The Effectiveness of Concepts on Reuse of Parts of Non-functional Fluorescent Lamps

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Abstract – *Fluorescent lighting system is commonly used as an electric light source in residential houses and commercial buildings. It uses fluorescent lamps that have energy saving features and longer lifespan compared to incandescent bulbs. However, fluorescent lamps become defective and people dispose them improperly. Broken fluorescent lamps may release mercury posing a significant threat to people and the environment. From this perspective, this study applied the concepts of reusing the parts of non-functional fluorescent lamps. Specifically, it tested the effectiveness of electronic ballast of defective compact fluorescent lamp (CFL) and voltage multiplier circuit in driving the used and busted fluorescent bulbs. It utilized the two group experimental research design and observation guide sheets were used to gather the data from twenty respondents. Results have shown that electronic ballast taken from busted CFL bulb and voltage multiplier circuit were very effective in driving the used fluorescent lamps, and the two applied concepts were significantly different on their effectiveness in driving busted fluorescent bulbs. Therefore, disposal of lamp wastes into the environment can be minimized thus decreases the quantity of mercury released from broken lamps and the risk of mercury inhalation by humans can be prevented.*

Keywords – *effectiveness, fluorescent lamps, lamp waste, reuse*

INTRODUCTION

Fluorescent lamps are electric light source mostly found in residential houses, offices, schools, hospitals, and commercial buildings. The energy-saving features and longer lifespan of fluorescent lamps make it as highly recommended replacement for incandescent light bulbs by numerous government agencies [1]. The lifespan of compact and circular fluorescent lamps can reach 10,000 hours, and linear fluorescent lamps can reach up to 20,000 hours [1], [2].

However, non-functional and broken fluorescent lamps are thrown into the garbage bins together with other wastes. Similarly, the major drawback of a fluorescent bulb is that it contains a small quantity of mercury which is toxic [3], [4]. This toxic mercury is released and spread into the air upon breakage of the fluorescent lamp [5], [6] that can be inhaled by humans, and the lungs absorb 80-97% of the inhaled mercury [4]. Also, the mercury released from broken fluorescent lamps poses a danger to human health which can cause several kinds of illness to the brain and kidney [7].

In the Philippines, DOE-DENR Joint Administrative Order No. 2013-09-2001 tasked the lighting industry to frame systematized disposal of lamp waste, and people were encouraged to segregate their lamp waste from other wastes and dispose of them properly [8]. Consequently, the Regional Study on Mercury Waste Management in the ASEAN countries conducted by UN Environment reported that from 2002 up to mid-2014, Philippines had generated approximately 60 metric tons of waste fluorescent lamps [9]. The amount of fluorescent lamp wastes generated in the Philippines is due to the lack of recycling and material recovery facility for lamp wastes.

Interestingly, Sukanta et al. [10] investigated on reutilization of fused fluorescent light to overcome and extend its lifespan. They proposed and tested a system circuit model (figure 1) to relight fused fluorescent bulbs.

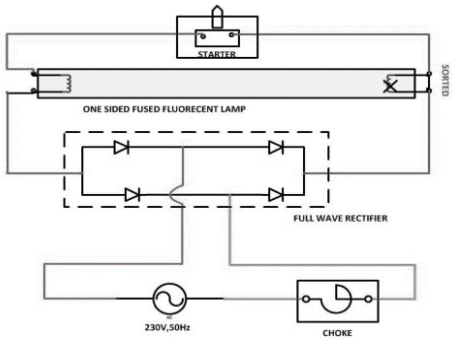

Figure 1. System Circuit Model [10]

The circuit utilized the full wave bridge rectifier to produce DC (direct current) voltage across the two filaments of the fluorescent tube. One of the input terminals of the rectifier circuit connects in series with the choke, and the terminals of the rectifier and choke connect to power source. Moreover, a starter is attached to the filament at each end of the lamp.

Laboratory experiments show that the proposed model relighted the fused fluorescent and they found out that the striking voltage of fused fluorescent bulbs is higher than the usual AC voltage supply resulting in the increased flow of current [10]

However, [10] did not show data on the size of the lamp as well as the number of hours/days the proposed model was used to light up the fused lamp.

