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LIGHTING: A NEW CONCEPT ON RE-UTILIZATION OF FUSED FLUORESCENT LAMP

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ABSTRACT

In estimate, around six billion fluorescent lamps are discarded every year. In human life, suddenly fused fluorescent lamp creates a lot of problem. Then authors think how fused fluorescent lamp can be re-utilized and this mentioned problem can be overcome. Therefore authors motivated a simple method to design a prototype model in the laboratory. This paper presents a new concept to analyze the process of lighting with fused fluorescent lamp using bridge rectifier circuit. And what are the role of choke & starter in this mechanism of circuit model. Experimentally, characteristics of fused fluorescent lamp are also analyzed throughout this paper.

Key words: *UV, STP, DC, PIV and AC.*

1. INTRODUCTION

Fluorescent lamp is basically a glass tube with two electrodes; one at each end. It produces light in aspects of two main physical principles: **i)** Electric discharge in mercury vapour

-here electrical energy converts into radiant energy in fluorescent lamp which relies on inelastic scattering of electrons [1]. An incident electron collides with an atom in the gas. If the free electron has enough kinetic energy, it transfers energy to the atom's outer electron, causing that electron to temporarily jump up to a higher energy level. The collision is 'inelastic' because a loss of energy occurs. This higher energy state is unstable, and the atom will emit an ultraviolet photon as the atom's electron reverts to a lower, more stable, energy level. Most of the photons that are released from the mercury atoms have wavelengths in the ultraviolet (UV) region of the spectrum predominantly at wavelengths of 253.7 nm and 185 nm [2]. These are not visible to the human eye, so they must be converted into visible light. **ii)** The second is fluorescence phenomenon by which ultraviolet photons are absorbed by electrons in the atoms of the lamp's interior fluorescent coating, causing a similar energy jump, then drop, with emission of a further photon [3]. The photon that is emitted from this second interaction has a lower energy than the one that caused it. The chemicals that make up the phosphor are chosen so that these emitted photons are at wavelengths visible to the human eye. The difference in energy between the absorbed ultra-violet photon and the emitted visible light photon goes toward heating up the phosphor coating.

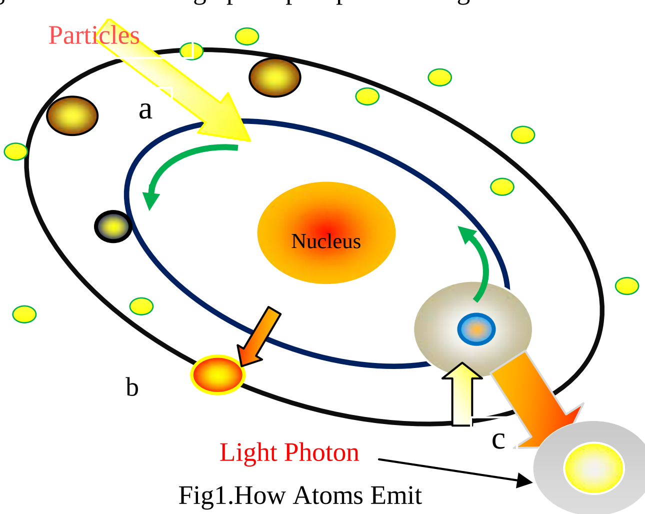

Fig1.How Atoms Emit

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a. A collision with a moving particle excites the atom.

b. This causes an electron to jump to a higher energy level.
c. The electron falls back to its original energy level, releasing the extra energy in the form of a light photon.

