

Efficiency of a portable electronic vulcaniser

E.Z. Ramis

University of Eastern Philippines
Catarman, Northern Samar, The Philippines

ABSTRACT: This research was developed and executed for the modernisation of old vulcanising equipment to save time, investment, manpower and the environment through accurate temperature setting and timing of the vulcanising process and by eliminating the problem of gas emissions as produced by conventional (gas fired) vulcanisers. In constructing the product, a letter G body configuration made of GI pipe with a 31.5 cm long log bolt with some special appliances were installed. The level of effectiveness of the equipment was tested using Class A gum. The temperature at which the gum was best bonded to the rubber tyre was 60°C in 1 minute, while Class B gum bonded at 60°C in 2 minutes. The rate of energy consumed by the electronic vulcaniser was much less than for a conventional vulcaniser at a greater level of efficiency. Apart from the technical research, implications for engineering and technology education regarding this technology are also outlined and discussed briefly in this paper.

INTRODUCTION

This study is about modernising the vulcanisation process for automotive, motorcycle, bicycle and other inflatable tyre tubes. An electronically-operated vulcaniser is an environmentally friendly piece of equipment. Modernisation creates new machines that are more accurate, easier to operate, more comfortable and capable of fulfilling their purposes. Examples include a fan turned into an air-conditioner, an abacus into a computer and so many things that have been improved with the advancement of technology. In the industry and economy, worn out tyres are recycled instead of being disposed of into the surroundings and the environment. The production of rubber, specifically in tyre making, may be reduced and manpower will increase and the industry will earn more income.

The portable electronic vulcaniser (PEV) uses heat energy to vulcanise the rubber but it does not exude any harmful substances that could affect the environment in the vulcanisation process. Therefore, it is an environmentally friendly product.

Electricity is a form of energy. It is associated with an electric charge, a property of certain elementary particles, such as electrons and protons, two of the basic particles that make up the atoms of all ordinary matter. An electric charge is an electric current. Electricity can be utilised in many ways, including this electric vulcanising equipment [1]. It can be converted efficiently into other forms of energy and it can be stored. Because of its versatility, electricity plays a part in nearly every aspect of modern technology.

The conditions in a vulcanising shop can be improved by modernising the vulcanising equipment. Adding features, such as a buzzer, timer and temperature gauge may greatly increase the efficiency and accuracy of the vulcanising equipment. This study determined the accurate temperature and duration of the vulcanising process using an electric vulcaniser, which eliminates the problem of carbon dioxide emissions produced by conventional, gas fired vulcanisers. These produce about 2.772 kg of carbon dioxide for 1 litre of diesel fuel and/or 2.331 kg of carbon dioxide for 1 litre of petrol [2].

Global warming is the rise in the average temperature of the earth's oceans and atmosphere and it is projected to continue. The scientific consensus is that global warming is occurring and was initiated by human activities, especially by those that increase concentrations of greenhouse gases in the atmosphere. These include a) carbon dioxide (CO_2), from deforestation and burning of fossil fuels; b) methane (CH_4) emissions from livestock and other agricultural practices and by the decay of organic waste in municipal solid waste landfills; c) nitrous oxide (N_2O), emitted during agricultural and industrial activities, as well as during combustion of fossil fuels and solid waste; and d) 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 [3].

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

OBJECTIVES

The efficiency of the portable electronic vulcaniser (PEV) was tested to help improve the handling convenience of the electric power device, which is beneficial to the community, the environment and the industry. Specifically, this study was conducted to:

1. identify the design of a portable electronic vulcaniser;
2. determine the material component of the portable electronic vulcaniser;
3. determine the appropriateness of the heating element use in electronic vulcaniser;
4. determine the desirable temperature to exactly bond the Class A & B vulcanising gum to the rubber tyre in one and two minutes respective; and
5. find out the efficiency and cost-analysis of the portable electric vulcaniser.

RATIONALE

The underlying principle of this study is to determine the efficiency of the portable electronic vulcaniser in order to upgrade the living conditions of the stakeholders in vulcanising shops in the Philippines.

STATE OF THE ART

The modernisation of the conventional vulcaniser (gas emitting apparatus) required the researcher to add a new process that incorporated a unique idea into this field of technology. The experimental set-up required different temperatures to be tested for a constant time in vulcanisation. Five trials were conducted to find the perfect temperature at which the gum would bond perfectly to the rubber after one minute for Class A vulcanising gum and two minutes for Class B vulcanising gum.

