Global Scientific JOURNALS
GSJ: Volume 10, Issue 4, April 2022, Online: ISSN 2320-9186
www.globalscientificjournal.com

AN INNOVATION OF IGNITION SYSTEM AS SPARK PLUG TESTER AND INSTRUCTIONAL MOCK-UP DESIGN

By:
Alex L. Señara, D.M.,Nikki D. Quento, MTTE, Cand., Oran Ian Clark B., Badal Dave Vincent M.

Abstract

This project is based on developing an Innovative Sparkplug Tester with the entire ignition System driven by AC induction Motor. It helped the College of Engineering Technology major in Automotive Technology in Tagoloan Community College to have a prototype for Testing Spark quality output and use also as an instructional mock-up for demonstration in line to the Ignition System. The Project Goal is to Test the Spark quality Output for the better performance of the Internal Combustion Engine. Since the project is cost-efficient, the materials are readily available in sales car parts. The study is focused on the Innovative Sparkplug Tester.

The research design that was used in this study is Developmental Research. The study focuses on innovating an existing product which is the Prototype Sparkplug Tester for Motorcycle. Developmental research is a systematic work drawing on existing knowledge that is directed to producing new materials, products, and devices; installing new processes, systems, and services; and improving substantially those already produced or installed. Before the study was conducted, the approval to conduct this study was secured from the office of the Dean of the College of Engineering Technology, and the researcher provided all the necessary materials and components used in making the Innovative Sparkplug Tester.

After finishing the final product of this study which is the Innovative Sparkplug Tester for Testing Spark Quality Output, it was found out that after doing functional testing and evaluation, the Innovative Sparkplug Tester is exceptionally functional. It was also easy to operate by the student or instructors because of the simple and well-guided switches.

Keyword: *Ignition System, Sparkplug Tester, Instructional Mock-Up*

I. Introduction

A spark plug is a critical ignition system component that must function under the most extreme situations. It requires greater service attention and is usually the shortest-lived component of the gasoline engine since it is exposed to combustion chamber pressures and temperatures and contaminated combustion products (Britannica, 2013) . Thus they are exposed to high voltage shock hazards; the right tool is needed to diagnose the problem (Hanipah, 2013). This study was made to develop an instructional model of an ignition system that is made as a spark plug tester. It is essential as a sparkplug tester because the automobile's ignition system was made prototype to become a tester so that we can get an accurate reading of the spark plug. According to (Twinkl.com, -) A prototype is a test model of a product or technology that can use to make enhancements, upgrades, or fundamental modifications. It is an original model, form, or instance that serves as a basis for other processes (Techopedia.com, 2017).

The researchers came up with this study due to the lack of facilities in Tagoloan Community College; this is beneficial to the institution and the instructors and students. The instructors can use the instructional mock-up sparkplug tester using the ignition system to discuss the principles and operation of the system. To visualize how the system works, the students must see how the sparkplugs deliver a current during the engine operation. (Stephen A. Adalikwu, 2013) , stated that the Instructional Material can help students grasp the whole theory of

the ignition system. In delivering instructions, teaching materials act as a conduit between the teacher and the students.

They can also be used to motivate students during the teaching and learning process. According to (Bukoye, 2019) , effective teaching may be unattainable without functional instructional materials to increase innovative production in modern disciplines such as science and technology. (Tuimur & Chemwei, 2015) , also stated that the utilization of instructional materials is one key aspect of teacher education that receives a lot of attention.

The Input-Process-Output (IPO) Model will provide the general structure and guide for the direction of the study. In the IPO Model, a process is viewed as a series of boxes connected by inputs and outputs. According to (Naelga & Chavez, 2017), Information's and materials objects flow through a series of task or activities based on a set of rules of description as cited by (Amey, 1995). The knowledge, ideas, and resources used to create the project were the inputs to the framework's inputs model. It entails planning, designing, and determining the tools, materials, and equipment required for the project's development. Fabrication and project construction are among the methods used in the process. Furthermore, during the project's execution, testing and assessment were carried out to ensure the project's functioning and efficacy. The output results from information flowing out of the processing system in the project (Naelga & Chavez, 2017).