There are two processes:

i) Impact ionization is the process in a material by which one energetic charge carrier charge can lose energy by the creation of other charge carriers[4]-[6]. This process is a relatively harsh form of ionization producing a wide range of molecular fragments. The electron impact source consists of a heated filament that produces electrons which are accelerated to another electrode called the ion trap. Sample vapor diffuses into the electron beam and become ionized and fragmented the size depending on the electron energy which is controlled by the accelerating potential on the ion trap electrode. Low energy electrons produce molecular ions and larger fragments, whereas high energy electrons produce many smaller fragments and possibly no molecular ions. After the ions are produced, they are driven by a potential difference.

ii) An electron avalanche is a process in which a number of free electrons a medium (usually a gas) are subjected to strong acceleration by an electric field ,ionization the medium's atoms by collision (called impact ionization), thereby forming "new" electrons to undergo the same process in successive cycles. Electron avalanches are essential to the dielectric breakdown process within gases [6]-[7]. The process can culminate in corona discharges, streamers, leaders or in a spark or continuous arc that completely bridges the gap. The process extends to huge sparks — streamers in lightning discharges propagate by formation of electron avalanches created in the high potential gradient ahead of the streamers' advancing tips. Once begun, avalanches are often intensified by the creation of photoelectrons as a result of ultraviolet radiation emitted by the excited medium's atoms in the aft-tip region.

Plasma begins with a rare natural 'background' ionization event of a neutral air molecule, perhaps as the result of photo excitation or background. If this event occurs within an area that has a high potential gradient, the positively charged ion will be strongly attracted toward, or repelled away from, an electrode depending on its polarity, whereas the electron will be accelerated in the opposite direction. Because of the huge mass difference, electrons are accelerated to a much higher velocity than ions [8]-[9].High-velocity electrons often collide with neutral atoms inelastically, sometimes ionizing them. In a chain-reaction — or an 'electron avalanche' — additional electrons recently separated from their positive ions by the strong potential gradient, cause a large cloud of electrons and positive ions to be momentarily generated by just a single initial electron. However, free electrons are easily *captured* by neutral oxygen or water vapor molecules (so-called electronegative gases), forming negative ions. In air at STP, free electrons exist for only about 11nanoseconds before being captured. Captured electrons are effectively removed from play — they can no longer contribute to the avalanche process. If electrons are being created at a rate greater than they are being lost to capture, their number rapidly multiplies, a process characterized by exponential growth [10].

Therefore, when the light is turned on, the electric power heats up the cathode enough for electrons emission. These electrons collide with and ionize noble gas atoms inside the bulb surrounding the filament to form plasma by a process of impact ionization. As a result of avalanche ionization the conductivity of the ionized gas rapidly rises, allowing higher currents to flow through the lamp. Fluorescent lamps are negative differential resistance devices, so as more current flows through them, the electrical resistance of the fluorescent lamp drops, allowing even more current to flow. Connected directly to a constant-voltage power supply, a fluorescent lamp would rapidly self-destruct due to the uncontrolled current flow. To prevent this, fluorescent lamps must use an auxiliary device, a ballast, to regulate the current flow through the lamp [11].

Functions of Starter and Choke:
Starter consist of a bimetallic plate in a glass bulb filled with argon gas .When supply is ON, current passes through this and discharged argon gas .Due to this ,bimetallic strip bends and closes contact. At this stage, the choke, the filament of the tube and the starter become connected in series across the supply. A current flows through filaments and hits them. Meanwhile the argon discharge in the starter tube disappears and after a cooling time, the strip causes a sudden break in the circuit [12]. This causes a high value of induced emf in the choke. The induced emf in the choke is applied across both of the filaments of the fluorescent lamp and is

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responsible for initiating a gaseous discharge because initial heating has already created good no of free electron in the vicinity of filaments. Thus, the fluorescent lamp starts giving light output. Once the discharge through the tube is established, a much lower voltage than the supply voltage is required to maintain it [13]. A reduction in voltage available across the tube during running condition is achieved by having a voltage drop across the choke. In this way, different elements maintain their role and circuit of fluorescent lamp provide visible light.

Different causes of ends of life of Lamp:

Emission Mix:

The emission mix is responsible for electrons pass through the gas when the cathode is heated. And it goes into plasma state. During course of operation of fluorescent lamp many gaseous atoms, electrons, molecules strike the filament and reduces the emission mix. When all the emission mix is gone, the cathode can not passes sufficient electrons into the gas field to maintain the discharge at the designed operating voltage of tube.