ANALYSIS OF THE PROBLEM

The electronic vulcaniser and the conventional vulcaniser have a common problem. The electric vulcaniser, if not watched properly during the vulcanisation process, can damage the rubber tyre. In the conventional vulcaniser, if the gas is not properly measured or controlled, the rubber tyre will burn. To solve the aforementioned problem and the environmental concerns, this innovative technology which is expected to be applied over time as technology changes, has been studied.

Flowchart of the Study

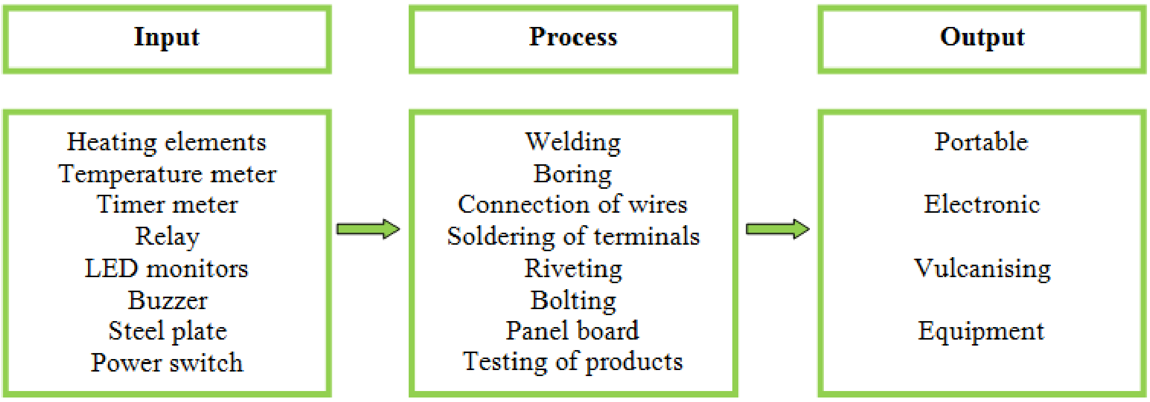

Figure 1: Flowchart of the study.

REVIEW OF THE LITERATURE

The work environment refers to the aggregate of surroundings and conditions that affect the quality of work, life and the individual whether as an employee or an entrepreneur.

Former President Fidel V. Ramos stressed that the living conditions of the people in every sector of society can be improved by initiating a family investment or other group. He wanted the Philippines to be a New Industrialised Country (NIC) in Asia and the Pacific by 2000. Thus, Executive Order No. 318, s.1991, was passed to reinforce a functional programme in the implementation toward industrial reform and development [4].

The Technical Education Skills Development Authority (TESDA) reported the government's quest to realign technician education programme to be of paramount importance. On the other hand, the Presidential Commission on Educational Development (EDCOM), based on the result of its survey, recommended the conduct of feasibility studies and projected modern educational design to revitalise the c hanging demand of the nation's youth for effective manpower development. Mismatch problems between the education sector and industry are vital issues as regards the graduates of colleges and universities, wherein most of them cannot find jobs because they lack the skills needed by industry. Hence, graduates of technical courses have a wider range of employment compared with those graduates of white-collar professions [5].

With these plans and standards, a n ational employment plan, as the basis for technical education and a skills development plan, was recommended and provided for improvement for the following problems: enrolment, workload distribution, poor quality of teaching skills of teachers, lack of fitness between programmes and graduates, and limited time for the on-the-job training.

Vulcanisation is the chemical process by which the physical properties of natural or synthetic rubber are improved; the finished rubber is stronger and is resistant to swelling and abrasion, and elastic over a greater range of temperatures. In its simplest form, heating rubber with sulphur brings about vulcanisation.

In modern practice, a temperature of 140°C - 180°C is deployed and in addition to sulphur and accelerations, carbon black oxide is usually added, not merely as an extender but to improve further the qualities of the rubber. Vulcanising gum, which is a classified *ready to heat* rubber, is now utilised to repair worn out interior/exterior rubber tyres with the help of vulcanising equipment. Certain problems, such as inaccuracy of the product, are evident throughout third-world countries as the first-world countries never used them [6].

