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Design and Construction of Multi-Purpose Hand Crank Mechanical Energy Charger

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***Abstract*: The high demand for energy requires humanity to search for alternatives to improve and sustain the standard of living in the modern world. As a way to explore other possibilities of energy sources during emergencies as well as the development of eco-friendly technology, this paper aims to design and construct a multi-purpose mechanical energy charger using the product design and development method of research. Findings showed that the device is capable of producing electricity with its mechanical hand-crank for smartphones, rechargeable mini fan, and rechargeable flashlight.**

Meanwhile, the device is cheaper compared to the existing charging device in the market. It was also assessed that the device has social acceptability and technologically sound attributes based on its effectiveness, portability, usability, and user-friendliness. After the design and fabrication, it is recommended that there is a need to further improve the device with longer trials and verifications to obtain its most desirable performance for technology utilization and commercialization.

Keywords: Multi-Purpose Mechanical Energy Charger, Reverse Engineering, Design & Construction,

I. INTRODUCTION

In the global perspective, the high demand for energy requires humanity to find solutions and improve the way of living in the modern era. The world is facing serious and emerging energy problems, greenhouse gas emission, energy costs, climate change, and pollution. These concerns are related to human activities. At present, 80% of the electrical production of the world is sourced out from nuclear fuels and fossils (Global Energy Report, 2019). A projection from the World Energy Council shows that the primary demand for energy will be tripled by 2050, as the population tends to increase and grow at 8-9 billion while developing nations will elevate living standards. With the global population is swelling and the industrialization is on the rise among developing countries, humanity needs a great amount of energy which is generated from fossil fuels extracted from the earth's deep surface causing detrimental effect to the environment (Gray, 2017). The economic development of a country depends on energy security for driving and improving the quality of the life of the people.

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Without affecting the environment, electric power generation is possible using renewable energy. The focus of researchers, scientists and technologist is the process of finding energy sources which have been experimented widely across the globe. From the results of different experiments conducted, the generation of electrical energy from mechanical energy is concluded to be the most efficient.

With the existing problem, the proposed solution is the design and construction of a multi-purpose mechanical energy charger. This designed and constructed hand crank multi-purpose mechanical charger is covered by plastic and equipped with the USB charger, aluminium as hand crank for rotating to earn powered electricity supply of battery. In general, it is used to charge electronic devices that are used in case of emergency. It can also be taken anytime, anywhere even when one is travelling because it is portability. The developed device has a multi-purpose capacity. It can be used to charge cellphones, mini electric fans, and power banks which other existing technologies in the market do not have.

This project can be beneficial to families located in the far-flung and disaster-vulnerable areas. It can be used in times of disaster and power shortages. The device consists of 5v and 30v or more that can be used in mini-electric fans 30v and 5v cellphones, and other gadgets that can drive the voltage. Through the manual operation of the hand-crank, it can generate energy which powers small gadgets and devices.

This study was conducted to design and construct a multi-purpose hand crank mechanical charger. It specifically aims to present the components and specifications and the method of construction.

II. REVIEW OF EXISTING DEVICE

The developed device has multi-purpose, portable and lightweight capacities as its distinct differentiations from other devices developed previously. It can be used to charge cellphones, mini electric fans, and power banks which other existing technologies in the market do not have. Basing from the literature, hand-crank based battery is not new since there are studies reviewed by the researchers to identify the pattern of development of the developed device. Technically, Moyers, Coombe, and Hartman (2004) fabricated hand-crank generators for soldier missions. The device is found effective and efficient for 24-volt batteries to provide power to military radios and other equipment. A further innovation was recommended. Consequently, Lee, Koo, Moon & Han (2012) designed an axial flux permanent magnet (AFMP) generator for a portable hand crank generating system. Moon, Lai, Park & Koo (2014) also designed a battery charger for a portable human-powered generator which is physiologically designed for males which can generate 100w using feet cranking motions.

