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Fabrication of a Motor Vehicle Ignition System Simulation Tool

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Abstract

The rapid development of technology has had a significant impact on innovations in learning media within the field of education, including practical activities conducted in the Thermal Laboratory of Politeknik Negeri Bandung. Learning about thermal engines, particularly gasoline engines, requires a thorough understanding of how the ignition system works. Until now, students have only received explanations through theory or videos, resulting in limited comprehension and insufficient stimulation for the development of practical skills. This study aims to develop a learning media in the form of an ignition system simulation tool for motor vehicles. This tool allows students to directly observe the ignition process, thereby enhancing their understanding and analytical abilities regarding the performance of the ignition system. The simulation tool was created using a DC motor as a substitute for engine rotation. The process of fabricating this simulation tool includes several stages, namely needs analysis, design, fabrication, and testing. The test results indicate that the DC motor in this simulation tool is capable of producing a maximum rotational speed of 3100 RPM, with a power requirement of 12 V and a current of 2 A. The spark produced at the spark plug appears blue and clearly visible, indicating that the tool can function optimally as an interactive learning media.

1 Introduction

The rapid development of technology today has had a tremendous impact on various aspects of life. One area where technology is developing is education (1)(2). Education has an important role in improving human resources. To improve human resources, it can be done by efforts to improve the quality of education. The success of achieving educational goals depends a lot on the quality of the implementation of the learning process (3–5). The success of the learning process can be influenced by the availability of adequate facilities in educational institutions, including facilities available in the laboratory [6][7].

In the learning process at the thermal laboratory of Politeknik Negeri Bandung about thermal machines, discussing how engine work, especially gasoline engines. One aspect of how a gasoline engines can work is that it requires an ignition system (8). So far, students have only been given discussion topics or videos about the ignition system. This causes students to tend to be limited to theory and unable to develop practical problem-solving skills.

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To overcome this problem, the fabrication of a motor vehicle ignition system simulation tool has become one of the promising solutions. The ignition system created is a conventional ignition system. Because the system structure is simple and the mechanical components are easy to see, and the conventional ignition system is easier to understand for the basic concept of ignition (9). By using simulator technology, students or learners can gain realistic practical experience without the need for an expensive physical component.

Several previous studies have shown that the use of learning media in the learning process can increase student motivation and activity in participating in learning (10–12). A study conducted by Alfian et al, highlighting the benefits of using combustion engine teaching aids as a learning media will make it easier for student to understand and learn about the working principles of such system (13). The trainer learning media was also developed by Yusuf et al by using learning media trainers can improve student learning outcome (14). According to Susanto's opinion, as cited in a study that the development of a fully transistor ignition system learning media can improve student achievement (15). This study aims to provide realistic experiences for students and also increase their motivation to learn, especially in ignition system practicums.

2 Research Methods

The research method used was the R&D method. This method aims to produce valid products, practical and effective through testing and refinement based on identified needs. This development method is commonly used in education and technology to create innovative new products and test their effectiveness before it is widely implemented.

This method was chosen because it aligns with the requirements for developing an ignition system simulation tool, which requires a systematic approach to produce a product that is effective, safe, and compliant with standards. The creation of this ignition simulation tool was carried out starting from requirement analysis, system design, tool fabrication, and testing stages, as illustrated in the flowchart in figure 1.

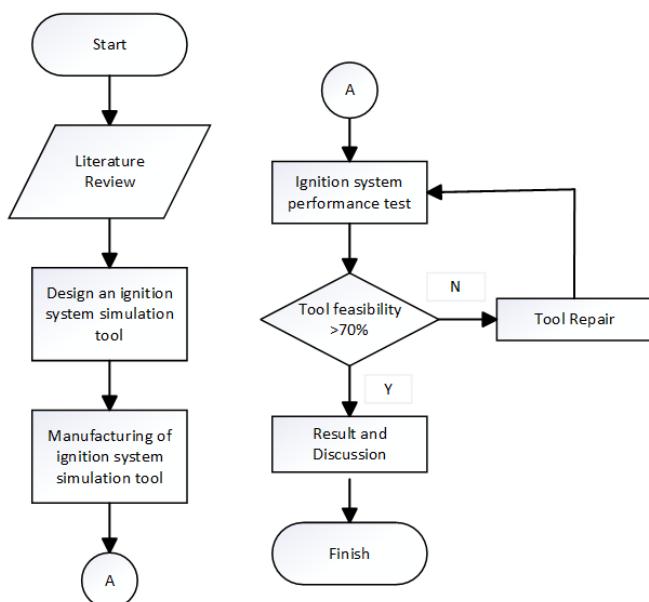


Figure 1. Flow Diagram of Fabrication of a Motor Vehicle Ignition System Simulation Tool

