Open Access Library Journal

Semi-Auto-Open Portable Electric Vulcanizer (SAO-PEV): An Innovation

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Received 26 July 2014; revised 16 September 2014; accepted 22 October 2014

Abstract

In this 3rd study—Semi-Auto-Open Portable Electric Vulcanizer (SAO-PEV) is to minimize the delayed opening of the vulcanizing head for releasing and removing the vulcanized rubber tire and to eradicate the haphazard operation after the post vulcanization process. This machine is made of steel materials with GI pipes gauge 20 with a configuration of an elongated letter "C" with a mica heating element that were attached to the vulcanizer head and the Electronic Control Unit (ECU); thus, this machine weighted 9.25 kg. For post vulcanization process, the vulcanizer head was released by turning the lock latch in 1 to 2 minutes while in the 2nd study of Portable Electronic Vulcanizer, it took 5 to 8 minutes to unscrew the lag bolt to remove the finished vulcanized rubber tire. In constructing the product, special gadgets were installed and added with a safety fuse. The level of effectiveness was based on the first study to avoid inconsistencies of data. For Class A gum, the best temperature which bonded exactly to the rubber tire was 60˚C in 1 minute while for Class B gum it bonded at 60˚C in 2 minutes respectively. The rate of energy consumed by the electronic vulcanizer, for Class A gum is Php 0.0757 and for Class B gum is Php 0.15 respectively with an efficiency of 85.22% and for conventional vulcanizer for Class A gum is Php 1.08 with an efficiency of 43.38% and for Class B gum is Php 1.52 respectively with an efficiency of 78.08%. The study revealed that more tires can be vulcanized in a short period of time, therefore greater income over time.

Keywords

Semi-Automatic Portable Electric Vulcanizer, Electronic Vulcanizer, Portable Vulcanizer

Subject Areas: **Agricultural Engineering, Industrial Engineering**

1. Introduction

This study is all about the modernization of the vulcanization process for automotive, motorcycle, bicycle and

How to cite this paper: Ramis, E.Z. (2014) Semi-Auto-Open Portable Electric Vulcanizer (SAO-PEV): An Innovation. *Open Access Library Journal*, **1**: e956. http://dx.doi.org/10.4236/oalib.1100956

any inflatable tire tubes. Electronic operated vulcanizer is environmentally-friendly equipment. Modernization of gadgets occurs for the benefit of human beings. Old things turn into new ones that are more accurate, easier to operate, more comfortable and capable of doing their purposes; such that the fan turns into an air-conditioner, abacus into a computer, and so many things have been improved with the advancement of technology. In the industry and economy, worn-out tires are recycled instead of being disposed to the surroundings and the environment. The production of rubber, specifically in tire making, may be lowered; manpower will increase and the industry will gain more income.

The Portable Electronic Vulcanizer (PEV) uses heat energy to vulcanize the rubber but it does not exude any harmful substances that may affect the environment in the vulcanization process. Therefore, it is an environment-friendly product.

In study 1—Design and Fabrication of Portable Electric Vulcanizer & study 2—Efficiency of Portable Electronic Vulcanizer (PEV), these machines had a letter G body configuration. An Electric Control Unit (ECU) was added to have an easy operation and to get the exact bonding time to the inner tube rubber tires. The parts of Portable Electric Vulcanizer (PEV) machine that hold the heating element to the rubber tire are the lag bolt that tightens and loosens the vulcanizing gum to the rubber during the vulcanization process.

The proper operation in tire vulcanization involved in pressing the inner tube rubber tire with the heating element by means of a lag bolt through a circular handle. In tightening and loosening this lag bolt causes the delayed operation in the post vulcanization operation and sometimes is hazardous to the operator if he forgets to wear the proper working gloves. In this process, it takes 5 to 8 minutes to unscrew the lag bolt to remove the finished vulcanized rubber tire.

In this 3rd study—Semi-Auto-Open Portable Electric Vulcanizer (SAO-PEV) is the best solution for these delayed operations in releasing the vulcanizing head to remove the vulcanized rubber tire and to eradicate the haphazard operation after the post vulcanization process.

