandescent lamps.

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LED have the most important drawback is of its high price or we can say initial Cost due to technology. So high price compared to CFL and Incandescent lamps make people to think on use of LED. LED performance depends largely on correctly engineering the fixture which is to manage the heat generated by the LED, thus causing deterioration of the LED chip itself. LEDs must be supplied with the correct voltage and current at a constant flow. This requires some electronics expertise to design the electronic drivers. LED's can shift color due to age and temperature.

IV. COMPARATIVE ANALYSIS

TABLE II Comparison of Three different Lamps

| Factors | LED | CFL | Incandescent Lamp |
|--------------------------|------------|-------------|-------------------|
| Watt | 8.5W | 20 W | 60W |
| Lumens | 800 | 825 | 750 |
| Efficiency | 80lm/W | 57.5lm/W | 7.5lm/W |
| VTG Range | 85-256 V | 200-250V | 1.5-300V |
| Temperature | 2727K | 2700K | 2700K |
| CRI | 93 | >75 | 100 |
| CO ₂ Emission | 4.4Kg/yr | 7.3Kg/yr | 290.173Kg/yr |
| Heat Emitted | 3 butts/hr | 30 butts/hr | 341 butts/hr |
| Life span | 50000hr | 8000hr | 1200hr |
| Cost | 300Rs | 150Rs | 20Rs |
| Working year cost | 126Rs | 280Rs | 840Rs |

V. CONCLUSION

As per the conducted comparative analysis, it has been concluded that incandescent lamps or bulbs are still in usage in developing countries only due to its low cost. But, CFLs and LEDs bulbs are proved alternative for long term saving and better environmental growth. Though, LEDs offer high initial cost; it is still equivalent to energy saving upto five times of the energy consumed with CFL. If all the incandescent lamps are even replaced by CFL then, energy conservation is possible upto saving energy as much that thirty lakhs of domestic consumers can get electricity every year. Also, this change will result into reduction of CO₂ emission emerging out of thermal or diesel power plant to generate electricity.

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