Burned Filament:

After the lifetime of lamp's the filament can burn and loose the capability of heat up. In normal condition both filament works in series. When starter breaks the circuit, then both filaments come into series inside the lamp. When it burnt out, can't make the circuit complete and it is called fused.

Ballast Electronics:

It is integral part of the fluorescent lamp. If it burnt out, the circuit is not completed. So that it must be changed.

Loss of mercury:

Because of excessive heating of mercury, it's molecules are slowly absorbed by the phosphor. And at one point mercury is completely absorbed by the phosphor inside the tube. Hence, loss of mercury is causes initially an extended run-up time to full light output; and at a point it causes the lamp to glow a dim pink when the mercury runs out and the argon base gas takes over as the mercury on the discharge [15].

Darkening of the fluorescent lamp occurs because of:

a) Effect of mercury on the fluorescent coating and

b) Material given off by the electrodes. The letter specially contributes to the darkening at the ends of the fluorescent lamp, which occurs late in life. The rate of depreciation in light output diminishes throughout life, the first hundred hours produces as much or more darkening as the following thousand hours. The percent lumens at thousands hours life may on the average the expected to be as good or better than for vacuum filament lamps of the same colors.

2. SYSTEM MODEL:

Here, a mechanism is presented by which fused fluorescent lamp can be enlighted:

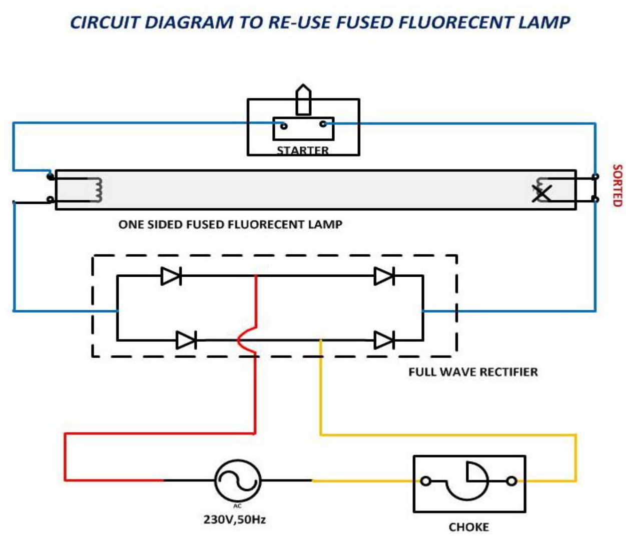

Fig2. Circuit Diagram of Experimented Model

In this model, only healthy filament of fused fluorescent lamp can emit the sufficient electrons and collected by other one to glow up.

In the circuit a DC voltage is provided across two filaments with fixed polarity through a Full Wave Bridge Rectifier. In which one port inputs are two different tube-end-pins connection. And other's port inputs are Supply Line and Choke input point connection. Choke is connected between supply line and bridge rectifier input terminal to control the current flow through back emf process. Starter is also connected across the tube to develop striking voltage. Here Starter and Choke functions same as in a healthy fluorescent lamp.

Different Models for making this type of Circuit:

a) When both end pins of fused filament are shorted and connected through bridge rectifier output.

b) When either one pin of fused filament is connected through bridge rectifier output and starter input.

Either of the above configurations can be used for this type of the making circuit.

When power supply is ON, unhealthy filament is bypassed and healthy filament is connected through starter, bridge rectifiers output and choke in series

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with power supply. In this process healthy filament is heated and emits electrons. When starter breaks up it's contact, a high voltage is induced in the choke. This voltage is converted into DC voltage by the bridge rectifier and applied across the fluorescent lamp. Here the healthy filament must get negative polarity and the unhealthy filament must get positive polarity. Due to this reason, only healthy filament acts as electrons emitter and unhealthy filament acts as electrons collector. This makes both filaments in series with other circuit elements. This circuit arrangement eliminates fused due to:

i) Unhealthy Filament due to material loss
ii) Only one Broken Filament
iii) Low gaseous volume in the tube
iv) Low amount of mercury (Hg) in the tube.