OBJECTIVES OF THE STUDY

This study applied the concepts on reusing the parts of non-functional fluorescent lamps such as fluorescent bulbs and the electronic ballast taken from a busted CFL bulb. Specifically, this study tested and determine the level of effectiveness of electronic ballast taken from busted CFL and voltage multiplier circuit in driving the used and busted fluorescent bulbs. It further tested the null hypothesis that there is no significant difference on the level of effectiveness between the CFL ballast and voltage multiplier circuit at 0.01 level of significance.

METHODS

This section presents the research design, materials, procedures, respondents, locale, instruments, data gathering procedures, the method of scoring, and statistical treatment of data.

Research Design

The study utilized the two-group design of experimental research. The two-group design has two comparable groups employed as experimental and control group or two groups are both experimental groups [11].

The experimental groups compared in the study were the electronic ballast taken from a busted compact fluorescent lamp (CFL) (figure 2), and the voltage multiplier circuit (figure 3). These circuits were used to drive the used and busted fluorescent lamps and their effectiveness were observed.

Figure 2. CFL ballast

Figure 3. Voltage Multiplier

Research Materials

Table 1. Materials, Tools, and Instruments

Quantity	Unit	Description
2	pieces	Used 10 watts Linear Fluorescent tube
2	pieces	Busted 10 watts Linear Fluorescent tube
2	pieces	Used 20 watts Linear Fluorescent tube
2	pieces	Busted 20 watts Linear Fluorescent tube
2	pieces	Used 40 watts Linear Fluorescent tube
2	pieces	Busted 40 watts Linear Fluorescent tube
2	pieces	Used 22 watts Circular Fluorescent tube
2	pieces	Busted 22 watts Circular Fluorescent tube
2	pieces	Used 14 watts U-shaped fluorescent tube
2	pieces	Busted 14 watts U shaped fluorescent tube
1	piece	Electronic ballast taken from busted CFL
1	piece	Voltage multiplier circuit
1	piece	Blade cutter
1	piece	Diagonal cutting pliers
1	piece	Long nose pliers
1	piece	De-soldering pump
1	piece	Soldering Iron
1	meter	Soldering lead
1	piece	Multi-tester
4	meters	Hook up wire
1	roll	Electrical tape
2	pieces	Switch

Table 1. shows that the researcher prepared and utilized the following materials, tools, and instruments in performing the experimental procedures.

Research Procedures

The researcher layout the wiring connections of the electronic ballast taken from busted CFL and voltage multiplier circuit to drive the used and busted fluorescent lamps and performed the following procedures in employing the two concepts of driving the used and busted fluorescent lamps.

Concept 1: Utilizing the electronic ballast taken from busted CFL to drive the used and busted fluorescent lamps.

The researcher used the cutter to open the compartment underneath the bulb plug of busted compact fluorescent lamp (CFL) and utilized the long nose and diagonal cutting pliers to disconnect the wiring connection of the fluorescent tube and bulb plug to remove the electronic ballast. Soldering iron and lead were used to connect the wires to the power input and output terminals of the electronic ballast. Figure 4 shows the outputs of the CFL ballast were connected to the terminals of the fluorescent tube respectively, and the wires connected to the power input of the ballast were connected to a switch and male plug to be plugged into the power source.

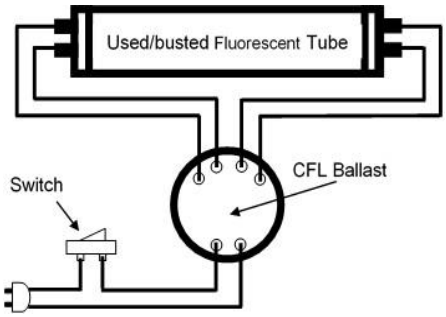

Figure 4. Wiring connection of electronic ballast taken from busted CFL bulb to drive the used and busted fluorescent lamps.

Concept 2: Utilizing a voltage multiplier circuit to drive the used and busted fluorescent lamps

The researcher developed a voltage multiplier circuit that produces a high DC voltage output.

Figure 5. shows that the output terminals of the voltage multiplier circuit is connected to one terminal at each end of the fluorescent tube. Wires were connected to the power input of the voltage multiplier circuit and connected to a switch and male plug which is plugged into the power source.