The living condition in the vulcanizing shop can be upgraded by modernizing the vulcanizing equipment. Adding features such as buzzer, timer and temperature gauge may greatly increase the efficiency and accuracy of the vulcanizing equipment. This study determined the accurate temperature and duration of the vulcanizing process using the electric vulcanizer which eliminates the problem of gas emission (carbon dioxide) produced by the conventional (gas fired) vulcanizer of about 2.772 kg of carbon dioxide for 1 litre of diesel fuel and/or 2.331 kg of carbon dioxide for litre of petrol into the atmosphere [1].

Global warming is the current rise in the average temperature of earth's oceans and atmosphere, and it is projected to be continually rising. The scientific consensus is that global warming is occurring and was initiated by human activities, especially by those that increased concentrations of greenhouse gases in the atmosphere, such as: 1) carbon dioxide (CO_2), from deforestation and burning of fossil fuels; 2) methane (CH_4), emissions from livestock and other agricultural practices and by the decay of organic waste in municipal solid waste landfills; 3) nitrous oxide (N_2O), emitted during agricultural and industrial activities, as well as during combustion of fossil fuels and solid waste; 4) fluorinated gases, such as hydro-fluorocarbons, per-fluorocarbons, and sulphur hexafluoride which are synthetic, powerful greenhouse gases that are emitted from a variety of industrial processes [1].

This experimental research was conceived to generally contribute to the mitigation of global warming, and specifically, to provide empirical evidence and knowledge so that investors in this small-scale business industry can outright start the business.

2. Technical Description

2.1. Rationale

The underlying principle of this study is to determine the ease of the operation of the SAO-PEV in order to upgrade the living condition of the stakeholders of vulcanizing shops in Northern Samar in particular and Region VIII and the country in general through a new design of the vulcanizing equipment called as the Semi-Auto-Open Portable Electric Vulcanizer (SAO-PEV) of the post operation of the vulcanization process.

2.2. Objectives

The efficiency of the Semi-Auto-Open Portable Electric Vulcanizer will eventually help improve in the post vulca-

nizing operation, which is beneficial to the community, the environment and industry. The product may help the operation of businesses in the community, ease the labor and production cost.

Specifically, this study is conducted to:

1) Identify the design of a Semi-Auto-Open Portable Electric Vulcanizer (SAO-PEV);

2) Determine the material component for the innovation of the portable electric vulcanizer (SAO-PEV); and

3) Find out the efficiency between the existing vulcanizer to the new innovated Semi-Auto-Open Portable Electric Vulcanizer (SAO-PEV) in terms of post vulcanization operation.

This SAO-PEV and the conventional vulcanizer (carbon dioxide emitting apparatus) has a common problem. In removing the vulcanized product, its needs to loosen the lag bolt thorough its circular handle that sometimes lock-up due to change in metal temperature that slightly expand during the heating process. Sometimes the mica heating element portion is twisted causing the electrical wiring to be detached or cut-off. Likewise, the electric vulcanizer if not watched properly during the vulcanization process, it can damage the rubber tire. Likewise, the conventional vulcanizer, if the gas is not properly measured or controlled, burning of the rubber tire will occur. To solve the aforementioned problems and the environmental concern, (gas emission), this innovative technology (electric operated vulcanizer) is studied which is expected to be applied over time as technology changes.

2.3. Flow Chart of the Study

Figure 1, the flow chart of the study, shows construction steps of this innovated machine in three steps. The first steps is the input includes the raw materials in making the product; the second process includes the steps in making the product and data gathering and the last steps output product Semi-Auto-Open Portable Electric Vulcanizer (SAO-PEV).

2.4. Specific Basis/Theoretical Framework

McClelland classifies people in relation to their dominant need for achievement, power of affiliation, as viewed by successful entrepreneurs.

McClelland explains that “people who are high in need achievement are highly motivated to strive for the satisfaction that is derived from accomplishing a trade or occupation which are most the times challenging task, like in the design and fabrication of electric vulcanizer, were patience, endurance and dexterity must be present on the individual” thus people are the graduates of technical education [2].