3 Result and Discussion

The fabrication of this tool began with the determination of design parameters based on direct field observations and a literature review concerning the requirements for laboratory-scale learning media. The aim of this device is to support the learning process on conventional ignition systems in motor vehicles.

3.1 Design

The design of this simulation tool is based on empirical field observations, with the aim of producing a simulation tool that meets both functional requirements and safety standards. The design results of the conventional motor vehicle ignition system simulation device are presented in Figure 2.

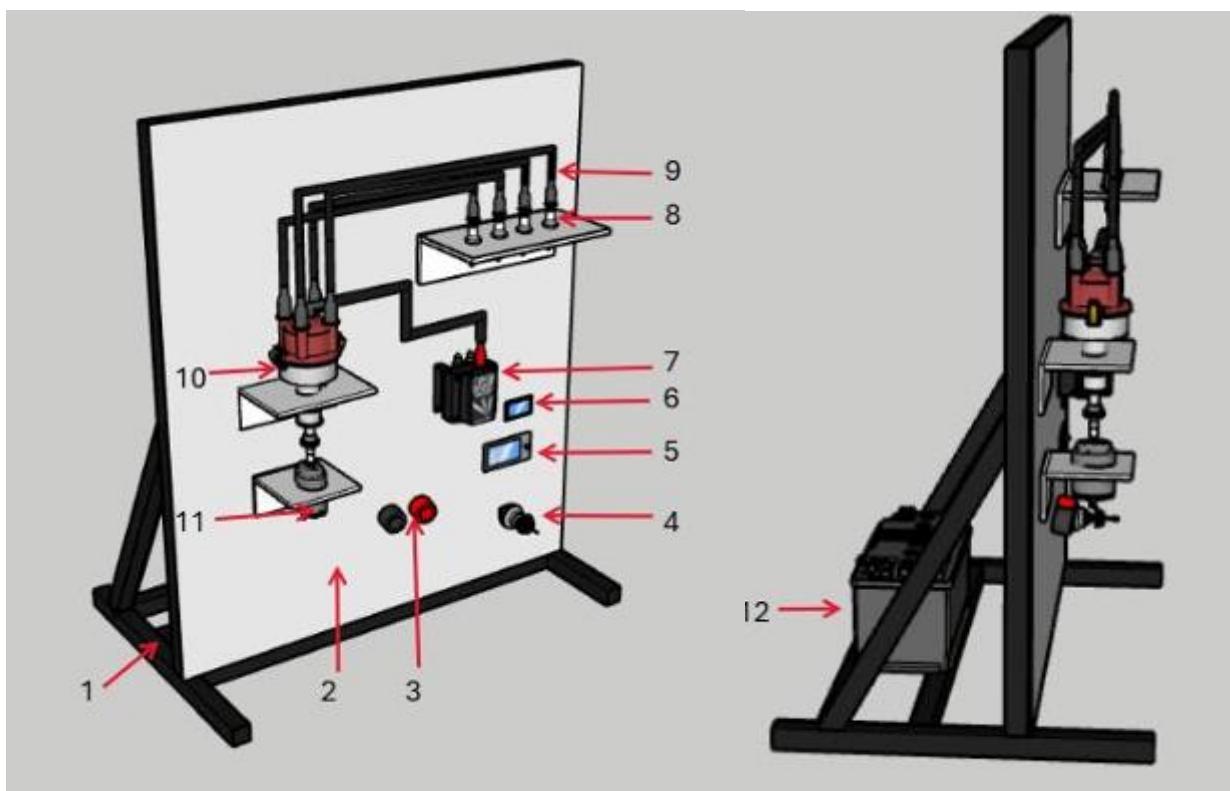


Figure 2. Design of a conventional ignition system simulation tool

Description:

1. Frame
2. Simulation panel
3. Binding post terminal
4. Ignition switch
5. Dimmer speed control
6. LCD
7. Coil
8. Spark plug
9. High voltage cable
10. Distributor
11. DC Motor
12. Battery

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The motor vehicle ignition system simulation tool is designed to be portable. During laboratory sessions, the device is placed on a table to ensure that the simulation process can be clearly observed. The dimensions of the device are 40 cm in length, 60 cm in width, and 72 cm in height. This conventional ignition simulation tool is also designed to allow students to directly observe the spark at the spark plug. The operating principle of the device is illustrated in Figure 3.

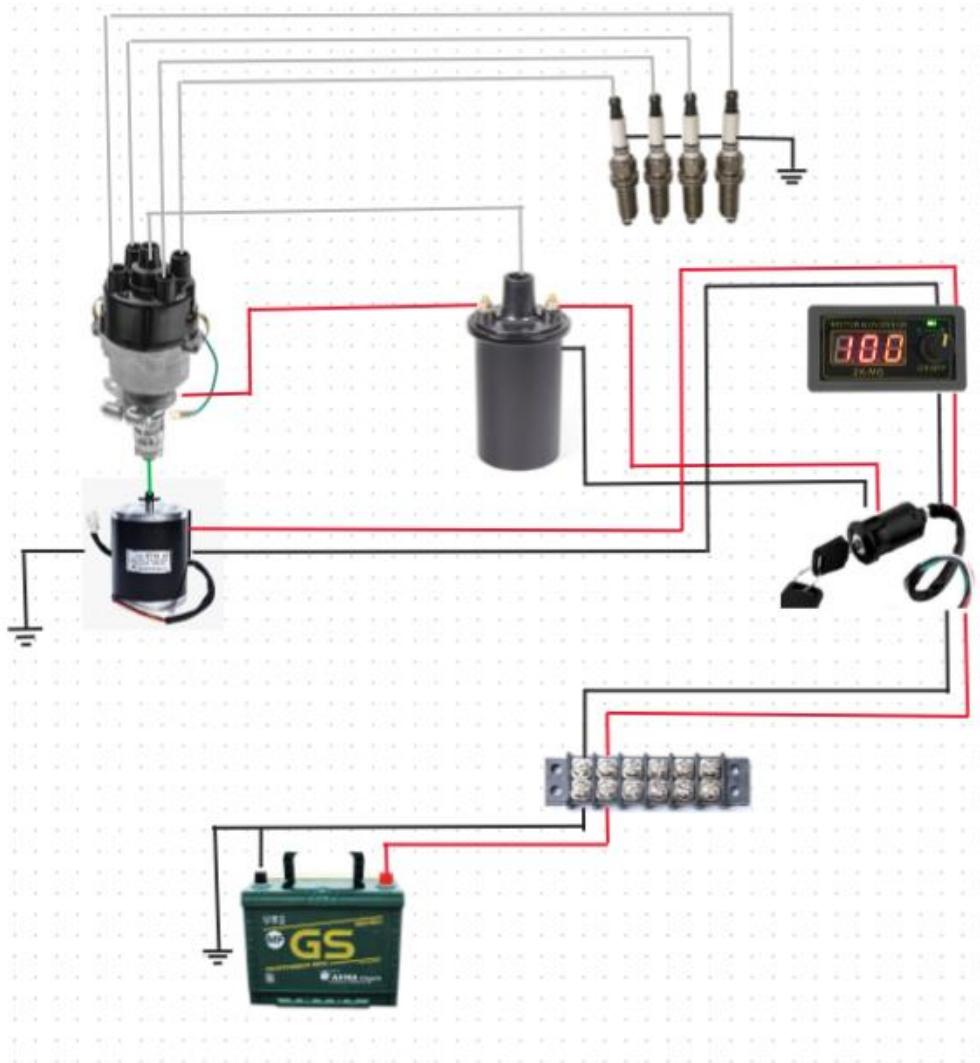


Figure 3. Design diagram of a conventional ignition system simulation tool

As shown in Figure 3, the ignition system simulation tool is powered by a 12V battery. This voltage supplies the entire circuit, including the ignition coil, ignition switch, and breaker point. To operate the ignition simulation tool, the ignition key is turned to the ON position. When the switch is in the ON position, electric current flows to the dimmer, DC motor, and coil. The dimmer is used to regulate the current intensity, allowing the user to adjust the motor's rotational speed as required. The motor's rotational speed directly affects the characteristics of the spark at the spark plug.

3.2 Fabrication process

The conventional ignition system simulation tool was fabricated to realize the results of the design. The fabrication process of the conventional ignition system simulation device is illustrated in Figures 4 and 5.



Figure 4. Ignition simulation tool frame