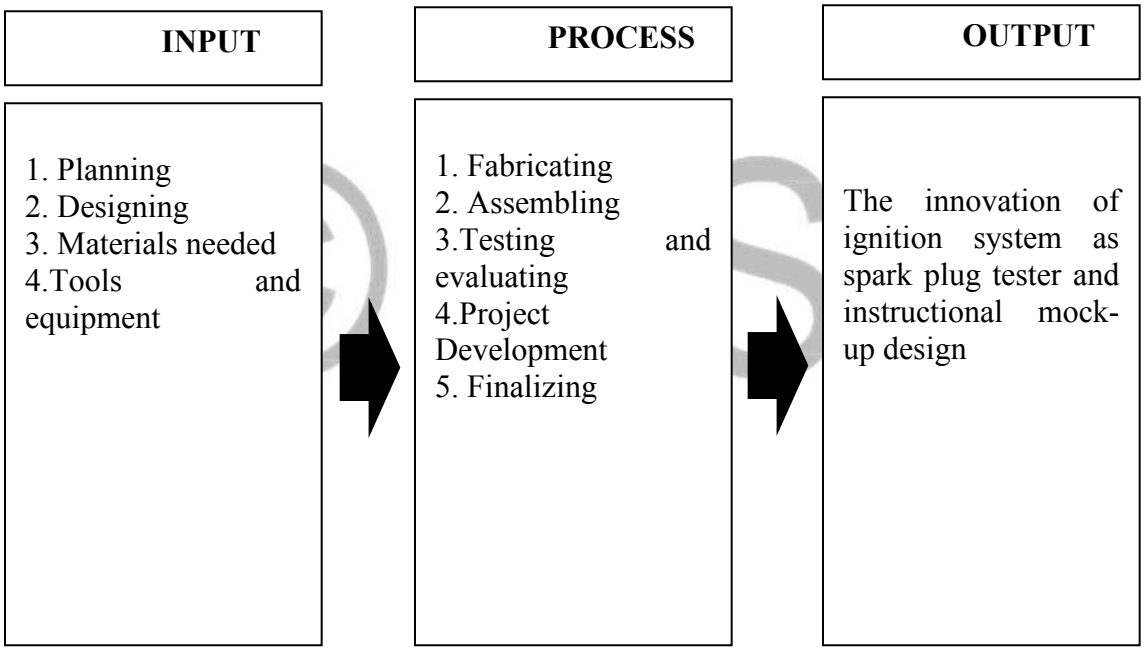

Figure 1. Paradigm of the Study

II. Method

2.1. Research Design

The study developed the automotive ignition system as a sparkplug tester and instructional mock-up design; the developmental research was applied. Developmental research is essential in the field of technology. According to (Richey & Klein, 2010) , the systematic study of creating, producing, and assessing instructional programs, processes, and products that must meet internal consistency and effectiveness criteria has been classified as developmental research, as opposed to simple instructional development.

Furthermore, the descriptive method was applied. The purpose of descriptive research is to define entities, events, or conditions by reviewing them as it is in nature. The researcher will not employ any of the variables but rather only describes the sample and the variables. Although a descriptive study can explore multiple variables, it is the only design that can also explore a single variable (Siedlecki, 2020).

The researcher will use a quantitative technique to research this study. Quantitative approaches are statistical and programming tools that assist decision-makers in solving various issues. These strategies use numbers, symbols, mathematical expressions, and other components of quantity as supplements to the decision makers' judgment and intuition. Quantitative methods, in other words, are procedures that offer decision-makers a systematic and powerful means of analysis based on quantitative data to gain predetermined goals (Dubey, Kothari, & Awari, 2016).

2.2 Project Design

This project's design and development are founded on the idea that design and development research is a practice (Richey & Klein, 2007) . It underlines the similarities between instructional design and scientific problem-solving techniques. In such a project, the researcher creates novel interventions as potential answers to real-world problems (Rothman & Thomas, 1994) . Designers use scientific methodologies to aid their understanding of the design and development process throughout the design and development process (Richey & Klein, 2007).

This Illustration in figure 2.2.2 discusses the block diagram and flow of the system. First, the supply for the AC motor is alternating current to rotate the crankshaft gear connected to the camshaft gear and the distributor shaft using a timing belt. Then, the primary voltage source is the battery for the ignition system. Turn on the Ignition Switch during the rotation of the distributor; this is to build up the magnetic field to the primary windings of the ignition coil. When the distributor assembly rotates the distributor, the reluctor teeth pass by the igniter of the distributor, the magnetic field will collapse, and the magnetic field will transfer to the secondary winding. The high Surge of voltage will flow to the High tension wires to the Sparkplug.