Former President Fidel V. Ramos [3], he stressed that the living condition of the people in every sector of society can be improved by initiating family investment or group. He wanted the Philippines to be a New Industrialized Country (NIC) in Asia and the Pacific by 2000 and beyond. Thus, Executive Order No. 318, s. 1991, was passed to reinforce functional program in the implementation toward industrial reform and development.

With this plans and standards, a national employment plan as basis for technical education and skills development plan was recommended and provided for improvement, for the following problem, namely: enrollments, workload distribution, poor quality of teaching skills of teachers, lack of fitness between programs and graduates, limited time for the on-the-job training.

Our country today must recognize the present educational technologies status that these may be used whenever possible to enhance and equalize the opportunities in this field of technical education, like in the engineer-

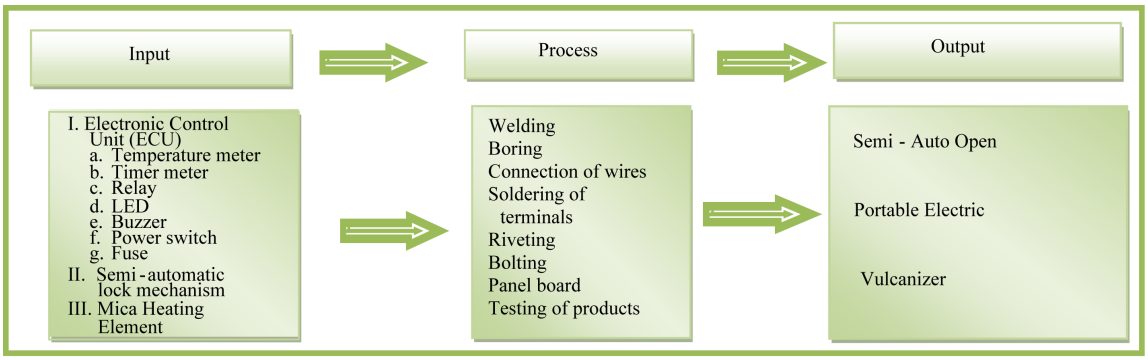

Figure 1. Flow chart of the study.

ing field, considering that license professional engineers, undermine the people who graduated technical education only, even though that these people are sometime more skillful than them. The problem of mismatch does not only embrace from technology graduates but they are included for some do not carry practical skills.

3. Review of Related Literature

The work environment refers to the aggregate of surrounding things and conditions that affect the quality of work life and the individual itself being an employee or an entrepreneur.

Strengthening the so called technical and technician training and vocational training efficiency becomes and essential to the Filipinos lives as nation, providing job opportunities among those who could not afford to pursue higher education.

3.1. Implications for Engineering and Technology Education

Engineering and technology education is the advancement of technological capabilities and to nurture and promotes the professionalism of those engaged in this field of education. This field of education opens the door to discovery and offers a tremendous variety of careers options. This tends to search the best and less expensive ways to utilized nature forces/energy to meet the today's challenging world. Like for instance, about technology changes, *i.e*. firewood to cooking gas; manual electrical operated machines to today's fully automated programmable operations.

Engineering education is the activity of teaching knowledge and principles related to the professional practice in engineering. It includes the initial education for becoming an engineer and any advanced education and specialization that follow [4].

In engineering and technology education goes hand in hands to the rapid pace of globalization pressures nations to be competitive in order to survive. In this field of education its ushers the freer permeability of human resources among countries. While it poses as a huge challenge to the survival of Filipino workforce in the global market, it yields various opportunities. This challenge pushes for the continuing development and replenishment of manpower through this field of education in order to ensure that there are workers of the right quality and right quantity for jobs that are made available at any given instance. Further, it urges for a stronger labor market intelligence and technology development. Lastly, it encourages transformation of the Filipino workforce to be knowledge-based and adaptable to shifting skills or even occupations [5].

Vulcanization is the chemical process by which the physical properties of natural or synthetic rubber are improved; finished rubber has higher strength and resistance to swelling and abrasion, and elastic over a greater range of temperature. In its simplest form, heating rubber with sulfur brings about vulcanization.

