DESIGN AND CONSTRUCTION OF ELECTRICAL SYSTEM TRAINERS HONDA BEAT MOTORCYCLE

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Abstract. *The development of automotive technology demands the availability of relevant and applicable learning media, especially in understanding motorcycle electrical systems. This study aims to develop a Honda Beat motorcycle electrical trainer as a practical medium for Mechanical Engineering students. The method used is the research and development method (R&D) to produce learning aids that suit the needs of practical learning. This trainer integrates the main motorcycle electrical systems, such as ignition, starter, lighting, and signals. Test results show that all components function properly and the system voltage is in the range of ±12 volts. Validation against several previous studies shows that this trainer is in accordance with the technical specifications of the Honda Beat motorcycle and is suitable for use in automotive engineering learning. Thus, this trainer can increase the effectiveness of the practical learning process of electrical systems in the field of Mechanical Engineering.*

Keywords: *Development; Educational Trainers; Electrical Systems; Mechanical Engineering Motorcycles.*

1. INTRODUCTION

Technological developments in the automotive sector have brought significant changes to motorcycle electrical systems, from conventional systems to more complex and integrated systems. One example is the use of an electronic fuel injection (FI) system on the Honda Beat motorcycle, which requires a deep understanding of the working principles and interconnections between electrical components. Understanding electrical systems is a fundamental aspect of mechanical engineering, especially in the automotive realm, because it directly affects vehicle performance, efficiency, and safety (Eliza et al., 2024).

In the context of higher education, particularly in Mechanical Engineering programs, students' ability to understand and analyze vehicle electrical systems still faces several challenges. One of the main challenges is the limited availability of practical learning media capable of representing the real-world conditions of modern motorcycle electrical systems. (Akhmadi & Suprihadi, 2020) Learning processes that rely solely on theoretical approaches or two-dimensional visualizations are considered ineffective in providing students with practical and comprehensive understanding. This results in low technical skills in the diagnosis, maintenance, and analysis of motorcycle electrical systems.

To bridge the gap between theory and practice, a learning tool in the form of an electrical system trainer designed to mimic actual vehicle conditions is needed. The trainer must be able to present a realistic arrangement of electrical components, current flow paths, and allow for safe and controlled simulation of faults or testing of component functions. Using the trainer, students are expected to more easily understand the working concepts of electrical systems, improve analytical skills, and gain a more contextual and applicable learning experience (Chadry et al., 2023).

This research aims to design and build a motorcycle electrical system trainer based on the Honda Beat Fuel Injection type, which complies with the manufacturer's standard configuration. The design was carried out by considering aspects of functionality, safety, and effectiveness as a learning medium in an engineering education laboratory

environment. With this trainer, it is hoped that it can support a more interactive learning process, improve students' technical competence, and contribute to the development of practice-based engineering education methods (Fadhilah & Intan, 2022).

2. LITERATURE REVIEW

2.1 Need for Visual and Interactive Learning Media

When teaching the Honda Beat motorcycle's electrical system, a theoretical approach is often insufficient to provide students with a comprehensive understanding. The concepts of electrical flow, the relationships between components, and how the electrical system works require a visual and interactive approach to facilitate comprehension. Therefore, the use of media such as indicator panels, LED lights, and electrical diagrams is very helpful in conveying material concretely and increasing student engagement during the learning process (Ariyanto, 2024).

2.2 Motorcycle Electrical System Trainer

The Honda Beat electrical system trainer was developed as a learning tool that represents the real-world conditions of a motorcycle's electrical system. This trainer allows simulations of various conditions, such as component testing, electrical faults, and analysis of system response to damage. The use of this trainer has proven effective in improving students' practical skills and providing a deeper understanding of modern electrical systems (Hendra et al., 2023).

2.3 Honda Beat Motorcycle Electrical System

The Honda Beat's electrical system consists of five main subsystems: the ignition system, charging system, lighting system, signal system, and starter system. These five systems are integrated and function to generate, store, and distribute electrical energy to all motorcycle components efficiently and safely (Fitriyanto et al., 2023).

2.4 Ignition System

The Honda Beat uses a CDI ignition system that generates sparks for combustion in the engine's combustion chamber. This system is designed to provide precise and efficient ignition timing, thereby improving engine response and overall vehicle performance (Sukirno, 2018).

2.5 Charging System

On the Honda Beat, the charging system uses an alternator combined with an ACG starter. Mechanical energy from the engine is converted into electrical energy, then channeled to the regulator for adjustment and storage in the battery. This system ensures a stable power supply while the engine is operating (Rifdarmon, 2018).