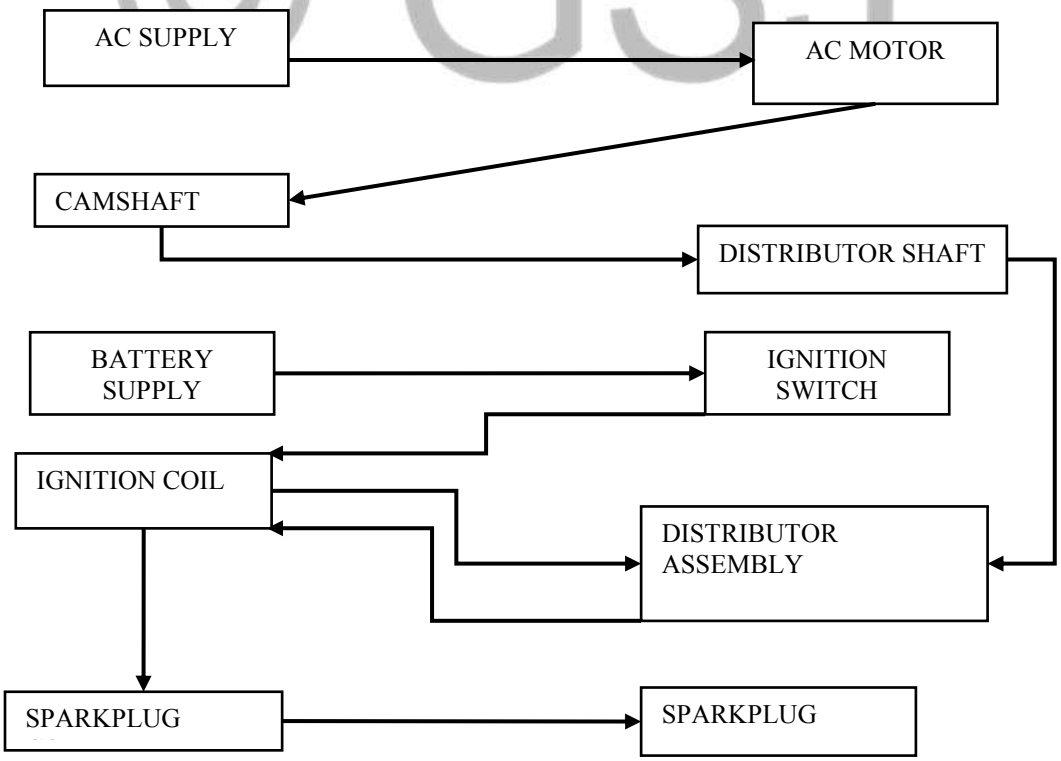

Figure 2. Project Design Block Diagram

2.3 Project Development

The first phase was project development and collecting data and references from past research about this product to see if we could continue developing the product. The researchers listed a set of materials needed and canvass the materials to be used. After that, the researchers agreed to purchase the components and construct them. Subsequently, we check the circuit connection and troubleshoot how the product operates formerly and operates as expected. We finalize it and then finish the product.