3.2. Vulcanization Methods [6]

A variety of methods exist for vulcanization. The economically most important method (vulcanization of tires) uses high pressure and temperature. A typical vulcanization temperature for a passenger tire is 10 minutes at 170˚C. This type of vulcanization is called compression molding. The rubber article is intended to adopt the shape of the mold. Other methods, for instance to make door profiles for cars, use hot air vulcanization or microwave heated vulcanization (both continuous processes). Six types of curing systems are in common use. They are: 1) sulfur systems; 2) peroxides; 3) urethane crosslinkers; 4) metallic oxides; 5) deuce; 6) acetoxysilane.

3.3. The Discovery of Vulcanization

Vulcanizing gum is a ready-made natural rubber that is vulcanized to bond the rubber tire. Vulcanization of rubber is a chemical process of treating rubber or related polymers by adding sulfur or similar "curatives" at great heat to improve elasticity and strength of rubber or to harden them. Therefore, vulcanization of rubber is a curing process of rubber that involves high heat and the addition of sulfur or other equivalent curatives [7].

3.4. Rubber

Newly discovered rubber class such as vulcanizing gum is now utilized on repairing worn-out rubbers such as an automobile tire. Vulcanizing gum is classified according to its texture, bonding temperature and the content of

accelerators. The three classes of the gum were as follows [7]:

- **Class A**—usually bonds on the rubber 30˚C - 70˚C and is smooth; used small punctured and cracks in the inner tube rubber tire.
- **Class B**—usually bonds on the rubber 35˚C - 80˚C and is moderately rough; used medium or punctured holes and cracks/scars in the inner tube rubber tire.
- **Class C**—usually bonds on the rubber 45˚C - 90˚C and is very rough; seldom available in the market and issued in tire repairing big punctured and cracks/scars in the inner tube rubber tire and mostly usually used for tire recapping.

4. Related Studies

Research on the chemistry of natural rubber led in the 19th century to the isolation of isoprene, which could be reconverted into a rubber-like substance by polymerization. This process by which long chainlike molecules were created attracted continued research in early 20th century; in World War I, German scientists produced some 2500 tons of useful synthetic rubber. In the 1930's and in World War II, several polymerizing processes were developed in Germany, the Soviet Union, Britain, and the United States [7].

The technological development begins with basic research, when a scientist discovers some new phenomenon or advances new theory. Other reaches the examine the breakthrough for its potential utility. If further development leads to a prototype and engineering refinement make commercial exploitation practical. Then, the technology is finally put to, use may be widely adopted [8].

Actually, there are vulcanizing equipments that are electric operated but don't have any electric control gadgets. If not properly used, the vulcanizing gum may be burnt as for the tire; same as with the manually operated vulcanizing equipment, and it also wastes more time, labor, money and manpower in the vulcanizing shop operation.

5. Methodology

This chapter discusses the processes that were done during the experiment and the tools that were used during the experiment.

5.1. Research Design

The study utilized experimental research method which included the new design, selection and identification of materials, assembly or fabrication, and testing process:

1) ***New design.*** The new design of the SAO-PEV vulcanizing equipment was based on its portability and light weight, and its post vulcanization operation. The following nomenclature of this SAO-PEV machine are as follows:

a) The machine weights 9.25 kilograms; total length of 49 cm, height of 33.5 cm, back width (panel board) of 22 cm with front width (front base) of 14 cm and environment-friendly machine.

b) Its body configuration is an elongated letter C appearance. A movable arm is bolted at the top of the base, that is made of GI pipe schedule 40 × 49 cm in length × 6.3 cm in diameter, and attached to it is a detachable vulcanizer head of 15.5 cm in length × 6.5 cm in width × 1.5 cm in thickness.

c) The base was made of channel bar with dimension of 47 cm in length × 9 cm in width × 6.5 cm in height and thickness of 0.30 cm that served as foundation of the equipment; an extension flat bar 6 cm by 2 cm with a center hole of 0.05 cm in diameter is welded at both sides end of the vulcanizer and intended for stationary position of the machine.

d) A flat type 300 watts mica heating element is attached to the vulcanizer head and a box type panel board of 22 cm in length × 27 cm in width × 8 cm in thickness.

e) This newly innovated vulcanizer called as Semi-Auto-Open Portable Electric Vulcanizer (SAO-PEV) take only 1 minute to 2 minutes to open the vulcanizer head by turning down the latch handle after the vulcanization process is completed.