Subsequently, Singla, Dhand, and Virk (2016) developed a hand-crank generator for powering lower-limb exoskeletons for elderly persons. Hence they developed a mathematical model in relation to the speed cranking and charging power. Additionally, Jain, Aravind, Prasad, & Chakravarthy (2013) have designed a virtual prototype of a mechanical hand crank mobile charger. They used the compound gear train. They recommend further technological innovation for the device.

Moreover, Reddy, Sreekanth, & Narayana (2013) developed a type of mobile charger using wind power, electrical power, and human power. The device can also be used to charge while travelling using turbines. In Indonesia, Rahamanm Hoque, Das, Maysha & *Morshed* (2016) designed a portable dual-mode mobile charger with hand crank generator and solar panel. The device is convent as well as economical to be used but needs further technological advancement.

In more recent studies, Tikare, Parab, & Tikare (2016) proposed a modern and easier way of charging electronic devices using the crank. Das, Hashunao & Mazumdar (2015) have developed a hand-driven battery charger (HDBC) system where the battery can charge the 4.8-6V battery. Watanabe (2019) also designed a mechanical charger which is capable of producing 5v for cellphones.

In the Philippines, being one of the disaster-prone countries of the world suffering from major storms, typhoons, volcanic eruptions, earthquakes and other natural disasters and calamities, has limited R&D studies conducted along with multi-purpose hand-crank driven mechanical energy charger. Hence, this study was conducted.

III. MATERIALS AND METHOD

A. Research Design

This study employed the Product and Design Development Method of research with the developed prototype design of multi-purpose hand crank mechanical charger guided by the framework of Input-Process-Output.

The input component utilized needs analysis, field observations, interviews, and reviews of the existing mechanical charger in the market and literature. The process component followed the product development method starting from design, construction, testing, and evaluation. Finally, the output component is the innovative multi-purpose hand crank mechanical charger.

B. General Considerations

This study designed and developed a free-energy charger. It followed the following considerations: Cost-effective; Easy to operate; It is portable and can be used anytime and anywhere; It is a user-friendly material; It will be useful for travelers; It has efficient and quality characteristics; Easy to dismantle and easy to clean features; It has safety features and standard; A material of the construction is not too much expensive; Has ease of construction and assembly; and eco-friendly and disaster-saving technology.

In order to make a well-functioning free energy charger, the following were the criteria used to evaluate the whole product. There are set project criteria that need to have complied with the design project: effectiveness, efficiency, user-friendliness, portability, usability, and performance.

The criteria were evaluated by giving out survey forms to the users. Random stratified sampling was used in gathering the survey respondents wherein they have grouped the respondents into clusters according to users.

C. Process of Construction

In order to design and develop a multi-purpose hand crank mechanical charger, the following process and procedure were considered: (1) Secure all the components and parts listed; (2) Check the plate circuit board for any possible defects; (3) Soak the plate circuit board on the ferric chloride to remove the undesired metal elements; (4) Insert and solder the components in the plate circuit board; (5) Make sure that each component are placed in the correct orientation; (6) Review the work, and make sure that everything is correct; (7)Use a multi-tester to make sure that there is no short circuit.

D. Evaluators of the Product and Analysis of Data

The evaluators of the product were the faculty members and students of the College of Technology of one Public Higher education Institutions in the Philippines. To analyze the data, mean was used in analyzing and presenting the findings of the study. To assess the quality of the designed and developed free energy charger, the following scale of one as the lowest and five as the highest with descriptions from Very Much Capable to Not Capable.