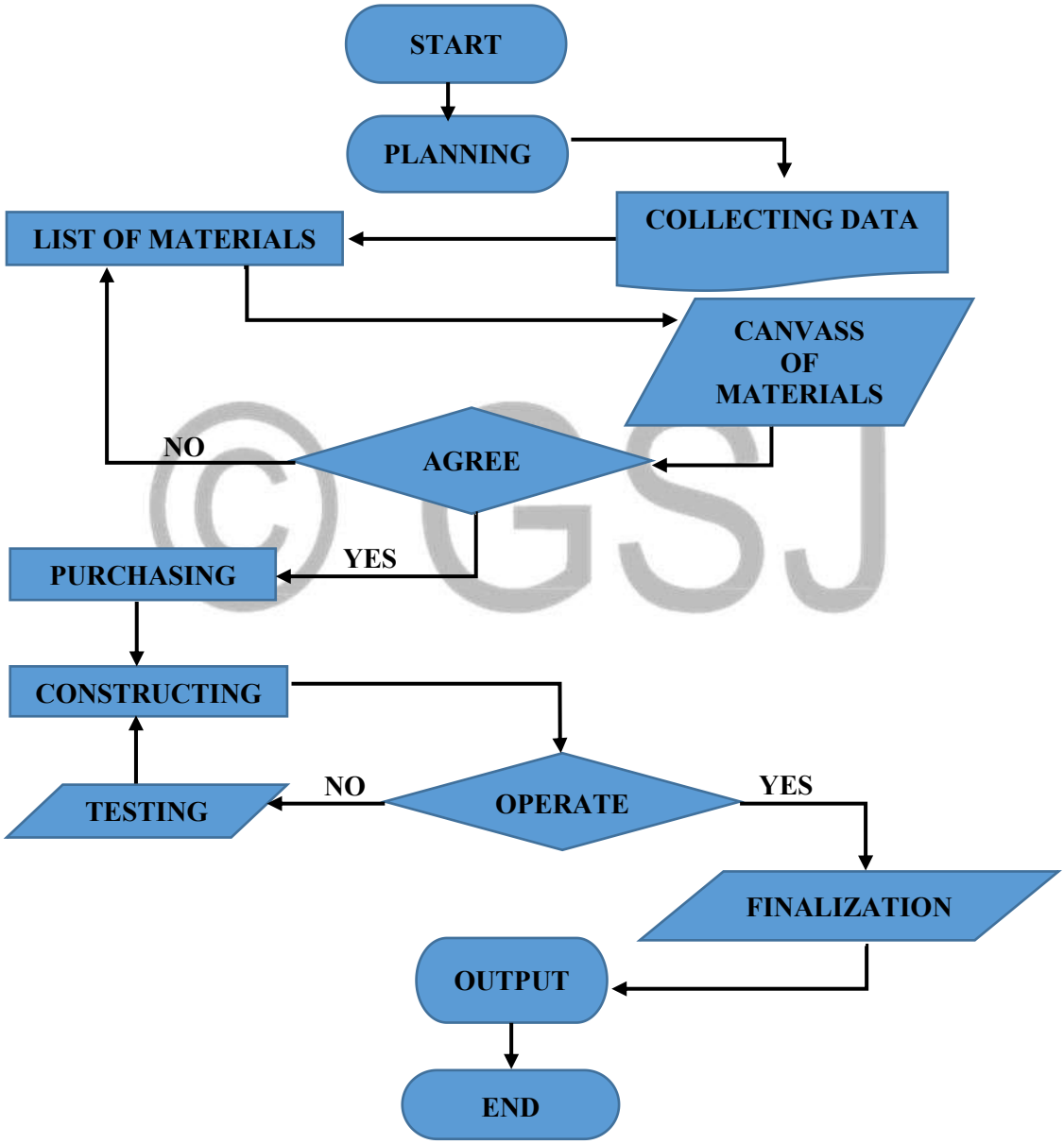

Figure 3. Project Development Flow Chart

2.4 System Design

Bench Table

The Bench Table is designed to meet the technical requirements of competition. The objective of the Bench Table is to encapsulate all components of the Ignition System. (Johnson, Kumar , Praneeth, & Kola, 2017) Stated in their study that the principle aspects measured during the design process is the safety, positioning of different components, Structural weight, and Operator ergonomics. The priority of the design is safety; analysis is done after the design to ensure that the objective is met.

AC Induction Motor

When an electrical electrode is placed in a rotating magnetic field, the electromotive force induces across the conductor, which is known as electromagnetic induction. It is used to drive the camshaft, which is coupled to the distributor gear (Circuitglobe.com, n.d.).

Ignition Switch

When the key is pressed, the ignition switch activates the voltage from the battery to the ignition coil, which ignites the engine. The spark plugs receive the engine spark from the coil or coils, which ignites the fuel and allows the car to run (Nora, 2021).

Distributor Assembly

The ignition coil delivers voltage to the spark plugs through the distributor. The rotor and cap are the two main components of the distributor, with the former spinning inside the latter. The output connections are located on the cap (Seniorcare2share.com, n.d.).

Ignition Coil

To create the high voltage required to produce a spark at the spark plug to ignite the combustible mixture.

Sparkplug Chord

Carry the high-voltage electricity produced by the ignition coil to the terminal of the spark plug. Once at the plug, the electricity travels to the other end of the plug, and jumps a gap between electrodes to produce the "spark" that ignites the fuel mixture.

Sparkplug

The spark plug is linked to the high voltage produced by an ignition coil, electricity flows from the coil, and a voltage differential occurs between the spark plug's center electrode and the ground electrode (Scraba, n.d.)

Camshaft

A camshaft is a rod that revolves and slides against machinery to convert rotational motion into linear motion. As the camshaft is pushed by the machinery, it moves further and further away from the axis of rotation, resulting in a change of motion (Afework, Jenden, Kosasih, Logan, & Donev, 2018)

Fuse

Electrical safety device that provides over-current protection to the functional electrical circuit, It'll prevent short circuits to avoid any accident.

2.5 Testing and Operating Procedure

2.5.1 Operating Procedure

In this stage, the researchers will discuss how to operate the innovative sparkplug tester so that they can achieve the desired control output.

1. Turn on the switch for the AC motor to rotate the distributor Shaft.
2. Turn on the ignition switch to supply voltage to the distributor Assembly
3. Insert the sparkplugs into the high tension wire.

2.5.2 Testing Procedure

In this procedure, the researchers use the multi-tester to check the Resistance of every Sparkplugs and visual check to determine the right Spark Quality Output.

1. Test the output voltage of the Battery.
2. Test the output voltage of the ignition coil.
3. Test the output voltage of Sparkplug.

2.6 Project Evaluation

In this phase, Innovative Sparkplug Tester will be evaluated using the following criteria:
As to reliability – evaluation of the system in terms of operational capacity to perform its task.
The Parameter to be measure is testing its reliability in terms of:

1. Spark Test of the sparkplug #1 in every 10 seconds for 10 trials within 2 Minutes.
2. Spark Test of the sparkplug #2 in every 10 seconds for 10 trials within 2 Minutes.
3. Spark Test of the sparkplug #3 in every 10 seconds for 10 trials within 2 Minutes.

As to accuracy – evaluation of the system in terms of resistance measurement of the sparkplugs.
The parameter to be measure is testing its accuracy in terms of:

1. Resistance measurement of sparkplug #1 using multi-tester.
2. Resistance measurement of sparkplug #2 using multi-tester.
3. Resistance measurement of sparkplug #3 using multi-tester.

As to validity- evaluation of the system in terms of rpm measurement of the Distributor
The parameter to be measure is testing its validity in terms of:

1. Rpm measurement trial of distributor in every 30 seconds with the interval of 1 minute for 10 trials.

As to functionality – evaluation of the system in terms of its functionality.
The parameter to be measure is testing its functioning in terms of:

1. Can this sparkplug tester be easy to operate to control.
2. Can this sparkplug tester check the sparkplug spark output.
3. Can sparkplug tester determine the condition of the sparkplugs.

As to its overall impression – in terms of usefulness of the system in a certain area.