The Discovery of Vulcanisation

Goodyear thought that rubber could be improved by processing it with other substances. As Goodyear was displaying a mixture of rubber and sulphur, the piece slipped from his hand into the fire. When he removed it, he found to his amazement that the mass had charred without melting. Goodyear named this process of combining rubber with sulphur by heat *vulcanisation*. Later he discovered that the addition of lime, magnesium and lead compounds sped up the vulcanisation process. Elastic substances are obtained from the exudations of certain tropical plants (natural rubber) or are derived from petroleum and alcohol (synthetic rubber) [7].

Newly discovered rubber classes such as vulcanising gum are now utilised for repairing worn-out rubber, such as an automobile tyre. Vulcanising gum is classified according to its texture, bonding temperature and the content of accelerators. The three classes of the gum were as follows [8].

- Class A – usually bonds on the rubber 30°C-70°C and is smooth;
- Class B – usually bonds on the rubber 35°C-80°C and is moderately rough;
- Class C – usually bonds on the rubber 45°C-90°C and is very rough.

RELATED STUDIES

Technological development starts with basic research when a scientist discovers some new phenomenon or advances a new theory. Others then examine the breakthrough for its potential utility. If further development leads to a prototype and engineering refinement makes commercial exploitation practical, then, the technology that is finally put to use could be widely adopted [9].

Technological changes take place in many directions at once; that is, it is multi-lineal. Bar codes, for example, are used to track items not only in grocery stores but also in warehouses, assembly lines, shipping docks, libraries, even in the Department of Defence. Technological changes are also nonlinear; developments take irregular directions. There are many dead ends and each highly visible advance may depend on a host of small developments (including failures) [10].

Actually, electrically-operated vulcanising equipment already exists, but do not have any electronic control devices. If not properly used, the vulcanising gum may be burned, just as with manually operated vulcanising equipment. It also wastes more time, labour, money and manpower in the vulcanising shop operation.

MATERIALS AND METHODS

The materials and methods used in the construction and experimentation of this study were:

- a heating element, a 3 00 W heating device that heats the vulcanising gum and rubber or interior tyre for the vulcanising process;
- an analogue temperature gauge used to a set specific temperature in centigrade for the duration of the vulcanisation process;

- a digital timer device used to set a s pecified time in seconds/minutes/hours for the burning operation of the vulcanising equipment;
- a PC printed circuit board on which all of the electronic parts were installed;
- an LED, a light emitting diode that serves as a light monitoring device;
- boring tools used for drilling holes in the PCB for placement of the electronic parts;
- a relay to conduct power to the timer, temperature gauges once the vulcanisation process takes place;
- a buzzer that sounds when the heating activity is finished;
- nuts and bolts used to tighten some electronic parts to the PCB and as holder of the PCB circuit;
- a circuit made in a PCB so that current will flow;
- a hacksaw that is used for cutting metals as parts of the machine;
- a welding machine is used to join metals for assembling the vulcaniser;
- aluminium sheeting that is used as a shield or protector of the rubber tyre during the vulcanising process;
- a control panel that houses the component parts of the electronic vulcaniser;
- power switches for power connection to the circuit or vulcanisation process;
- the main source provides a prescribe current to any circuit connected to it; and
- the body of vulcaniser that is the holder of all the component parts used in this vulcaniser.

The wiring for the machine to function was assessed by the researcher with the assistance of an electronics expert. For mass production, this machine will cost only Php 5,700.00 (approximately US130).

RESEARCH DESIGN

The study utilised an experimental research method that included the new design, selection and identification of materials, assembly or fabrication, and a testing process:

1. *New design.* The design of the vulcanising equipment was based on its portability and its weight of only 6.30 kilograms and environment-friendly machine. Its body configuration is a letter G in appearance that is made of GI pipe of schedule 40; the base was made of 0.3 cm flat bar that served as the foundation of the equipment; a flat type 300 W heating element and a box type panel board.
2. *Selection and identification of materials.* Selection and identification of materials were considered for this study. The timer that controls the duration of the vulcanising process; a temperature gauge that controls the temperature in the process; a power switch that is used to cut the power supply to the machine; LED as light monitoring device and the buzzer that sounds when the vulcanising process is completed; a stainless circular handle with 315 mm by 12mm lag bolt, used for pressing the heating element and the rubber tyre, and a flat type 300 W heating element was connected to the circuit, which is enclosed by a panel board made of galvalum sheet to complete the portable electronic vulcaniser.
3. *Fabrication*. Based on the plans and design, the body was moulded in a pipe bender to form a letter G configuration, the flat bar was cut to its desired length then welded to form the base and welded it a gain to the body of the vulcaniser. 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 electronic vulcanising equipment.

