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Design and development of fuel consumption meter on motorcycle based on injector pulse width using arduino uno microcontroller

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Abstract

Motorcycles equipped with fuel injection systems commonly utilize dashboard indicators to ascertain the amount of fuel remaining, resulting in riders having an imprecise understanding of fuel consumption. As a result, motorcyclists may find it difficult to evaluate fuel use during specific time periods. In order to tackle this issue, the researcher develops a digital gadget that employs a microcontroller to regulate performance. The device exhibits fuel usage data in relation to injector pulse width. Moreover, the device can also function as an educational tool for vocational high school students to acquire knowledge about the operation of EFI motorcycle fuel systems. This study employs a research and development methodology, with a specific focus on a 2021 Honda Beat FI motorbike that was tested in the Automotive Engineering Vehicle Testing Workshop at Universitas Negeri Padang. The analysis of experimental data during idle rotations at 20, 40, and 60 seconds reveals average percentage errors of 2%, 1.73%, and 11.76% correspondingly. This leads to an overall device error rate of 4.74% throughout all test situations. The data was obtained through a comparison between the measurement data from the device and the actual measurement data. The error rate signifies the device's precise measurement of fuel usage in real-world situations.

Keywords

Fuel consumption meter, injector pulse width, arduino microcontroller

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Introduction

Indonesia, as a developing nation with significant geographical distances between its regions, heavily depends on a wide array of transportation modes including automobiles, motorcycles, railways, aircraft, and both public and private transportation [1]. Among these options, motorcycles equipped with electronic fuel injection (EFI) have become increasingly popular because of their cost-effectiveness and positive impact on the environment. Consequently, there has been a surge in the desire for motorcycles equipped with EFI, which has necessitated the development of tools to accurately gauge fuel consumption in these vehicles. The creation of a device to quantify fuel usage in motorcycles equipped with electronic fuel injection is essential, serving both practical and educational objectives. With the ongoing changes in transportation, there is an increasing demand for creative methods to assess and enhance fuel efficiency in vehicles. This paper seeks to fulfil this requirement by presenting the investigation and development of a device capable of precisely quantifying fuel consumption in EFI motorcycles utilizing a microcontroller [2].

The working principle of EFI system relied on three main parts, namely input (sensor), process (ECU) and actuator (Injector, spark plug, etc). The operation of injectors in Electronic Fuel Injection (EFI) systems is a crucial element in modern internal combustion engines [3]. These injectors are specifically engineered to accurately deliver predetermined amounts of fuel to engine cylinders, substantially contributing to combustion efficiency and overall performance. Injectors function by utilizing an intricate mechanism that entails the regulated act of opening and closing a valve. The accurate timing and duration of fuel injection are crucial for achieving the best possible combustion, following the fuel requirements determined by different engine conditions. The concept of injector pulse width is crucial in understanding the complexities of injector operation. The duration the injector remains open during each injection cycle, known as this parameter, is of utmost importance in fuel delivery control. The injector pulse width has a direct effect on the amount of fuel that is injected into the combustion chamber, which in turn has a significant impact on the important air-fuel mixture [4].

The injector pulse width plays a crucial role in maintaining and achieving the necessary air-fuel ratio that is vital for efficient combustion. The ratio has a direct impact on the performance of the engine, the level of emissions produced, and the efficiency of fuel consumption. Electronic control units (ECUs) play a crucial role in precisely adjusting the injector pulse width by analyzing real-time data from a variety of sensors. The fuel injection pulse width is measured in milliseconds (ms). The parameter value directly correlates with the duration of the injector opening during each fuel injection cycle. A higher parameter value results in a longer opening time, leading to a richer fuel mixture in the engine. Conversely, a lower parameter value indicates a shorter opening time, resulting in a leaner fuel mixture [5].

Consequently, as the pressure on the fuel rail always remains nearly constant, the amount of fuel consumed can be determined by calculating the injector pulse width. The objective of this research is to design a device capable of calculating fuel consumption based on the injector pulse width. The device's design and construction are driven by the goal of creating a reliable instrument for measuring fuel consumption, which can also serve as a valuable educational tool for vehicle testing courses. This paper seeks to enhance the field of vehicle testing and education by analyzing the theoretical underpinnings of EFI systems, the operational principles of EFI, and the factors that impact fuel consumption.