2. ***Selection and identification of materials.*** Selection and identification of materials were seriously considered for this study. The timer that controls the duration of the vulcanizing process; temperature gauge that controls the temperature in the process; power switch that is used for cutting the power supply to the machine; fuse

that disconnects when current above threshold and protect the circuit from high currents, LED as light monitoring device and the buzzer that sounds when the vulcanizing process is completed; a circular GI pipe is used as arm and for pressing the heating element and the rubber tire and a flat type 300 watts mica heating element was connected to the circuit which is enclosed by a panel board made of galvalum sheet to complete the portable electronic vulcanizer.

3. *Fabrication*. Based on the plans and design, the movable GI pipe arm was moulded in a pipe bender to form a letter J configuration; the channel bar, angle bar and flat bar was cut to its desired length then welded to form the base; the semi auto open mechanism is housed and bolted inside the safety lock housing located at the front of the machine. Fabrication of the panel board was undertaken to house the circuit board of this machine.

4. *Testing process.* Testing of the machine was undertaken to determine the workability of the machine.

Figure 2 shows the schematic diagram of the electric vulcanizing equipment that works simultaneously from the power input to the electronic parts that function accordingly until the vulcanization process is completed.

5.2. Materials

The materials used in the assembly in constructing the SAO-PEV were the following:

A. Materials:

- 1 pc—GI pipe—gauge 20 × 2.5” diameter × 17 inch long
- 1 pc—GI pipe—gauge 20 × 3/4” diameter × 2 inch long
- 1 pc—GI pipe—gauge 20 × 1/2” diameter 2 inch long
- 2 pcs—Flat bar—1/4 “× 2” × 17.5 inch
- 2 pcs—Flat bar—1/4 “× 4” × 6”
- 4 pcs—Assorted bolts and nuts
- 1 set—Motorcycle seat lock switch