Figure 5. Ignition simulation tool panel instalation

The fabrication of the ignition simulation tool begins with the construction of the frame, followed by the fabrication of the panel and the painting process. Subsequently, the components of the ignition system simulation device are assembled, as shown in Figure 6.



Figure 6. Installation of ignition simulation tool components

3.3 Tool Testing

The completed ignition system simulation tool was then tested to evaluate its performance. The tests conducted included: DC motor rotation testing, battery power consumption testing, and the intensity of spark plug sparks against the variation in DC motor rotation testing.

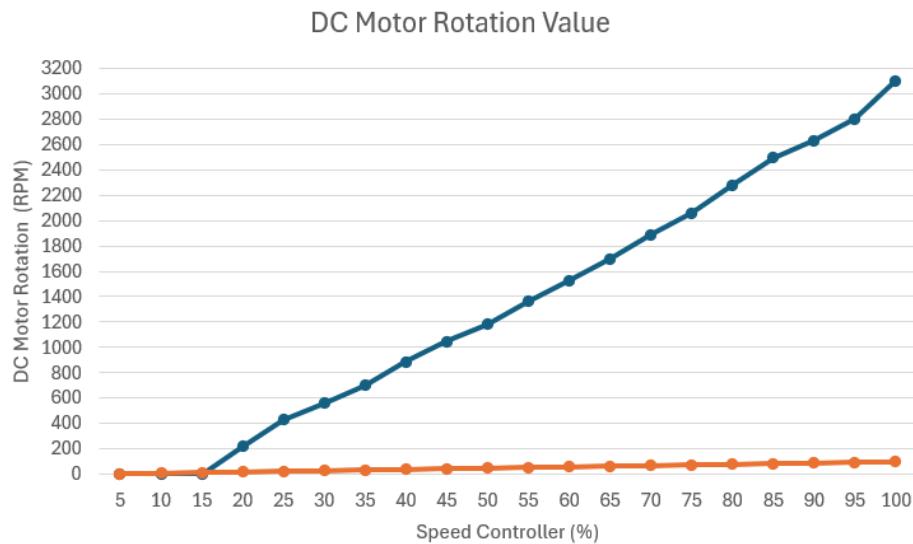
3.3.1 DC Motor Rotation Testing

In the ignition system simulation tool, a DC motor is used as a substitute for the internal combustion engine. A speed control device (dimmer) is employed to adjust the DC motor's speed as required. The data displayed on the speed controller screen is represented in percentage (%) values ranging from 0% to 100%. To determine the motor speed in revolutions per minute (RPM), measurements were taken using a tachometer. The testing method involved measuring the DC motor speed at every 5% increment of the speed controller setting. The results of the motor speed test are presented in Table 1.

As shown in Table 1, the lowest percentage value displayed on the speed controller's LCD is 5%, at which the DC motor does not operate. The motor begins to run when the speed controller is set to 20%, resulting in a motor speed of 220 RPM. Figure 7 illustrates that higher percentage values correspond to higher motor speeds. At the maximum percentage of 100%, the DC motor achieves a rotational speed of 3100 RPM.