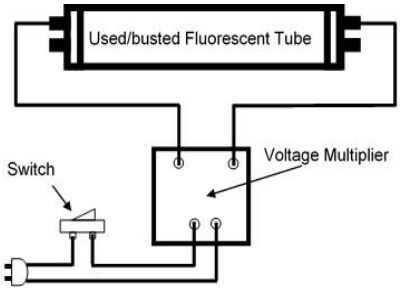

Figure 5. Wiring connection of voltage multiplier circuit used to drive the used and busted fluorescent lamps

Respondents of the Study

The respondents were twenty (20) BS in Industrial Education students major in electronics technology enrolled during the school year 2016-2017. Ten (10) were fourth-year level, and (10) were third-year level students. They were chosen because they would be the immediate beneficiary of the experiment results in a way that they can apply the concepts of reusing the parts of non-functional fluorescent lamps in their respective homes. The researcher conducted an orientation and training to the respondents as a panel of evaluators and discussed with them the details on how to evaluate the effectiveness of CFL ballast and voltage multiplier circuit in driving the used and busted fluorescent lamps. The orientation and training of the respondents happened on July 28, 2016.

Research Locale

The study was conducted at the Electronics Technology Shop where used and busted fluorescent lamps are stored. The shop is located at the Industrial Arts Building at Eastern Visayas State University-Main Campus Tacloban City.

Research Instrument

A three (3) point scale observation guide sheets were used by the respondents to determine the level of effectiveness of CFL ballast and voltage multiplier circuit in driving the used and busted fluorescent lamps. The effectiveness was categorized into three: (3) Very Effective; (2) Effective; and (1) Not Effective.

Data Gathering Procedures

The researcher gathered the panel of evaluators and handed them the observation guide sheets to record

their observations on the effectiveness of the CFL ballast and voltage multiplier circuit in driving the used and busted fluorescent bulbs. The CFL ballast and voltage multiplier circuit were used simultaneously for thirty (30) days specifically, three (3) days per fluorescent lamp. The data gathering was conducted in August – September 2016.

Data Scoring Procedures

The study utilized the data scoring in table 2 to determine the level of effectiveness of the electronic ballast taken from the busted compact fluorescent lamp (CFL) and voltage multiplier circuit in driving the used and busted fluorescent bulbs. It utilized the 3-point scale scoring with their corresponding point range, qualitative interpretation and description to ensure that evaluators would record objective observations.

Table 2. Data Scoring

Range	Scale	Interpretation	Verbal Description
2.50 – 3.00	3	Very Effective	The fluorescent tube lights up and remains lighted for 8 hours and more in a day for three (3) days.
1.50 – 2.49	2	Effective	The fluorescent tube lights up and remains lighted for 1 hour and more but less than 8 hours a day for three (3) days.
1.00 – 1.49	1	Not Effective	The fluorescent tube lights up in less than an hour in a day for three (3) days. The fluorescent tube did not light up.

Statistical Treatment of Data

The study utilized the computer software package Minitab to compute the weighted mean on the level of effectiveness of the CFL ballast and voltage multiplier circuit in driving the used and busted fluorescent lamps. And two-sample t-test was used to determine whether a significant difference exists between the CFL ballast and voltage multiplier circuit on their effectiveness in driving the used and busted fluorescent lamps.

RESULTS AND DISCUSSION

The respondents evaluated the effectiveness of the 9-watts CFL ballast and voltage multiplier circuit in driving the used and busted fluorescent lamps namely: 10-watts, 20-watts, 40-watts, linear fluorescent tubes, 22-watts circular fluorescent bulb and 14-watts U-bulb.

The effectiveness of CFL ballast and voltage multiplier circuit in driving the used fluorescent bulbs

The CFL ballast and voltage multiplier circuit were very effective (VE) in driving the used fluorescent lamps. The CFL ballast was consistently very effective in driving all the used fluorescent lamps. While the effectiveness of the multiplier circuit depends on the size of the fluorescent lamp.