Methods

This research primarily aims to conduct a need analysis for the development of a microcontroller-based fuel consumption measurement device for motorcycles equipped with electronic fuel injection. The study highlights the growing demand for motor vehicles and the resulting necessity for a methodical and intentional research approach to develop and enhance a product that can precisely measure fuel consumption in motorcycles equipped with electronic fuel injection systems. The research seeks to fill the gap in current literature by developing a fuel consumption measurement device specifically designed for motorcycles equipped with electronic fuel injection systems. The demand for this device arises from the technological progress in motor vehicles, specifically the implementation of EFI, which creates a lack of tools for precisely measuring fuel consumption in these vehicles. Moreover, the study highlights the possibility of using the created device as an educational tool for students studying automotive engineering, specifically in vehicle testing courses. This emphasizes the necessity for educational tools that can effectively aid in learning and experimentation in the field of vehicle testing and measurement of fuel consumption. To summarize, this research highlights the necessity for a dependable and precise fuel consumption measuring device for motorcycles equipped with EFI. Additionally, it emphasizes the possibility of using this device for educational purposes in the automotive engineering field.

The fuel consumption meter hardware depicted in Figure 1 exhibits a mechanical design. This tool comprises circuits for input, processing, and output. The input circuit of this device is derived from the keypad. The keypad presents a range of choices regarding the duration it will require. The microcontroller circuit will process the input received from the keypad. The microcontroller serves as the central circuitry of this tool as it is responsible for reading and calculating the fuel consumption of the vehicle within a specific timeframe. Following the product design phase, a design validation process is conducted to assess the effectiveness of the fuel consumption measuring device in the tool design. Design validation is conducted by proficient individuals who possess expertise in product design or prototype issues. This process aims to identify both the strengths and weaknesses of the design, with the intention of receiving clear and constructive feedback and recommendations to enhance the product. The validation of the fuel consumption measuring device design is established in this step. The design of the tool was validated by three individuals, specifically professors from the automotive engineering department who specialized in teaching testing and autotronic courses, or one of them.

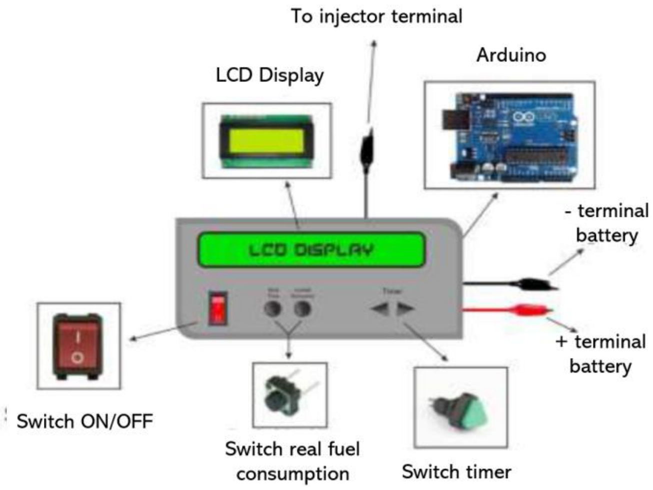

Figure 1. System design and component

Following design validation by the validator, the design revision process is undertaken to identify any remaining discrepancies or errors in the product that need to be corrected, with the goal of refining and improving the product. At this stage, researchers enhance the product design that has already been validated using suggestions for improvement obtained from design validation. Next, continue with the production of the product. During the product manufacturing phase, there are multiple essential steps that need to be carried out. These include producing the necessary hardware and software, printing circuits, assembling electronic components, programming microcontrollers, and constructing a secure housing or frame for the fuel consumption measuring device. The process of creating electronic circuits for hardware and developing software programmers is conducted by researchers with the assistance of colleagues from the Department of Electronics Engineering at FT UNP.

The test involves assessing the synchronization between the hardware and software components of the fuel consumption measuring device. Specifically, it determines whether the software programmed can successfully operate on the hardware. If this test proves to be successful, it can proceed to the usage test. However, if it is unsuccessful, the product will undergo revisions before it can be manufactured. Sugiono (2013: 302) states that the product design cannot be tested directly but must be created first to produce a product. Product trials are performed to assess the quality of a product that arises from research and development. Once the fuel consumption measuring device is deemed valid, a trial is conducted to assess its ability to meet the criteria as a motorcycle fuel consumption measuring device. Moreover, data collection is conducted to evaluate the efficiency of the fuel consumption measuring device. Data collection is accomplished through direct measurement of fuel consumption using a specifically designed tool.

Results and Discussion

Product revisions are conducted with the aim of achieving perfection in the final product. A single iteration of product revision was conducted in this study. Several modifications have been made to the product design, including the incorporation of cables into the injector, resizing the tool design, and the addition of a reset button. This design revision serves as a guide for creating a product with optimal and gratifying outcomes. After collecting comments from automotive engineering experts, it was recommended that the product undergo revisions prior to the manufacturing process. Once the revision has been enhanced, the subsequent phase involves developing a product capable of generating data on fuel consumption within a specified timeframe, as illustrated in Figure 2. The data presented above is obtained from the trial use of the tool as shown in Table 1. Testing is conducted at intervals of 20, 40, and 60 seconds. The time interval remains constant at 20 seconds. This is done with the intention of streamlining the process of comparing the data acquired from different sources. During the testing phase, the tool exhibited an average error rate of 4.74%.