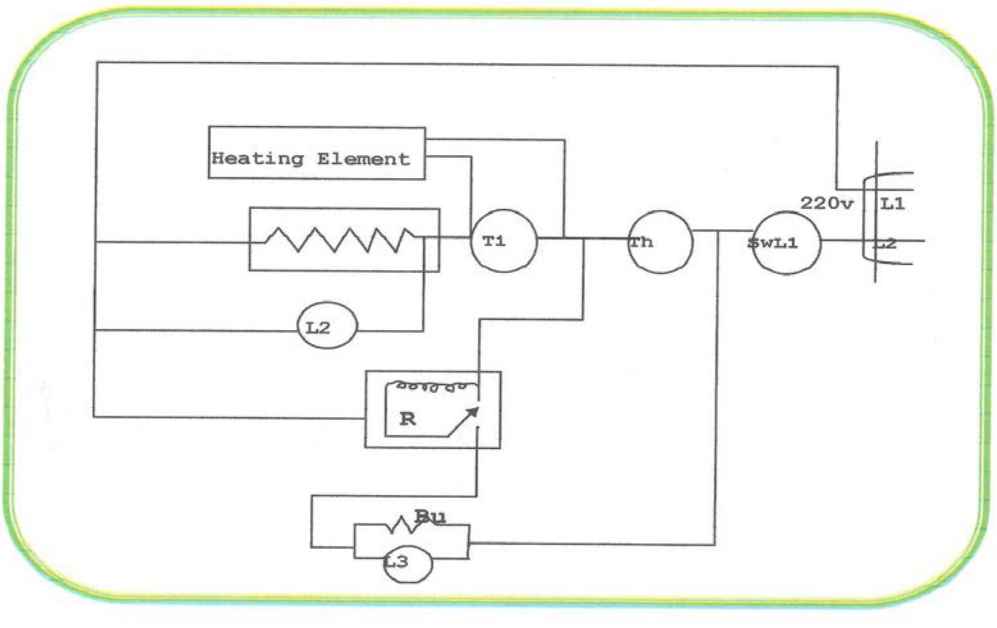

Figure 2: The schematic diagram of the electronic vulcaniser.

To determine the efficiency of the product in vulcanisation, the researcher used some worn out automobile tyres. Several tyres were vulcanised at different temperatures and for different lengths of time with the temperature interval of 10°C ranging from 30°C to 60°C and at a constant time of 1 minute for Class A vulcanising gum and 2 minutes for Class B vulcanising gum. The results were then recorded and determined what temperature and time the vulcanising gum bonded to the tyre best.

RESULTS AND DISCUSSION

The efficiency and rate of energy consumed by the electronic vulcaniser was compared with the manual gas vulcaniser (Table 1).

Table 1: Efficiency and rate of energy consumed of electronic/conventional vulcanising using Class A and Class B vulcanising gum.

Type of Vulca-niser	Time in Minutes		Temperature In °C		Power/Fuel Consumed		Cost in kWh/ 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
Electronic	1	2	60		0.005 kWh	0.10 kWh	Php 15.1441		Php 0.0757	Php 0.15	Good Bonding		85.22%	
Conven-tional	5	10			20 ml	30 ml	Php 0.054		Php 1.08	Php 1.52			43.38 %	78.08 %

Data in Table 1 show that for the electronic vulcaniser, the temperature at which the gum was bonded to the rubber tyre best. It was 60°C for one minute for Class A gum with a power consumption of 0.005 kWh valued at Php 0.0757 and an efficiency of 85.22%, while the Class B gum bonded at two minutes at 60°C, with power consumption of 0.10 kWh valued at Php 0.15 and an efficiency of 85.22%.

For the conventional vulcaniser, the temperature at which the gum was bonded best to the rubber tyre was 60°C in five minutes for Class A gum, with fuel consumption of 20ml 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%.

Figures 3 and 4 compare the result of the vulcanising process using the electronic and the conventional vulcaniser at 60°C temperature.