Table 1. Motor rotation test

No	Speed Control (%)	RPM
1	5	0
2	10	0
3	15	0
4	20	220
5	25	430
6	30	560
7	35	703
8	40	886
9	45	1045
10	50	1181
11	55	1361
12	60	1526
13	65	1700
14	70	1890
15	75	2060
16	80	2280
17	85	2495
18	90	2630
19	95	2800
20	100	3100

**Figure 7.** DC motor rotation value graph

3.3.2 Battery Power Usage Testing

The battery power consumption test was conducted using the same procedure as the DC motor speed test. Battery power consumption data were recorded only after the DC motor speed had stabilized, with a time interval of approximately 3 minutes between measurements. As shown in Table 2, higher motor speeds require higher current. At 220 RPM, the current drawn is 0.9 A. Each increase in motor speed results in a corresponding increase in current. At the maximum speed of 3100 RPM, the current consumption reaches 2 A.

Table 2. Battery usage when the sistem is working

Speed Control	DC Motor Rotation	Battery			
		%	RPM	V	DC Motor Input Current(A)
5	0	12	0	0	0
10	0	12	0	0	0
15	0	12	0	0	0
20	220	12	0.14	0.9	
25	430	12	0.16	1.54	
30	560	11.8	0.2	1.61	
35	703	11.7	0.23	1.68	
40	886	11.7	0.27	1.74	
45	1045	11.7	0.33	1.80	
50	1181	11.7	0.42	1.85	
55	1361	11.7	0.47	1.91	
60	1526	11.7	0.54	1.94	
65	1700	11.7	0.61	1.98	
70	1890	11.7	0.68	2.04	
75	2060	11.6	0.71	2.09	
80	2280	11.6	0.78	2.12	
85	2495	11.6	0.8	2.18	
90	2630	11.6	0.82	2.22	
95	2800	11.6	0.91	2.24	
100	3100	11.6	1.01	2.29	

3.3.3 The intensity of spark plugs sparks againts the variation in DC motor rotation testing

Based on the test data presented in Table 3, it can be observed that increasing the motor speed causes the spark transition between spark plugs to become imperceptible, whereas at lower motor speeds, the spark at the spark plugs and the spark transition between plugs can be clearly observed. At 220 RPM, the spark at the spark plug is clearly visible because the motor speed is relatively low, allowing the spark transition from one plug to another to be observed. In contrast, at the maximum speed of 3100 RPM, due to the very high motor speed, the spark transition between spark plugs cannot be observed.

Table 3. Result of observations of spark plug sparks

Motor rotation (RPM)	Sparks	Displacement of sparks between spark plug
220	Looks very clear	Visible
430	Looks very clear	Visible
560	Looks very clear	Visible
703	Looks very clear	Visible
886	Looks very clear	Visible
1045	Clearly visible	Visible
1181	Clearly visible	Visible
1361	Clearly visible	Visible
1526	Clearly visible	Looks less clear
1700	Clearly visible	Looks less clear
1890	Clearly visible	Looks less clear
2060	Clearly visible	Looks less clear
2280	Looks less clear	Looks less clear
2495	Looks less clear	Not visible
2630	Looks less clear	Not visible
2800	Looks less clear	Not visible
3100	Looks less clear	Not visible

4 Conclusion

The fabrication of the conventional ignition system simulation device resulted in an effective and safe learning medium for understanding the working principles of gasoline engine ignition. Based on the conducted tests, the simulation device functions properly and can be used as a clear visual demonstration tool. By using this device, users can directly observe the spark generation at the spark plug and also see the changes in spark behavior caused by variations in motor RPM. The presence of this device makes the learning process more practical, as it doesn't require the use of an actual vehicle engine.

The lowest DC motor speed in this simulation device is 220 RPM, while the maximum speed reaches 3100 RPM. To achieve the lowest speed of 220 RPM, the dimmer knob is adjusted until the percentage displayed on the LCD screen reaches 20%. To achieve the maximum speed of 3100 RPM, the dimmer knob is set to 100%. At a DC motor speed of 220 RPM, the spark transition between spark plugs is clearly visible due to the relatively low speed, whereas at 3100 RPM, the spark transition between spark plugs cannot be observed due to the very high speed. The current required to reach 3100 RPM is 2 A, while 0.9 A is required to achieve 220 RPM.

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