2.6 Starter System

The Honda Beat is equipped with an electric starter system using an ACG starter, which eliminates the need for a conventional starter motor. This system utilizes battery power to start the engine smoothly and efficiently. A kick starter is also available as a backup for easy starting in an emergency.

2.7 Lighting and Indicator Systems

The Honda Beat's lighting system includes headlights, brake lights, turn signals, and an indicator panel. All these components play a crucial role in providing lighting and visual signals to the driver and other road users. This system is designed for energy efficiency and is equipped with safety features to prevent problems such as short circuits or excessive current (Rahman Sembiring et al., 2024).

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3. RESEARCH METHODS

This research used engineering research methods focused on the design and construction of a Honda Beat motorcycle electrical system trainer as an interactive learning medium. The research was conducted in the Mechanical Engineering Laboratory from April to July 2025. The research stages can be seen in the flowchart Figure 1.

Figure 1. Flow diagram

1. Start

T The research began by determining the topic, main objectives, and scope of the project to be developed. The focus was to design and create an electrical system trainer representing the essential components of a Honda Beat motorcycle so that it could be used as an effective learning medium.

2. Problem Identification

At this stage, existing problems in the field are identified, particularly in the learning process of motor vehicle electrical systems. Generally, students only receive theoretical material without the support of representative practical media. This hinders a comprehensive understanding of the concept of electrical flow, the relationships between components, and how the system works. Therefore, trainer-based learning media that are realistic, safe, and easy to understand are needed.

3. Study Literature

This stage involves gathering information from various sources, such as books, scientific journals, Honda Beat service manuals, and references related to ignition, charging, starting, lighting, and indicator systems. The goal is to gain a thorough technical understanding of the Honda Beat motorcycle's electrical system and how it can be applied to the training medium.

4. Design

At this stage, trainer design is carried out systematically and structured.

a. The visual and mechanical designs were created using SolidWorks CAD software, which allows for the creation of realistic three-dimensional models of the trainer panels, including component placement, panel dimensions, and cable routing.

b. The electrical design is based on the original Honda Beat wiring diagram. The component connections and current paths are designed to closely mimic the actual vehicle system, while maintaining safety and ease of use during the learning process.

5. Trainer Fabrication

Based on the design, the trainer is then built by assembling original components such as the CDI, lights, switches, relays, and cables into a pre-designed panel. The work is carried out in stages and meticulously to ensure accurate positioning, strong connections, and the equipment's aesthetics and safety.

6. Testing and Validation

After the device was completed, comprehensive testing of all electrical system functions was conducted: ignition, charging, starting, and lighting. In addition to technical testing, validation of the design and device results was conducted by comparing them with relevant previous research. This validation aims to ensure that the function, structure, and effectiveness of the trainer comply with proven practice standards for improving learning quality.

7. Conclusion

Based on the design, manufacturing, and testing processes, it was concluded that the Honda Beat motorcycle electrical system trainer was successfully constructed and functions as intended. The design created with SolidWorks facilitates visualization and

assembly, while validation through comparison with previous research indicates that this trainer is suitable for lecture needs. This trainer can be used effectively as a practical medium to improve students' technical understanding.

4. RESULTS AND DISCUSSION

4.1 Result

The development of automotive technology demands a practical medium that can connect theory and field application, especially in learning the increasingly complex motorcycle electrical system. To address this challenge, a Honda Beat motorcycle electrical system trainer was designed as a practical learning tool that can represent the vehicle's electrical system realistically and functionally in a mechanical engineering laboratory environment. This trainer is designed to display the main electrical subsystems such as ignition, charging, starter, lighting, and signaling.

The construction of the trainer begins with the visual and structural design using CAD software. The panel design is arranged vertically on a work panel mounted on a metal frame. Figure 2. This design shows the arrangement of the Honda Beat's electrical components mounted on a flat surface that is ergonomic and easily accessible during the learning process. Each component position in the design is determined based on ease of practice, electrical circuit flow, and path readability.