2.7 Statistical Treatment

The tool used to determine the project's effectiveness was the survey questionnaire, according to (Roopa & Rani, 2012) A questionnaire is a list of mimeographed or printed questions filled for a respondent to provide his opinion,' according to the definition. The most common method of gathering primary quantitative data is through a questionnaire. A questionnaire allows for the collection of quantitative information standardized, resulting in data that is internally consistent and coherent for analysis. In the study of (Jansen & Warren, 2020) stated that statistical analysis methods are the engine that drives quantitative analysis, and they can range from simple computations to complex calculations that express data in numbers. (Elliott, 2021) Explained that viewing top-level findings with descriptive statistics like mean, median, and mode is often the initial step in studying a data set.

III. Results and Discussions

The results and findings of the study was presented step by step. It includes presentation of data gathered by the researchers on how to use different instruments to measure and evaluate how the project works. The following sections will describe and discuss the said project.

3.1 Project Description

3.1.1 Project Description

The Innovative Sparkplug Tester is a system for testing the spark quality output of the sparkplug that is convenient to use by the instructors and students. Below is the discussion of features of the Innovative Sparkplug Tester.

3.1.2 Project Structure

One of the essential aspects of a research paper was the project structure, considering the general information of the research.

3.1.3 Project Appearance

An innovative sparkplug Tester for testing spark output is made up of plywood coated with black paint; aside from that, the frame is made up of an angle bar and square bar to have a strong foundation; it is built using welding. We use screws and bolts to fix and combine all parts. The design was crafted using the existing outcome of the project is illustrated below.

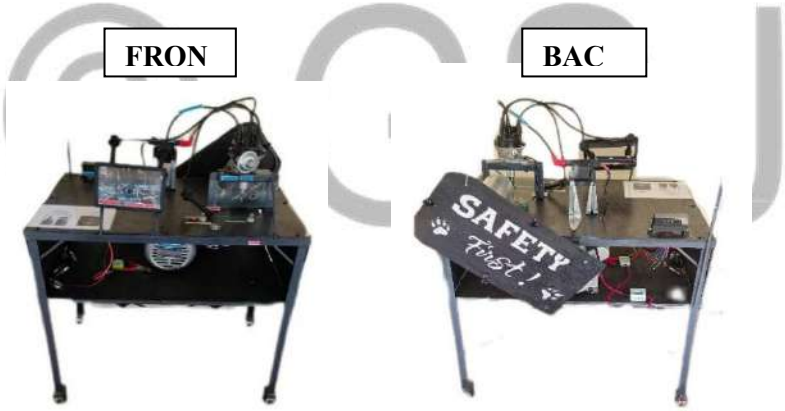

Figure 4. Project Appearance

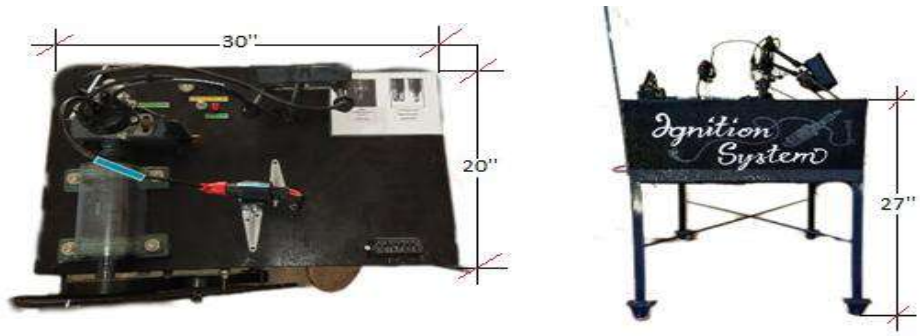

Figure 5. Project Dimension

3.1.4 Specifications'

The following are the different specifications of the Innovative Sparkplug Tester Mock-Up.

The specification of AC Induction Motor:

- 1 horsepower (hp)
- 750 Watts
- 7.7 Ampere
- 220 Volts

The specification of Sparkplug Chord

- High Temperature Resistance Cable
- Low Voltage Resistance Cable

The specification of Ignition Coil.

- Secondary winding high Resistance
- Primary winding is made of coated copper wire

The specification of Sparkplugs.

- NGK Platinum BKR6A
- BOSCH Platinum FR8DPX Germany
- BOSCH Platinum WR8DPP30W China

The specification of Distributor Assembly.

- Transistorized switch
- Magnetic pick-up coil

3.1.5 Project Capabilities and Limitations

The prototype shows how to test and determine the spark quality output of the sparkplug. And also it is a prototype for instructional manual for students to easily understand when spark occur and what the right spark is should the sparkplug released to ignite combustible mixture. The following listed below are some capabilities and limitations.

Capabilities

- Can test multiple Sparkplug
- Can determine the right spark output of the sparkplug

Limitations

- Cannot be operated without AC and DC supply

3.2 Project Testing and Operational Result

Table 1. *Tests Results of the Output of the Components*

Components	Output Voltage
Battery	12 Volts
Ignition coil	35,880 volts
Sparkplug	35,880 volts

The researcher tested the output voltage of the battery 12volts, Ignition coil, and sparkplug. The output voltages of the ignition coil and sparkplug are computed using ohm's law.