Here bridge rectifier is used because of similarity of its configuration to that of Wheatstone bridge, does not required a centre trapped transformer, easy to implement. The peak inverse (PIV=Vm across one diode) rating of the diode in bridge rectifier circuit is less than the used diodes in centre trapped transformer. It has 82.1% efficiency and value of ripple factor is 0.482.

And here half wave rectifier circuit can not be implemented because it does not pass current in the circuit in one half cycle of supply input.

Here if choke is not used, then a lot of current is passed through the circuit which can damage our healthy filament also; even if an equivalent resistance is connected in place of choke. As any element is not present in the circuit to control the current which is directly flowing from supply to healthy filament. So, this circuit model provides a controlled current flow to glow the fused fluorescent lamp continuously.

3. PERFORMANCE ANALYSIS:

Parameters: Normal Fluorescent lamp; striking voltage is 172 volt and extinguishing voltage is 136 volt in case of AC supply.
Fused Fluorescent lamp; Striking voltage is 180 volt and extinguishing voltage is 112 volt in case of DC supply through bridge rectifier circuit.

Table: 1

Type of Supply	Obs. No.	Applied Voltage increasing			Applied Voltage Decreasing		
		Applied Voltage (V)	Lamp Voltage(V)	Line Current(A)	Applied Voltage(V)	Applied Voltage (V)	Lamp Voltage(V)
A.C. (Normal Fluorescent Lamp)	1.	172	120	0.20	210	120	0.28
	2.	180	120	0.20	200	120	0.26
	3.	186	120	0.22	186	120	0.22
	4.	190	120	0.24	172	120	0.20
	5.	200	120	0.26	160	120	0.18
	6.	210	120	0.28	150	120	0.15

Table : 2

Type of Supply	Obs. No.	Applied Voltage increasing			Applied Voltage Decreasing		
		Applied Voltage (V)	Lamp Voltage(V)	Line Current(A)	Applied Voltage(V)	Lamp Voltage(V)	Line Current(A)
D.C. (Fused Fluorescent Lamp)	1.	180	130	0.22	208	124	0.32
	2.	188	129	0.24	196	127	0.28
	3.	196	129	0.26	188	129	0.24
	4.	200	128	0.29	180	131	0.20
	5.	204	125	0.31	172	132	0.16
	6.	208	124	0.31	160	135	0.14

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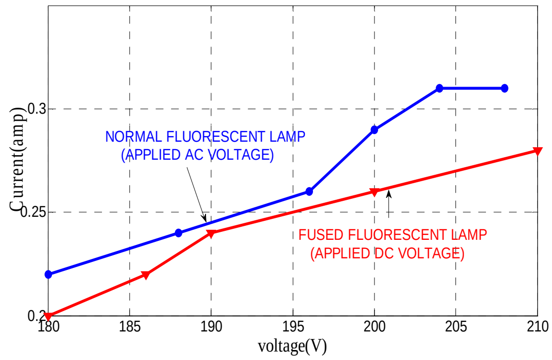

Fig.3 V-I Characteristics of Fluorescent Lamp

(Applied Increasing voltage)

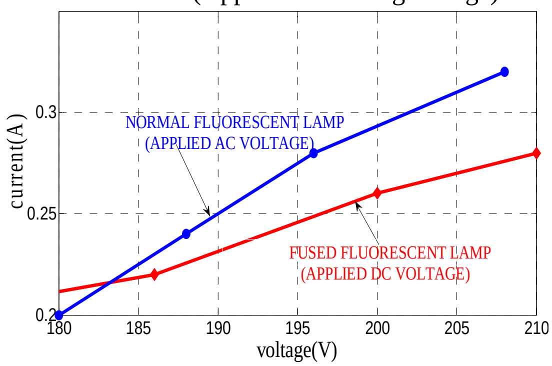

Fig.4 V-I Characteristics of Fluorescent Lamp (Applied Increasing Voltage)