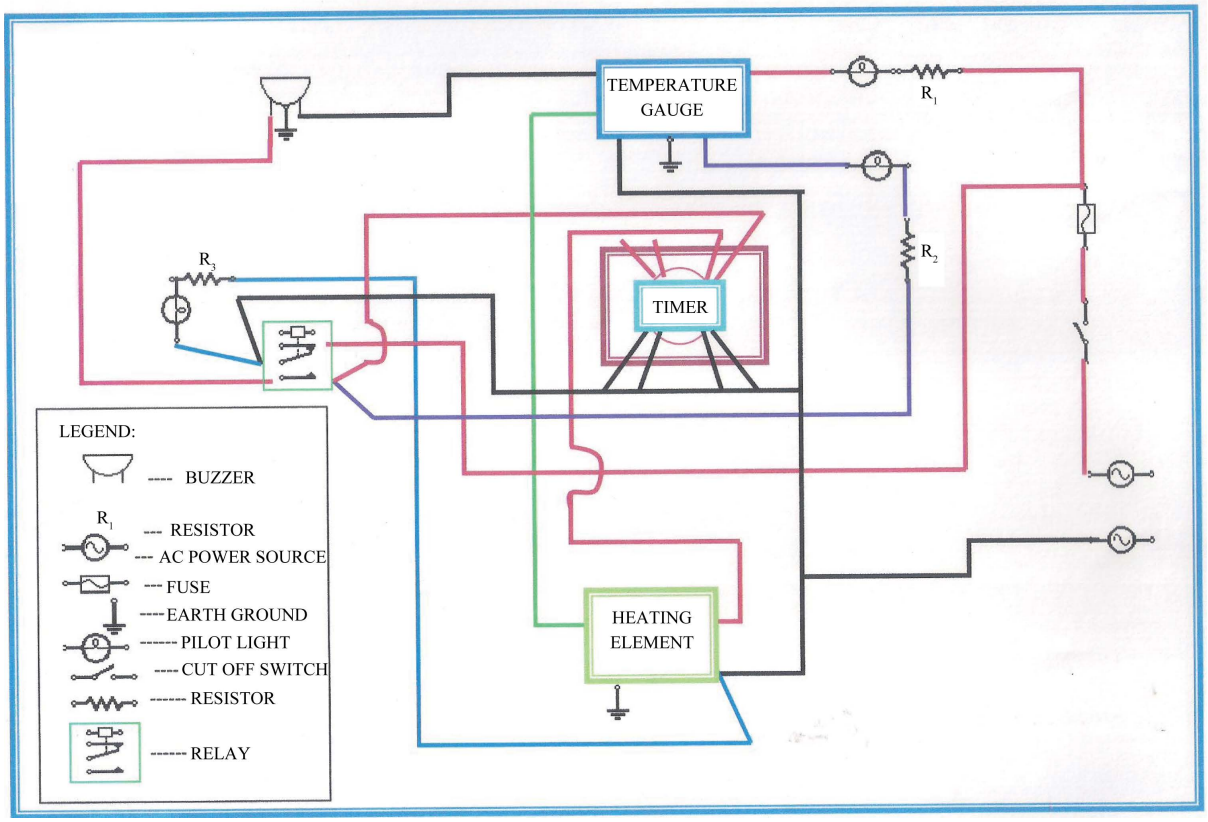

Figure 2. Schematic diagram of electric vulcanizer.

- 1 set—Mica heating element
- Tension spring
- LED
- 1 unit—Electric Control Unit (ECU)
  - Digital timer
  - Relay
  - Buzzer
  - Analog temperature gauge
  - Safety fuse

B. Tools

- 1 set—Portable electric drill
- 1 set—welding machine
- 1 set—Stationary electric drill
- 1 set—Hacksaw
- 1 set—Electric Cutter
- 1 set—Electric Grinder

These are the materials were needed in shaping the innovated SAO-PEV. The parts were measured and welded, boring of holes for bolts, tension spring and assembled as the new Semi-Auto-Open Portable Electric Vulcanizer.

6. Timetable of Research

This study was conducted in school year 2007-2008 in the Bachelor of Technology Department, College of Engineering, University of Eastern Philippines, University Town, Northern Samar.

7. Expected Output

The design of this Semi-Auto-Open Portable Electric Vulcanizer crop-up after the utilization and actual application and operation of the 1st design. The researcher found out technical difficulties in loosening the vulcanizing head thru the lag bolt via circular handle to release the vulcanized inner tube rubber tire that takes 5 to 8 minutes operation. With this minor difficulties and sometimes half-hazard to the operator this design was developed.

The design of this Semi-Auto-Open Portable Electric Vulcanizer machine is made of steel materials with GI pipes gauge 20 with a configuration of an elongated letter "C" with a mica heating element is attached to the vulcanizer head and the ECU to control the vulcanization process that release the vulcanizer head in 1 minute to 2 minutes that weight 9.25 kg.

The function of the component parts of the SAO-PEV machine that comprises of 8 parts, namely:

1) Head—supports the mica heating element and the vulcanizer compressor lock;

2) Compressor Lock—controls the gum and the inner tire tube patching;

3) Mica Heating Element—produces radiant heat for vulcanization process;

4) Bottom Plate—the bottom part of the vulcanizer processing unit where the material to be vulcanized is secured for the best results in the vulcanizing operation;

5) Electric Control Unit—houses all the electric parts used for the efficient operation of the SAO-PEV;

6) Base—hold and supports all parts of the SAO-portable electric vulcanizer;

7) Body—the main parts of the SAO-PEV that configure like a letter J that moves up and down and houses the vulcanizer head;

8) Safety Latch—a semi automatic lock for easy and secured locking of the mica heating element and bottom plate for best vulcanizing result.

The efficiency of the product in vulcanization operation, the existing PEV takes 5 to 8 minutes to open the vulcanizer head by means of unscrewing or loosening the lag bolt to release the vulcanized tire. While the newly innovated vulcanizer called as Semi-Auto-Open Portable Electric Vulcanizer (SAO-PEV) take only 1 minute to 2 minutes to open the vulcanizer head by turning down the safety lock switch.

The efficiency of tire vulcanization for Class A vulcanizing gum is based on its original results of the 1st study Design and Fabrication of Portable Electric Vulcanizer to get the best result and to avoid inconsistencies of da-

ta's result. This study have utilized and used the two classes of vulcanizing gum, that is the Class A, and Class B.