OHM'S LAW
I = Ampere
V = Volts
R = Resistance

Given:
Battery = 12 volts
Ignition coil Primary winding resistance = 4.5 ohms
Ignition coil Secondary winding resistance = 11.96 ohm

To find the voltage output of the ignition coil, let's find first the ampere for the ignition coil by dividing the battery 12 volts to primary winding resistance 4.5 ohms.

$$\boldsymbol{I = \frac{V}{R} = \frac{12volts}{4.5ohms} = 2.66 \approx 3\ Ampere}$$

Since the result is 3 A, the researchers can now solve for the output voltage of the ignition coil by multiplying the amperes to secondary winding resistance.

$$\boldsymbol{V = IR = 3A \times 11,960\ ohms = 35,880\ Volts}$$

Since the result is 35,880 volts, the output voltage of the ignition coil is 35,880 volts.

3.3 Project Evaluation

Table 2. *Reliability Test Result of Sparkplug Tester*

Rating Scale		
Spark output Condition (in terms of color)	Performance Rating	Numerical Rating
Bluish in spark	Very good	3
Yellowish in spark	Good	2
White in spark	Poor	1

Table 3. *Rating Result*

Trials (In every 10 sec.)	Sparkplug #1 (Bad Condition)	Sparkplug #2 (Used)	Sparkplug #3 (Brand New)
Trial 1	1	2	3
Trial 2	1	2	3
Trial 3	1	2	3
Trial 4	1	1	3
Trial 5	1	1	3
Trial 6	1	2	3
Trial 7	1	1	3
Trial 8	1	2	3
Trial 9	1	1	3
Trial 10	1	2	3
Total	**10**	**16**	**30**

The following data in the table above will be used to get the mode of the three sparkplugs.

a. In Sparkplug #1 results 1,1,1,1,1,1,1,1,1,1, the number 1 occurs more in 10 trials. Thus 1 is the mode. Therefore, sparkplug #1 spark quality output is poor.

b. In Sparkplug #2 results 2,2,2,1,1,2,1,2,1,2 the number 2 occurs six times more than the other number. Thus 2 is the mode. Therefore, sparkplug #2 spark quality output is good.

c. In Sparkplug #3 results 3,3,3,3,3,3,3,3,3,3, the number 3 occurs more in 10 trials. Thus 3 is the mode. Therefore, sparkplug #3 spark quality output is very good.

Table 4. *Accuracy Test Result of Sparkplug Tester*

Sparkplugs	Resistance Ω (With the use of multi-tester)
Bad Condition	6000 ohms above
Used Sparkplug	5000 ohms
Brand new	4000 ohms

The researchers tested the resistance of the Bad condition sparkplug, used sparkplug, and brand new sparkplug by using multi-tester.

Table 5. *Validity Test Result of Sparkplug Tester*

Trials (for every 30 seconds)	RPM (±) as per actual running operation	Idle speed of an engine
	Distributor Assembly	
Trial 1	819 rpm	600-1000 rpm
Trial 2	811 rpm	
Trial 3	807 rpm	
Trial 4	824 rpm	
Trial 5	815 rpm	
Trial 6	818 rpm	
Trial 7	801 rpm	
Trial 8	822 rpm	
Trial 9	797 rpm	
Trial 10	804 rpm	
Total Average	**811.8**	

The researchers tested the revolution per minute (rpm) of the distributor assembly for 10 trials in every 10 seconds as shown above. The listed total average rpm of the Distributor Assembly reaches the standard RPM of an engine in today's generation.

Table 6. *Rating Scale for Functionality of the Sparkplug Tester*

Range	Adjective Rating
4.1-5.0	Very Satisfied
3.1-4.0	Satisfied
2.1-3.0	Neutral
1.1-2.0	Unsatisfied
0-1.0	Very Unsatisfied

Table 7. *Questionnaires Data Result for Functionality of the Sparkplug Tester Mock-Up*

Operation	Results	
	Range	Adjective Rating
Can this sparkplug tester is easy to operate and control?	4.2	Very Satisfied
Can this sparkplug tester check the sparkplug spark output?	4.5	Very Satisfied
Can a sparkplug tester determine the condition of the sparkplugs?	4.0	Satisfied

The respondents tested the operation of the product on how to operate the switching control, checked the sparkplug output, and also determined the sparkplug condition.

3.4 Scoring Procedure

Likert scale scoring procedure used in describing the data.