It is shown from above experimental data analysis two graphs are plotted. And it shows that fluorescent lamp has the negative differential resistance characteristics i.e. as temperature increases it's resistance decreases. so as more current flows through them, the electrical resistance of the fluorescent lamp drops, allowing even more current to flow. Now, with a constant-voltage power supply, the current flow must be controlled otherwise fluorescent lamp would rapidly self-destruct. Another point should be noted that striking voltage of fused fluorescent lamp in modeled circuit is greater than the normal fluorescent lamp in AC supply, but it is not much differ as compared to normal fluorescent lamp in DC supply. But the result of extinguishing voltage maintains reverse order i.e. this voltage of normal fluorescent lamp in AC supply is greater with respect to experimented circuit.

4. CONCLUSION

A prototype system model is developed and operational in the laboratory on lighting with fused fluorescent lamp. Authors provide a mechanism by which fused fluorescent lamp can be re-utilized through a fixed polarity of DC supply with choke in series. In the circumstances, this model help to overcome the problem due to suddenly fused fluorescent lamp at instant and is very useful in all domestic purposes.

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REFERENCES

[1] P.Gallina et al., Proc. 11th Int. Symp. on the Science and Technology of Light Sources, LS11, p. 67, 2007.

[2] I.Snijkers et al., Proc. 11th Int. Symp. on the Science and Technology of Light Sources, LS11, p.361, 2007.

[3] A.Corazza et al., Proc. 11th Int. Symp. on the Science and Technology of Light Sources, LS11, pp. 193, 2007.

[4] G. S. Cho, N. O. Kim, Y. M. Kim, S. J. Kim, T. S. Cho, B. S. Kim, J.G. Kang, E. H. Choi, U.W. Lee, S. C. Yang, and H. S. Uhm, J. Phys. D, Appl. Phys., vol. 36, pp. 2526–2530, 2003

[5]Electronic Communication System by Kennedy and Davis, Tata Mcgraw hill publication,fourth edition, , pp 454-461.

[6] W. Vogel and D. Welsch, Quantum Optics (WILEY-VCH, Berlin, 2006), 3rd ed.

[7]Solid State Electronic Devices by Ben G.Streetman and Sanjay Banerjee, fifth

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edition,Prentice-Hall of India products, pp. 180-190.

[8] "On the theory of emission and absorption of electromagnetic radiation—An argument," Int. J. Electr. Eng. Educ., vol. 33, no. 3, pp.195–208, July 1996.

[9]T. S. Cho, N. O. Kwon, Y. M. Kim, H. S. Kim, S. J. Kim, J. G. Kang, E. H. Choi, and G. S. Cho, "Capacitive coupled electrode less discharge backlight driven by square pulses," IEEE Trans. Plasma Sci., vol. 30, no.5, pp. 2005–2009, Oct. 2002.

[10] Kiesel, Peter et.all, "Spatially modulated fluorescence emission from moving particles", applied physics letter, Vol.94, No.4, Page(s): 1-2-3,2004.

[11] E. Deng and S. Cuk, "Negative incremental impedance and stability of fluorescent lamps," in Proc. IEEE Applied Power Electronic Conf.(APEC'97), Atlanta, GA, Feb. 23–27, vol. 2, pp. 1050–1056, 1997.

[12] S.Wei,Y. Tam, and E.Hui, "A semi-theoretical fluorescent lamp model for time-domain transient and steady-state s imulations," *IEEE Trans. Power Electron.*, vol. 22, no. 6, pp. 2106–2115, Nov. 2007.

[13] K. H. Loo, D. A. Stone, R. C. Tozer, and R. Devonshire, "A dynamic conductance model of fluorescent lamp for electronic ballast design simulation," *IEEE Trans. Power Electron.*, vol. 20, no. 5, pp. 1178–1185, Sep. 2005.

[14] Fluorescent lamps by laser-induced fluorescence measurements ", J.Phys. D: Appl. Phys. 40, pp.163-167 (2007).

[15] Garner, R. "Interpretation of the external band technique for cathode fall measurements of fluorescent lamps" (2008) Journal of Physics D: Applied Physics, 41 (14),2008.

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