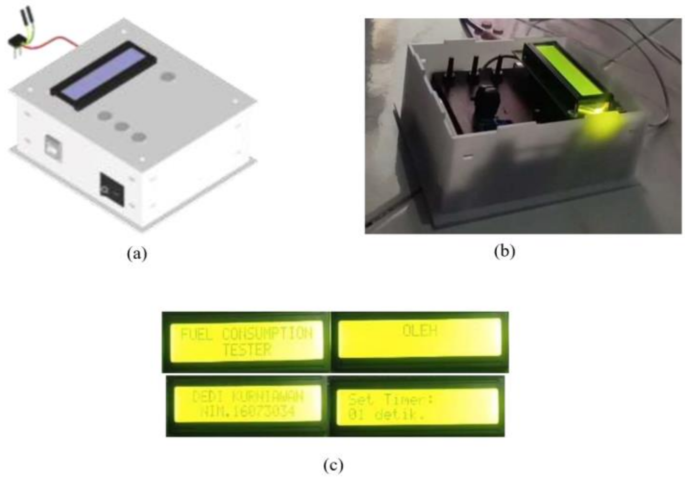

Figure 2. Fuel measuring product, a) display product, b) product testing, c) LDC display

Table 1. Measuring results

No	Testing time (s)	Fuel consumption value		Percentage of error (%)
		Fuel mattering (ml)	Manual measurement (ml)	
		0.81	0.8	1.25
		0.78	0.8	2.5
1	20	0.78	0.8	2.5
		0.77	0.8	3.75
		0.77	0.8	3.75
		1.57	1.5	4.66
		1.53	1.5	2
2	40	1.52	1.5	1.33
		1.51	1.5	0.66
		1.50	1.5	0
		2.27	2.5	9.2
		2.25	2	10
3	60	2.26	2.5	9.6
		2.25	2	10
		2.25	2	10
		Average		4.74

To achieve the research objectives of determining the fuel efficiency of a vehicle, it is necessary to first measure the volume of fuel consumed by the vehicle. Therefore, a fuel consumption measuring device is required for a motorcycle [6]. The fuel consumption meter has been developed utilizing the Arduino-uno as a microcontroller [5]. The Arduino Uno can determine the duration of the injector connection by establishing a parallel connection with the cable in the injector socket and subsequently converting the data. The LCD will display the converted results of the motorcycle's fuel consumption within the specified time. In addition to the Arduino-uno and LCD, this fuel consumption gauge is equipped with several other essential components. These include a battery, which serves as a power source to activate the LCD, Arduino-uno, and other components. The gauge also features an on/off button, two time setting buttons, a start button, and a reset button. Additionally, there is a voltage reader sensor and a connecting cable that links the injector to the fuel consumption gauge. Following the creation of the fuel consumption gauge, the author proceeded to carry out multiple tests on the device, varying the time intervals for each test. The test data is presented in Table 1, which shows the fuel consumption measurements obtained using the LCD and Measuring Glass. From the data, it is evident that when the injector is activated for 20 seconds, the duration of injector opening is merely 0.53 seconds. Similarly, for 40 seconds of activation, the injector remains open for 1 second, and for 60 seconds of activation, the injector is open for only 1.5 seconds. Based on the data, it can be inferred that the duration of the injector's opening is merely 2.5% when it is operational during the motorcycle's idle state.

Following the evaluation of the fuel consumption gauge, the author proceeds to conduct an additional test to ascertain the validity and efficacy of this tool. This involves removing the injector from the motorcycle and subsequently placing it into a measuring cup [7], [8]. Once all preparations are complete, activate the motorcycle and subsequently engage the starter, causing the fuel to be expelled into the measuring cup. The starter will automatically cease operation once it has reached the predetermined time [3], [9], [10]. Subsequently, the results in the measuring cup should be examined and recorded in the measurement table.

Conclusion

The research findings indicate that a tool has been developed to quantify fuel consumption in an injection motorcycle. The tool utilizes an Arduino-Uno microcontroller for its design and production. The microcontroller determines the duration of the injector connection by establishing a connection with the cable in the injector socket and subsequently converting the data. After converting the data, the microcontroller displays the amount of fuel consumed by the motorcycle within the specified time on the LCD screen. The validity of the fuel consumption measuring device on this injection motorcycle can be confirmed based on multiple tests, which reveal an average discrepancy of 4.74% between the data displayed on the LCD screen and the measurements obtained from the measuring cup.

Acknowledgments

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