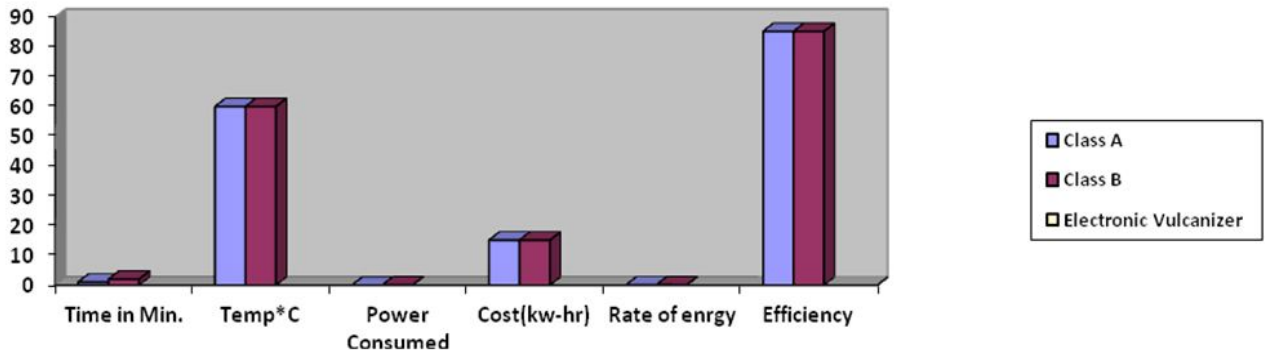

Figure 3: Electronic vulcaniser.

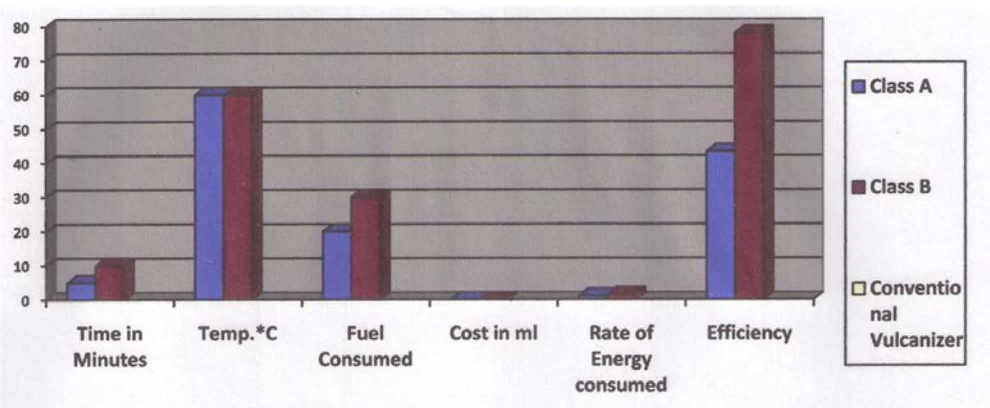

Figure 4: Conventional vulcaniser.

The figures show that the portable electronic vulcaniser is five times more efficient when compared to the conventional vulcaniser for both Class A and B vulcanising gum.

This study determined the accurate temperature and duration of the vulcanising process using the electric vulcaniser, which eliminates the problem of gas emissions produced by the conventional gas fired vulcaniser of about 2.772 kg of carbon dioxide for one litre of diesel fuel and/or 2.331 kg of carbon dioxide for one litre of petrol into the atmosphere.

IMPLICATIONS FOR ENGINEERING AND TECHNOLOGY EDUCATION

Engineering and technology education aims for the advancement of technological capabilities and to nurture and promote 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. It tends to search for the best and least expensive ways to utilise nature forces/energy to meet the today's challenging world.

Engineering and technology education is the activity of teaching knowledge and principles related to the professional practice of engineering. It includes the initial education for becoming an engineer and any advanced education and specialisation that follows [11]. Technology education often serves as the foundation for engineering education. In the Philippines, the Technical Education and Skills Development Authority (TESDA) is one of the authorised training centres for these careers, with others at some of the state universities and colleges, such as the Technological University of the Philippines (TUP)'s centre for excellence of engineering and technical-vocational education.