Table 3. Comparison of the two concepts in driving the used fluorescent lamps

Fluorescent Lamp	CFL Ballast n=20		Voltage Multiplier n = 20		Results of two-sample t-test	
	Mean	Int.	Mean		t-value	p-value
10-watts	2.98	VE	2.93	VE	1.44	0.159
20-watts	2.98	VE	2.92	VE	1.51	0.140
22-watts	2.98	VE	2.85	VE	1.84	0.073
40-watts	2.98	VE	2.78	VE	2.15	0.038
14-watts	2.98	VE	2.63	VE	5.33	0.000

Nevertheless, the small margin on the effectiveness between the concepts indicates no significant difference in driving the 10-watts, 20-watts, 22-watts, and 40-watts fluorescent lamps with $p > 0.01$. However, the CFL ballast and voltage multiplier circuit differ significantly in driving the used 14 –watt CFL U bulb, $p < 0.01$. The difference can be attributed to the size and shape of the fluorescent lamp.

The effectiveness of CFL ballast and voltage multiplier circuit in driving the busted fluorescent bulbs

The CFL ballast was not effective (NE) in driving the busted fluorescent lamps while the voltage multiplier circuit was very effective (VE) in driving the busted 10-watts, 20-watts, 22-watts, and 40-watts fluorescent lamp and effective (E) in driving the 14-watts CFL U bulb.

Table 4. Comparison of the two concepts in driving the busted fluorescent lamps

Fluorescent Lamp	CFL Ballast n=20		Voltage Multiplier n = 20		Results of two-sample t-test	
	Mean	Int.	Mean		t-value	p-value
10-watts	1.06	NE	2.68	VE	-20.09	0.000
20-watts	1.08	NE	2.67	VE	-18.25	0.000
22-watts	1.05	NE	2.65	VE	-15.28	0.000
40-watts	1.03	NE	2.55	VE	-13.03	0.000
14-watts	1.05	NE	2.16	E	-23.77	0.000

It can be noticed that there was a significant difference between the CFL ballast and voltage multiplier circuit on their effectiveness in driving the busted fluorescent lamps since $p < 0.01$. The difference between the applied concepts could be attributed to the structure and operating principles of the two circuits.

The findings of this study suggest that parts of a non-functional fluorescent lighting system such as fluorescent bulbs, and electronic ballast from busted CFLs could be reused to create an improvised fluorescent lighting system. The results are supported by Frund et al. [12] since they found out that 40% of discarded lamps can be repaired and prolong its useful life between six months to two years.

Moreover, the amount of mercury vapor released in broken fluorescent lamps depends on the age of the bulb and the quantity of mercury vapor in the bulb [2], [13]. Furthermore, spent fluorescent lights had very little mercury vapor and more than 94% of mercury remains either as a component of phosphor powders inside the glass tube [14]. Therefore, extending the lifespan of fluorescent bulbs would decrease the spread of released mercury from broken fluorescent lamps into the environment and can prevent the risk of mercury inhalation by the human. Also, the degree of effectiveness of the CFL ballast and voltage multiplier circuit further suggest that we should not immediately throw away non-lighting CFL bulbs and used and busted fluorescent tubes. Instead, we should reuse it to save money, resources, lives, and the environment.

CONCLUSION AND RECOMMENDATION

Based on the findings, this study concluded that the ballast from busted CFL bulb and voltage multiplier circuit could be used effectively as a driver circuit to relight the used fluorescent bulbs of various size and shapes. However, the voltage multiplier circuit is more capable of lighting the busted fluorescent lamps compared to the CFL ballast.

Also, the effectiveness of the CFL ballast and voltage multiplier circuit to drive the used and busted fluorescent bulbs depends on their configured operating principles and the size and shapes of the fluorescent lamps.

This study recommends that the method of doing the concepts on reuse of parts of non-functional fluorescent lamps should be printed in the form of leaflets to raise awareness among the people that used and busted fluorescent bulbs can be relighted thus prevent them from throwing it together with other waste to prevent accidental lamp breakage.

The study was limited to the application of voltage multiplier and electronic ballast taken from 9 watts busted CFL bulb to relight five different size and shapes of used and busted fluorescent tubes. The power consumption and light intensity of the relighted fluorescent bulbs was not measured due to the non-availability of the instrument to measure such parameters.

Researchers should conduct further study on the application of the concepts on using voltage multiplier circuit and different wattages of CFL ballast in driving more sizes and shapes of new, used and busted fluorescent bulbs to measure its power consumption and light intensity and compare it to the functional fluorescent and LED lamps.

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