E. Cost of Materials and Miscellaneous Items

Table- I: Cost of Materials

Items	Quantity	Unit	Price	Cost
Reverse motor	1	pc	Php 550.00	Php 550.00
Regulator	3	Pc	Php 105.00	Php 105.00
Plastic case	3/5	Inch.	Php 90.00	Php 90.00
USB female	3	Pc	Php 240.00	Php 240.00
Rotary switch	1	Pc	Php 35.00	Php 35.00
Led lights	1	Pc	Php 250.00	Php 250.00
Switch	1	Pc	Php 35.00	Php 35.00
Rechargeable battery	5	Pc	Php 250.00	Php 250.00
Wire	1	Meter	Php 25.00	Php 25.00
Soldering lead	2	Pc	Php 20.00	Php 20.00
Stick glue	2	Pc	Php 20.00	Php 20.00
Total Cost				**Php 1,610.00**

**The total cost, when converted to US Dollar, is 31.56.*

F. Material Specifications

Table- II: Material Component Specifications

Components	Quantity	Specification
Regulator	3	7805,7805,7806
Rotary switch	1	10k
Switch on/off	1	5 ampere
LED	4	12volts, 3 watts
Reverse motor/generator	1	24 volts
USB female charger	3	
Rechargeable battery	5	3.7 each
Led light	1	1 watt
Wire	2 meters	Used to send and receive electricity or electrical signal

IV. RESULTS AND DISCUSSIONS

A. Design Features of the Device

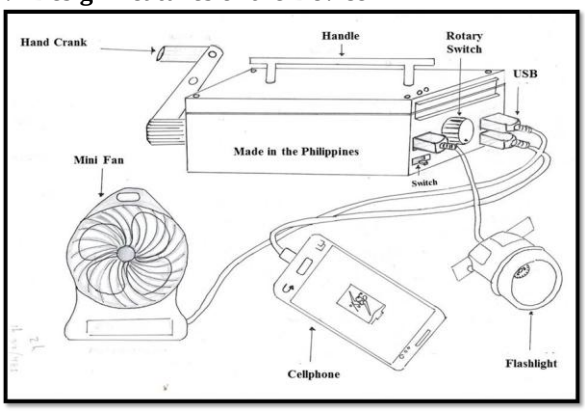

Figure 1. Isometric View of the Prototype design of Free Energy Charger

B. System Operation Block Diagram

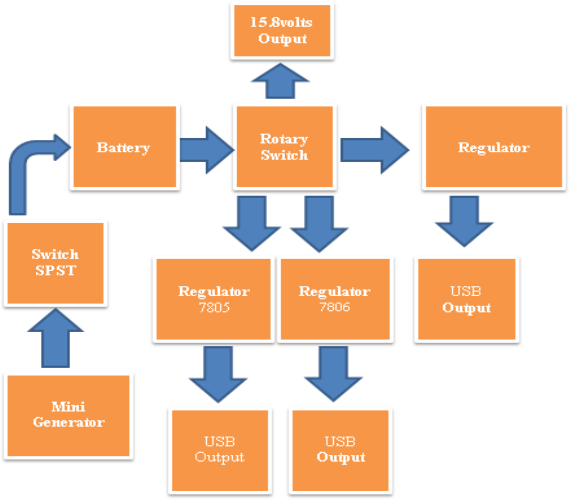

Figure 2. Shows the block diagram of the project and its operation.

C. Circuit Diagram

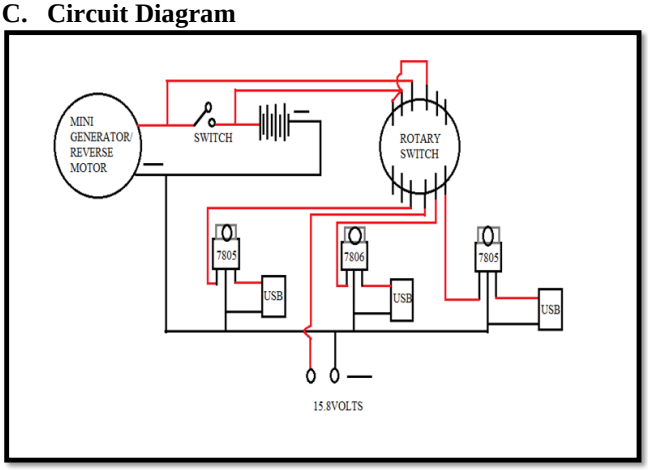

Figure 3. Shows the block diagram of the project and its operation.