The Philippines' Commission on Higher Education (CHED) and TESDA are forging a technology education programme called the Ladderised Education Program (LEP). The changes and developments in the work patterns and skills demanded by various industries, including the emerging ones, necessitate a very strong link between Technical-Vocational Education and Training (TVET) and higher education. The purpose of ladderisation is to open pathways of opportunities for career and educational progression of students and workers. Specifically, it in tends to create a seamless and borderless education and training system that allows mobility in terms of flexible entry and exit into the educational system. In essence, ladderised education is an empowering tool because it provides options or choices to a wider range of clientele on when to enter and to exit in the educational ladder.

More importantly, it creates job platforms at every exit and provides students with an opportunity to get a job and earn income. While there will be no structural and systems changes, the ladderised system provides for portability across levels for harmonisation of qualifications. Through active advocacy, it is expected that more State Universities and Colleges (SUCs) will be encouraged to ladderise their programmes. At present, the programme has been rolled out by TESDA and CHED for the Academic Year 2006-2007 covering eight priority disciplines such as agriculture and fisheries; health and medical services; information and communication technology; maritime; tourism/hotel and restaurant management; criminology; education; and engineering [12].

In engineering and technology, education goes hand in hand with the rapid pace of globalisation that pressures nations to be competitive in order to survive. In this field of education, it ushers in the freer mobility of human resources between countries. While it poses a huge challenge to the survival of the 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 become available at any given instance. Further, it urges a stronger labour 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.

For curriculum development, questions in philosophy of technology and engineering about the control of technology and responsibility for technology are important. For example, the answer to the questions: is technology autonomous or is it *controlled?* have a direct impact on the contents and structure of technical curricula [13].

From time to time, a new direction for engineering education is heralded. Recent examples from the literature include the renaissance engineer for the 21st Century and global engineers and socially responsible engineers, or science, technology and society (STS) engineers. Often engineering education can look at sustainability and issues concerning the considerate and appropriate application and development of technology as something that *is done in other countries that are underdeveloped*. The inclusion of sustainable developments into curricula is just one example of the models to adapt engineering education in our ever-changing environments [14].

SUMMARY

This study was conducted to determine the efficiency of a portable electronic vulcaniser. Testing was undertaken at the Bachelor level of the Technology Department, College of Engineering, University of Eastern Philippines for school year 2005-2006. 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 electronic vulcaniser was effective in vulcanising interior automobile, motorcycle and bicycle tyres. It further showed that the best temperature for bonding the gum to the rubber tyre was 60°C for 1 minute for Class A gum and 2 minutes for Class B gum.

The rate of energy consumed for the portable electronic vulcaniser 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 vulcaniser 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%.

CONCLUSIONS

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

1. The design of the portable electronic vulcaniser is made of a letter G body, which is made of gauge 20 GI pipe with a 0.05cm flat bar base. The height of the body is 41 cm; the base is 23.5 cm long and 10 cm wide; and the panel board has dimensions of 27.5 cm for the height, 22 cm for the width; and 8 cm for the thickness.
2. The material components of the electronic vulcaniser are the timer, temperature gauge/thermostat, LED, buzzer, relay and 300 W heating element.
3. The appropriateness of the heating element was demonstrated in the experiments conducted using this portable electronic vulcaniser, which is a unique flat-type heating element material with a 300 W output for a low cost power generation consumption.
4. The portable electronic vulcaniser requires 60^{o}C temperature for one minute to bond the gum to the rubber tyre for Class A vulcanising gum and two minutes at 60°C temperature to bond to the rubber tyre for Class B vulcanising gum. The electronic vulcaniser is, therefore, efficient as it requires only one and two minutes (for Class A and B vulcanising gum, respectively) to vulcanise as compared to the conventional vulcaniser that needs five minutes to finish the task.
5. In terms of energy consumption, the portable electronic vulcaniser is more economical as it consumes energy equivalent to Php 0.0757 (Class A vulcanising gum) and Php 0.15 (Class B vulcanising gum) with an efficiency of 85.22%, as compared to the Php 1.08 (Class A vulcanising gum) with an efficiency of 43.38% and Php 1.52 (Class B vulcanising gum) with an efficiency 78.08% of the conventional vulcaniser. The efficiency of the portable electronic vulcaniser is limited only for the vulcanisation of gum to the rubber tyres or inner tubes of the automobiles, motorcycle and bicycle or any inflatable rubber materials.