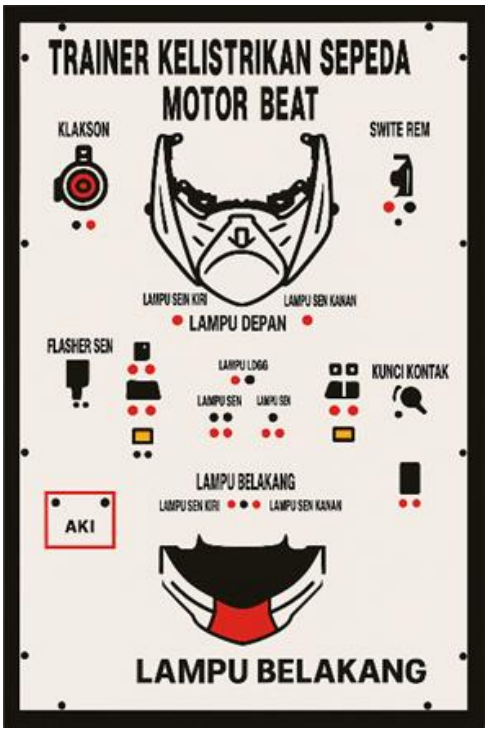

Figure 2. Trainer Design

After the design process is complete, an analysis of the electric current flow path in the motorcycle's electrical system is carried out. Electric current comes from the main power source, namely the battery with a nominal voltage of 12 volts, which is then channeled to the ignition system through the main switch (ignition key) and control components such as the CDI (Capacitor Discharge Ignition). The CDI plays an important role in producing sparks on the spark plug electrodes when the engine is started. Simultaneously, electric current also flows to the charging system, where the alternator produces alternating current (AC) which is then rectified into direct current (DC) by the regulator/rectifier to recharge the battery.

In the lighting and indicator system, electric current is distributed through special switches and relays, which then activate the headlights, turn signals, brake lights, and

indicators on the instrument panel. The wiring is systematically designed and color-coded to facilitate tracking of current distribution, allowing students to fully understand the relationships between electrical subsystems and the working principles of each component.

The trainer panel design developed is a visual representation of the electrical system of an injection-type Honda Beat motorcycle. This trainer is designed based on illustrations of the actual motorcycle body shape, both front and rear, to improve the connection between theory and field application. This panel is equipped with main electrical components such as the battery, ignition, horn, flasher, lighting system, signal system, and brake switch, which are positioned based on an ergonomic layout and in accordance with the structure of the original vehicle.

Each connection line between components is equipped with terminal markers (red and black) that represent the positive and negative poles. This system also allows for interactive simulation of electrical current flow: when the ignition is activated, electric current flows throughout the system such as the horn, turn signals, headlights, and the brake system. The switches available on the panel allow users to operate electrical components as in real conditions, while the turn signal flasher functions to create a flashing pattern on the turn signal automatically.

The trainer frame construction begins with the procurement of the main material in the form of Hollow Structural Section (SHS) steel measuring 25 x 25 mm with a thickness of 2 mm. The steel components are cut according to the design dimensions, then connected using a welding process to form the main frame Figure 3. After the fabrication process is complete, the entire surface of the frame is coated with anti-rust paint as a protection against corrosion and to increase the structure's durability to the environment.

Figure 3. Frame Welding

A plywood panel is installed as the main work surface in Figure 4, which houses all electrical components. The component arrangement considers ergonomic factors, ease of reading the circuit schematic, and user safety.

Figure 4. Trainer frame and panel assembly

Next, the electrical component assembly process is carried out, where components such as CDI, spool, ignition coil, regulator, switch, lights, and cables are assembled systematically based on the predetermined layout in Figure 5. The cable path is tidied up using a cable holder, and is labeled and given different color codes to differentiate the function of each circuit.

Figure 5. Trainer Results

After the trainer was completed, a functional test of the electrical system was carried out using a digital multimeter (Figure 5). The test included measuring the battery voltage, the output voltage from the regulator/rectifier, and verifying the function of the ignition, starter, lighting, and signal systems. The measurement results showed that the system voltage was in the range of ±12V and the entire circuit functioned properly according to

the technical specifications of the standard Honda Beat motorcycle electrical system.

Based on testing results using a digital multimeter, the battery voltage showed a stable value within ±12 volts under no-load conditions. This value indicates that the voltage source has met the minimum operational limits for reliable operation of other electrical components. This voltage stability also indicates that there are no internal faults in the energy storage system, such as excessive internal resistance or polarity mismatch.

After that, the output voltage of the regulator/rectifier, which is a crucial component in the charging system, was verified. The regulator functions to stabilize the alternator output voltage (ACG) and convert it to direct current (DC) which is used to recharge the battery and supply other loads. The measurement results show that the regulator output voltage is in the range of ±12 volts, in accordance with the operational range of the Honda Beat motorcycle charging system. This indicates that the current rectification process is running effectively and there are no indications of overvoltage or undervoltage that could risk the integrity of electronic components.