Table 1 shows the efficiency and rate of energy consumed by the electronic vulcanizer was compared with the manual gas vulcanizer.

Data on **Table 1** shows that the electronic vulcanizer had the best temperature in which the gum was bonded exactly to the rubber tire. It was 60˚C in 1 minute for Class A gum with a power consumption of 0.005 kw-hr valued at Php 0.0757 and an efficiency of 85.22%, while the Class B gum bonded at 2 minutes at 60˚C, with power consumption of 0.10 kw-hr valued at Php 0.15 and an efficiency of 85.22%.

For the conventional vulcanizer, the best temperature in which the gum was bonded exactly to the rubber tire was 60˚C in 5 minutes for Class A gum, with fuel consumption of 20 ml valued at Php 1.08 and an efficiency of 43.38%, while the Class B gum bonded at 10 minutes at 60˚C, fuel consumption of 30 ml valued at Php 1.52 and with an efficiency of 78.08%.

Figure 3 and **Figure 4** compares the result of the vulcanizing process using the electronic and the conventional vulcanizer at 60˚C temperature.

Figure 3, shows that the portable electronic vulcanizer is five (5) times efficient compared to the conventional vulcanizer for both Class A and B vulcanizing gum.

Likewise **Figure 4**, indicated that the conventional vulcanizer, its rate of energy consumes much higher than the electric vulcanizer.

This study determined the accurate temperature and duration of the vulcanizing process using the electric vulcanizer which eliminates the problem of gas emission (carbon dioxide) produced by the conventional (gas fired) vulcanizer of about 2.772 kg of carbon dioxide for 1 liter of diesel fuel and/or 2.331 kg of carbon dioxide

Table 1. Efficiency & rate of energy consumed of electronic/conventional vulcanizing using Class A & Class B vulcanizing gum.

Type of Vulcanizer	Time in Minutes		Temperature in ˚C		Power/Fuel Consumed		Cost in kw-hr/gas-ml		Rate of Energy Consumption		Results	Efficiency (%)	
	Class		Class		Class		Class		Class		Class	Class	
	A	B	A	B	A	B	A	B	A	B	A B	A	B
Electric	1	2	60		0.005 kw-hr	0.10 kw-hr	Php 15.1441		Php 0.0757	Php 0.15	Good Bonding	85.22%	
Conventional	5	10			20 ml	30 ml	Php 0.054		Php 1.08	Php 1.52		43.38%	78.08%

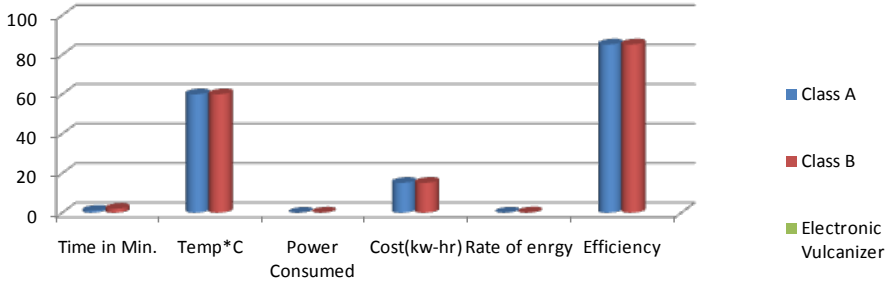

Figure 3. Electric vulcanizer.

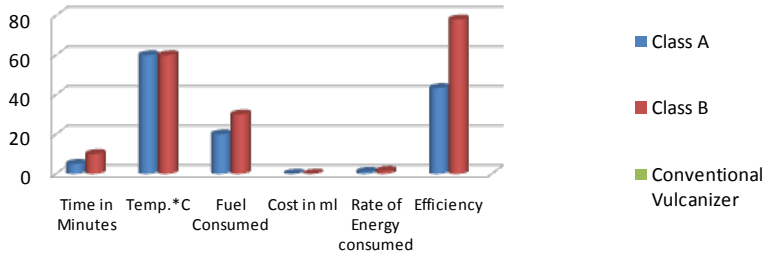

Figure 4. Coventional vulcanizer.

for 1 liter of petrol into the atmosphere.