Table 8. *5points Likert Scale*

Scale	Range	Adjective Rating
5	4.1-5.0	Very Satisfied
4	3.1-4.0	Satisfied
3	2.1-3.0	Neutral
2	1.1-2.0	Unsatisfied
1	0-1.0	Very Unsatisfied

Table 9. *Distribution of the respondents based on student Major in Automotive Technology*

Faculty	Frequency	Percentage
Automotive students	10	100%
Electronic students	0	0
TOTAL	10	100%

Table 10. *Student Evaluation Result in Innovative Sparkplug Tester*

QUESTION	FREQUENCY					Mean Average	Verbal Rating
	Very Satisfied (5)	Satisfied (4)	Neutral (3)	Unsatisfied (2)	Very Unsatisfied (1)		
1	5	5	0	0	0	4.68	Very Satisfied
2	4	6	0	0	0	4.44	Very Satisfied
3	4	6	0	0	0	4.55	Very Satisfied
4	3	6	1	0	0	4.3	Very Satisfied
5	1	9	0	0	0	4.26	Satisfied
Weighted Average						4.45	Very Satisfied

Table 11. *Data Interpretation Based on Student Evaluation*

Students			
	Question	**Weighted Mean**	Description
1	What is your rating about the performance of Innovative Sparkplug Tester?	4.68	Very Satisfied
2	What is your rating on the safety measure of the Innovated Sparkplug Tester?	4.44	Very Satisfied
3	Rating on the Application of the Research in the Laboratory?	4.55	Very Satisfied
4	Rating in academic impact of an Innovated Sparkplug Tester?	4.3	Very Satisfied
5	Rating on the physical appearance of the Research?	4.26	Very Satisfied
	Total	4.45	Very Satisfied

The result of the evaluation implies that the innovative sparkplug tester has given good rating by the respondents from the students of Tagoloan Community College. The innovative sparkplug tester has proven and evaluated that it is well-functional and the operation is in good condition.

Faculty	**Frequency**	**Percentage**
Automotive Instructor	3	75
Electronic Instructor	1	25
TOTAL	4	100%

Table 12. *Distribution of the respondents based on the faculty*

QUESTION	FREQUENCY					Mean Average	Description
	Very Satisfied (5)	Satisfied (4)	Neutral (3)	Unsatisfied (2)	Very Unsatisfied (1)		
1	4	0	0	0	0	4.27	Very Satisfied
2	3	1	0	0	0	4.27	Very Satisfied
3	4	0	0	0	0	4.4	Very Satisfied
4	4	0	0	0	0	4.4	Very Satisfied
5	3	1	0	0	0	4.2	Very Satisfied
Weighted Average						4.30	Very Satisfied

Table 13. *Frequency Distribution result in Faculty Evaluation*

Table 14. *Data Interpretation Based on Faculty Evaluation*

	Faculty		Adjective
	Question	**Weighted Mean**	**rating**
1	What is your rating about the performance of Innovative Sparkplug Tester?	4.27	Very Satisfied
2	What is your rating on the safety measure of the Innovated Sparkplug Tester?	4.27	Very Satisfied
3	Rating on the Application of the Research in the Laboratory?	4.4	Very Satisfied
4	Rating in academic impact of an Innovated Sparkplug Tester?	4.4	Very Satisfied
5	Rating on the physical appearance of the Research?	4.2	Very Satisfied
	Total	4.30	Very Satisfied

Items 1, 2, 3, 4, 5 obtained the highest rating which means that the Sparkplug Tester has a good appearance & performance, thus it can also use by faculties in laboratory lectures which will provide more inputs to students for testing and diagnosing different spark quality output.

IV. Findings/Recommendations

4.1 Summary of Findings

Based on the functional testing and evaluation procedures performed by the researchers with the guidance of the adviser, the Innovative Sparkplug Tester was examined and listed below are the findings experienced by the researchers during the study.

a. Project Design
- The design was heavy and not portable for its size.
- The Sparkplug Tester uses battery as main source to operate the sparkplug tester.
- Also the sparkplug tester has a limit of 3 sparkplug chord terminals for testing.

b. Project Development
- The development of the study was not that really hard. But some difficulties were experienced during the canvassing of the materials because some Auto Shops do not have any stocks, and we also use surplus parts to minimize the cost of the project.
- Researchers also experienced difficulties in aligning of the camshaft gear and AC motor gear.

3. Project Evaluation
- During the testing and operating procedure, the researchers found out some problems. Such as, there was a misalignment on belt and distributor driveshaft gears.
- The design is slightly vibrating during operation.

4.2 Conclusion

The researchers thoroughly examined and reviewed the results of the study and come up with the following conclusions.

a. Project Design

In terms of the design, it was clearly stated that there were flaws and errors made but it does not totally affect the performance of the Sparkplug Tester. It was truly acceptable to the respondents and attractive by its appearance.

b. Project Development

In terms of developing the project, it was a total success. The steps that the researchers made were evenly best for the project. However, there were changes that were made during the development but it comes out that what the researchers done was good and for the betterment for the study.

c. Project Evaluation

In terms of evaluating the project, researchers conducted some testing to prove that the study was important and can be used for alternative way of testing sparkplug spark output.

4.3 Recommendations

For the next researchers, the following recommendations should be followed.

a. Project Design
- Try to innovate some new design that helps to properly arrange the wires and the position of components.
- Plan a design that can easily operate the switches.

b. Project Development
- Make sure of the measurements.
- As early as you can, canvass the available materials and buy it as soon as possible.
- Be careful of the components, some has a manufactures defect.
- Measure the exact alignment of the devices arrangement.

c. Project Evaluation
- Before operating make sure that the connections are properly connected to the parts of sparkplug tester.
- Before operating check the components if it is in good condition.
- Never switch on the sparkplug tester if the sparkplug is not installed.