Testing the function of the ignition system, which consists of the CDI (Capacitor Discharge Ignition), ignition coil, and spark plug. When the ignition key is positioned in the ON mode and the starter button is activated, current flows from the battery to the CDI, which then regulates the timing of the high-voltage current discharge to the ignition coil. This coil then induces voltage to the spark plug electrodes, creating a spark. Observations show that the spark produced is consistent and at a frequency that matches the engine cycle, indicating that the ignition system is working functionally and is not experiencing problems.

In the starter system, verification is performed by observing the operation of the starter motor, which is activated via the starter switch and starter relay. Activation of this system demonstrates a quick response and a normal starter motor rotation sound, indicating there are no mechanical obstructions or high contact resistance in the electrical path.

For the lighting and signaling system, testing was conducted on the headlights, side lights, brake lights, and left and right turn signals. All components light up as intended when their respective switches are activated. The flasher unit integrated with the turn signal system also produces a stable flashing rhythm and meets the standard flashing frequency (±85 flashers/min), indicating that current is flowing properly and there is no significant voltage loss in the distribution line.

Additionally, all cables on the trainer panel are neatly arranged using cable holders and labeled for easy tracking during testing. The ergonomic component layout also facilitates visual verification of current flow and voltage distribution.

Overall, the test results show that the entire electrical trainer circuit works according to the technical specifications of the Honda Beat motorcycle's electrical system. The system voltage is distributed stably, and all functional electrical components demonstrate optimal performance. The success of this test confirms that the developed trainer has fulfilled its educational function as a comprehensive and applicable simulation and learning tool for motorcycle electrical practice.

4.2 Validation of results

Test results on the developed Honda Beat motorcycle electrical trainer demonstrated system performance that meets the vehicle's technical specifications. Battery voltage measurements showed a stable value within ±12 volts, and key systems, such as ignition, starter, lighting, and signals, functioned normally and responsively. To ensure the validity of these results, validation was conducted by comparing them to several relevant previous studies from the past five years.

Research conducted by Regia, Mukhnizar, and Abu (2023) in the journal Motivation shows that the ignition and fuel injection system on the Honda Beat PGM-FI motorcycle exhibits current and voltage stability within specifications, with controlled current distribution from the CDI to the ignition coil and spark plug. This research confirms our test results, which show that when the starter button is activated, the ignition system produces a consistent spark and matches the combustion rhythm, without voltage

interruption or power loss.

Furthermore, validation from research conducted by Mudana (2023) shows that the use of a Honda Beat FI electrical trainer in learning activities can improve students' understanding of electric current distribution, electrical components, and system voltage values. The measurement results in his study also showed that the motorcycle's electrical system works optimally with a voltage in the range of 12.4 – 12.8 volts. This is very much in line with the findings from our trainer testing, where the lighting system, brake lights, and signals functioned well when tested directly through their respective switches.

Furthermore, research by Putra and Warju (2020) stated that the Honda Beat PGM-FI electrical system trainer is suitable as a learning medium because all components such as the CDI, ignition coil, regulator, switches, and lights can be assembled and tested according to the actual working conditions of the vehicle. The researchers also emphasized the importance of ergonomic component layout and clear cable marking, two aspects that were also considered in the design and testing of our trainer. The logical component position and the labeled and color-coded cable system proved to facilitate the process of identifying and tracking currents during testing.

Based on these three sources, it can be concluded that the test results of the Honda Beat motorcycle electrical trainer developed have been validated theoretically and empirically. The suitability of the voltage value, system function, and ergonomic design applied has been proven through literature reviews and direct measurements in previous studies, thus strengthening the claim that this trainer is suitable for use as a learning medium for motorcycle electrical practice in vocational and automotive engineering educational institutions.

CONCLUSION

Based on the test results that have been carried out, it can be concluded that the Honda Beat motorcycle electrical trainer designed and developed in this study has met the functional and technical criteria as a learning medium in the field of Mechanical Engineering. All electrical subsystems including ignition, starter system, lighting, and signals show optimal performance, with the system voltage in the range of ±12 volts, in accordance with the specifications of the standard motorcycle electrical system.

The ergonomic component layout and systematic wiring arrangement facilitate current flow tracking and component identification during testing. This makes the trainer not only technically sound but also an effective learning tool for Mechanical Engineering students in automotive electrical system practical

The results of this test have been validated through comparison with three previous studies that demonstrated the suitability of the voltage values and performance of the Honda Beat's electrical system. Therefore, this trainer is deemed relevant and useful for supporting the mastery of automotive electrical system skills within the scope of Mechanical Engineering, particularly in the areas of maintenance engineering and light vehicle systems.

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