8. Summary

The experimental method of research was used. The researcher was responsible for the purchase of the materials needed for the study.

This study revealed that the portable electric vulcanizer was effective in vulcanizing interior tires of the automobile, motorcycle and bicycles. In the post vulcanization operation in releasing the vulcanized rubber tire that takes 1 to 2 minutes to open the vulcanizer head by turning down latch handle or the Semi-Auto-Open Mechanism.

The rate of energy consumed for the portable electronic vulcanizer was Php 0.0757 for Class A gum and Php 0.15 for Class B gum with an efficiency of 85.22%, while the conventional vulcanizer for Class A gum consumed a fuel equivalent to Php 1.08 with an efficiency of 43.38% while the Class B gum fuel consumption was equivalent to Php 1.52 with an efficiency of 78.08%.

9. Conclusions

Based on the findings of the study, the following conclusions were derived:

1) The new design of the SAO-PEV vulcanizing equipment was based on its portability and light weight, and its post vulcanization operation. The following nomenclature of this SAO-PEV machine are as follows:

a) The machine weights 9.25 kilograms; total length of 49 cm, height of 33.5 cm, back width (panel board) of 22 cm with front width (front base) of 14 cm and environment-friendly machine.

b) Its body configuration is like a letter L in appearance. A movable arm is bolted at the top of the base, that is made of GI pipe schedule 40 × 49 cm in length × 6.3 cm in diameter, and attached to it is a detachable vulcanizer head of 15.5 cm in length × 6.5 cm in width × 1.5 cm in thickness.

c) The base was made of channel bar with dimension of 47 cm in length × 9 cm in width × 6.5 cm in height and thickness of 0.30 cm that served as foundation of the equipment; an extension flat bar 6 cm by 2 cm with a center hole of 0.05 cm in diameter is welded at both sides end of the vulcanizer and intended for stationary position of the machine.

d) A flat type 300 watts mica heating element is attached to the vulcanizer head and a box type panel board of 22 cm in length × 27 cm in width × 8 cm in thickness.

2) Selection and identification of materials were seriously considered for this study. The timer that controls the duration of the vulcanizing process; temperature gauge that controls the temperature in the process; power switch that is used for cutting the power supply to the machine; fuse that disconnects when current above threshold and protect the circuit from high currents, LED as light monitoring device and the buzzer that sounds when the vulcanizing process is completed; a circular GI pipe is used as arm and for pressing the heating element and the rubber tire and a flat type 300 watts mica heating element was connected to the circuit which is enclosed by a panel board made of galvalum sheet to complete the portable electronic vulcanizer.

3) This newly innovated vulcanizer called as Semi-Auto-Open Portable Electronic Vulcanizer (SAO-PEV) take only 1 minute to 2 minutes to open the vulcanizer head by turning down the latch handle after the vulcanization process is completed.

The Internal Rate of Return (IRR) of the vulcanizing shop with capitalization of Php 185100.00 including this new electronic vulcanizer is only 3.3356 years operation.

This study determined the accurate temperature and duration of the vulcanizing process using the electronic vulcanizer which eliminates the problem of gas emission (carbon dioxide) produced by the conventional (gas fired) vulcanizer of about 2.772 kg of carbon dioxide for 1 liter of diesel fuel and/or 2.331 kg of carbon dioxide for 1 liter of petrol into the atmosphere.

10. Implication

The findings of this study have an important implication for future enhancement and improvement of the study. More tires can be vulcanized in a short period of time; therefore greater income over time. It is environment-friendly since it does not emit gas as compared to the conventional vulcanizing; and much more is lesser health hazard to the operator.

11. Recommendations

- It is recommended that this portable electric vulcanizer shall be used in every welding, automotive and machine shop to save time and investment in their operations;
- Small time businesses like vulcanizing shops in the Philippines are encouraged to provide this portable electric vulcanizing machine so that they can save money and labor in their operation;
- It is also recommended that this study can be innovated thru additional features like automatic shutting down of power supply or may be a remote controlled operation on the power switch.

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