- Never touch the sparkplug during the operation.

d. For further research

- Use genuine materials.
- Better to have a proper belt safety cover.
- Use inverter to convert the AC to DC supply.
- Better use DC motor instead of AC motor to easily connect from the battery.

V. References

Afework, B., Jenden, J., Kosasih, S., Logan, R., & Donev, J. (2018, September 3). *Energy Education*. Retrieved from energyeducation.ca: https://energyeducation.ca/encyclopedia/Camshaft

Britannica, T. (2013, February 19). *Editors of Encyclopaedia*. Retrieved from ignition system. Encyclopedia Britannica: https://www.britannica.com/technology/ignition-system

Bukoye, R. O. (2019). Utilization of Instruction Materials as Tools for Effective Academic Performance of Students: Implications for Counselling. *2nd Innovative and Creative Education and Teaching International Conference* (pp. 1-7). Niger State, Nigeria: Multidisciplinary Digital Publishing Institute.

Circuitglobe.com. (n.d.). *Circuit Globe*. Retrieved from Circuitglobe.com: https://circuitglobe.com/working-principle-of-an-induction-motor.html

Dubey, U., Kothari, D. P., & Awari, G. K. (2016). Quantitative techniques in business, management and finance: A case-study approach. *Taylor & Francis Group*, 503.

Elliott, R. (2021, January 21). *GeoPoll*. Retrieved from geopoll.com: https://www.geopoll.com/blog/quantitative-data-analysis/

Hanipah, H. B. (2013). Design And Development Of Portable Spark Plug Tester For Motorcycle User. *Universiti Teknikal Malaysia Melaka*, 1-8.

Jansen, D., & Warren, K. (2020, December). *Grad Coach*. Retrieved from gradcoach.com: https://gradcoach.com/quantitative-data-analysis-methods/

Johnson, J., Kumar , D. K., Praneeth, S., & Kola, Y. (2017). Design, modeling and development of a go-kart vehicle. *International Conference on Advances in Mechanical, Industrial, Automation and Management Systems (AMIAMS)* (p. 104). India: ResearchGate.

Naelga, A. D., & Chavez, R. M. (2017). An Innovation of Automotive Lighting System Trainer. *Journal pf Engineering And applied Sciences*(12), 9331-9336. Retrieved November 24, 2021

Nora. (2021, November 22). *Theinfinitekitchen*. Retrieved from Theinfinitekitchen.com: https://theinfinitekitchen.com/advices/what-is-ignition-switch-in-a-car/

Richey, R. C., & Klein, J. D. (2007). . Design and development research. *NJ: Lawrence Erlbaum*.

Richey, R. C., & Klein, J. D. (2010). *Design and Development Research.* New York: Lawrence Erlbaum Associates, Inc., Publishers. Retrieved January 26, 2022

Rivard, J. G. (1973). Closed-Loop Electronic Fuel Injection Control of the Internal Combustion Engine. *SAE Transactions, 82*(1), 30-46. Retrieved from http://www.jstor.org/stable/44716298

Roopa, S., & Rani, M. (2012). Questionnaire Designing for a Survey. *The Journal of Indian Orthodontic Society, 46*(3), 273-277.

Rothman, J., & Thomas, E. J. (1994). Intervention Research: Design and Development. *NY: Haworth Press Inc.*

Scraba, W. (n.d.). *Mobil*. Retrieved from Mobil.com: https://www.mobil.com/en/lubricants/for-personal-vehicles/auto-care/vehicle-maintenance/how-do-spark-plugs-work

Seniorcare2share.com. (n.d.). *SeniorCare2Share*. Retrieved from www.seniorcare2share.com: https://www.seniorcare2share.com/how-does-a-car-distributor-work/

Siedlecki, S. L. (2020). Understanding Descriptive Research Designs and Methods. *Clinical Nurse Specialist*, 8-12. doi:10.1097/NUR.0000000000000493

Stephen A. Adalikwu, I. T. (2013). THE INFLUENCE OF INSTRUCTIONAL MATERIALS ON ACADEMIC PERFORMANCE OF SENIOR SECONDARY SCHOOL STUDENTS IN CHEMISTRY IN CROSS RIVER STATE. *GLOBAL JOURNAL OF EDUCATIONAL RESEARCH*, 39-45.

Techopedia.com. (2017, June 9). *Techopedia.com*. Retrieved from www.techopedia.com: https://www.techopedia.com/definition/678/prototype

Tuimur, H. N., & Chemwei, B. (2015). AVAILABILITY AND USE OF INSTRUCTIONAL MATERIALS IN THE TEACHING OF CONFLICT AND CONFLICT RESOLUTION IN PRIMARY SCHOOLS IN NANDI NORTH DISTRICT, KENYA. *International Journal of Education and Practice*, 224-234.

Twinkl.com. (-, - -). *Twinkl*. Retrieved from Twinkl.com.ph: https://www.twinkl.com.ph/teaching-wiki/prototype