The Internal Rate of Return (IRR) of the vulcanising shop with a capitalisation of Php 185,100.00, including this new electronic vulcaniser is only 3.3356 years of operation.

This study determined the accurate temperature and duration of the vulcanising process using the electronic vulcaniser, which eliminates the problem of gas emissions produced by the conventional gas fired vulcaniser of about 2.772 kg of carbon dioxide for 1 litre of diesel fuel and/or 2.331 kg of carbon dioxide for 1 litre of petrol into the atmosphere.

IMPLICATION

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

RECOMMENDATIONS

- It is recommended that this portable electronic vulcaniser should be used in every welding, automotive and machine shop to save time and costs of their operations;
- Small time businesses like vulcanising shops in the Philippines are encouraged to acquire this portable electronic vulcanising machine so that they can save money and labour in their operation;
- It is recommended also that this study could be improved through additional features like automatic power supply shut down or perhaps a remote controlled operation on the power switch.

ACKNOWLEDGEMENT

This research work would not have been realised without the guidance of Almighty God.

Sincerest appreciation and gratitude are likewise extended to the following persons:

Dr Norman T. Diaz, R&D Director and Dr Tito M. Cabili, OIC, Research Director, University of Eastern Philippines, University Town, Catarman, Northern Samar, for their encouragement to present of this research paper; Dr Rolando A. Delorino, Vice-President for Research & Development/Extension, Chair, R&D In-House Review panel, for his valuable suggestion and support of this study; Dr Mindanilla B. Bruto, Member, R&D In-House Review panel, for her valuable suggestions to enrich this research paper; Dr Ronellie Salvador, Member, R&D In-House Review panel, for her encouragement, concern and refinement of the title of this research; Dr Helena T. Dela Rosa, Member, R&D In-House Review panel, for her guidance in the completion of this study; Dr Althea B. Cablay and Mr Julio Calumpiano, Jr, Members, R&D In-House Review for their intellectual insights and moral support; Mr Nilo B. Salazar, Member, R&D In-House Review panel, for his valuable suggestions for the success of this study; Mrs Maricel Navaroza, for her unselfish financial analysis computation; Prof. Romula R. Obleopas for her manuscript arrangement; Prof. Villa C. Carpio, for her untiring support and editing this manuscript; Dr Rem N. Laodeno, Dr Benjamin D. Varela, Engr. Jose Ariel Geriane, Engr. Constantine F. Merida, Engr. Leo M. Sauro, Prof. Joel J. Tejano and Prof. Nelito E. Getalado for their moral support .

Hon. Paul R. Daza - Governor, Northern Samar, for their financial assistance.

Atty. Mar. P. De Asis, PhD, President, for giving us full support and enthusiasm of this field of endeavour; and to those who contributed much for the success of this study, particularly my wife, Gigi and children, my friends and colleagues.

REFERENCES

1. Appleton and Lange's Review of Electricity.
2. http://www.en.wikipedia.com /…/USA environment protection agency.
3. http://www.en.wikipedia.com/.../electricity.
4. Ramos, F.V., Executive Order 318, s. 1991, Making Philippines Industrializing Country (NIC-hood Philippines).
5. Congressional Commission on Education, Making Education Work: An Agenda for Reform. Congress of the Republic of the Philippines, Manila, Quezon City (1993).
6. Encyclopaedia Britannica, 15th Edition.
7. Compton's Encyclopaedia, 1995 Edition.
8. Encyclopaedia Britannica, 15th Edition.
9. Compton's Encyclopaedia, 1995 Edition.
10. Ramis, E.Z., Determinants of Professionalism of Graduate School Students, Faculty and Administrator in State Universities and Colleges in Region VIII. Technological University of the Philippines, Manila. March (2002).
11. Wikipedia, the free Encyclopaedia.
12. Arroyo, G., Presidential Executive Order 358 entitled: To Institutionalize a Ladderized Interface between Technical-Vocational Education and Training (TVET) and Higher Education (HE).
13. Roy, T.R. McGrann, Philosophy of Technology in Engineering Education, Binghamton University (SUNY), mcgrann@binghamton.edu
14. Pritchard, J. and C. Baillie, C., How can engineering education contribute to a sustainable future? *European J. of Engng. Educ*., 31, **5**, 555-656 (2006).