D. Actual View of the Device

Figure 4. Actual View of the Device

Figure 6 presents the actual picture of the multi-purpose hand crank mechanical charger. The figures show the multi-purpose hand crank mechanical charger (upper figure); a flashlight (left); mini electric fan (centre); cell phone (right). The gearbox constitutes plastic plates with top and bottom surfaces. The top surface holds the handle. The front side surface hosts the switch, rotary switch, and three USB ports. The backside surface holds the mechanical crank.

E. Time of Operation of multi-purpose hand crank mechanical charger device

Table- 2: Material Component Specifications

Devices Attached	Number of mechanical twists	Maximum Charging Voltage (V)	Maximum Charging Current (mAH)
Smart Phone (Brand X)	200 twists	5volts	1300 mAh
Mini Fan	200 twists	5v0lts	1300 mAh
Flashlight	200 twists	5volts	1300 mAh

Results of the time operation of the multi-purpose hand crank mechanical charger are presented in Table 1. It shows that in the initial test of operation of 200 crank twists generate 5 volts maximum charging voltage with 1300 mAh for the devices attached to the USB input namely: smartphone, mini-fan, and rechargeable flashlight. Jain & Harmalkar (2011) suggest that mechanical energy is a requirement to produce electricity from the generator for which hand crank is used. The utilization of kinetic power can be used to charge electronics devices (Chakma et al., 2017). With the use crank attached to the developed device, it's main porous is to rotate the driving gear. Hence. The DC generator is manipulated by converting the mechanical energy into electrical energy-producing power to the different devices to be charged.

F. Assessment of the Device

Table- 3: Quality Assessment

Criteria	Mean	SD	Interpretation
Effectiveness	4.90	0.40	Very Much Capable
User-friendliness	4.86	0.34	Very Much Capable
Portability	4.90	0.30	Very Much Capable
Usability	4.90	0.30	Very Much Capable
Grand Mean	**4.89**		**Very Much Capable**

Table 3 presents the assessment of the multi-purpose hand crank mechanical charger device. A general rating of 4.89 described very much acceptable was given by the evaluators. This shows that the designed and constructed device is socially acceptable, technologically sound, and adaptable for utilization. Looking at the criteria, effectiveness, portability, usability, and user-friendliness were highly rated with very much acceptable attributes indicating that the constructed device has technological advantages. Meanwhile, suggestions were offered by the respondents to improve the product, particularly on its longer technology trials and verifications, simplicity, and device durability. The use of hand crank generators is effective and efficient to address different human concerns particularly on the issues of global warming, renewable green poor resources, disaster and emergency situations which has been suggested by numerous researchers (Moyers, Coombe, and Hartman; 2004; Lee, Koo, Moon & Han, 2012; Moon, Lai, Park & Koo, 2014; Singla, Dhand, and Virk, 2016, Aravind, Prasad, & Chakravarthy, 2013; Reddy, Sreekanth, & Narayana,2013; Rahamanm Hoque, Das, Maysha & Morshed, 2016).

V. CONCLUSION AND RECOMMENDATIONS

As a way to explore other possibilities of energy sources during emergency situations as well as the development of eco-friendly technology, the design and construction of the multi-purpose hand crank mechanical charger were initiated using the design and development method. Findings showed from the simple technical performance that the device is capable of producing electricity with its hand-crank for smartphones, rechargeable mini fan, and rechargeable flashlight. Meanwhile, the device is cheaper compared to the existing device in the market. It was also assessed to have socially acceptable and technological sound attributes based on its effectiveness, portability, usability, and user-friendliness.

After the design and fabrication, the following recommendations are offered: (1) there is a need to further improve the device with longer trials and verifications to obtain its most desirable performance; (2) durability testing should be conducted to identify its actual capacity and performance; (3) consider ergonomics study of the device to further suit to the capacity of different users; (4) application of the material for intellectual property rights should be initiated.

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