BIS ENERGY AND ENGINEERING

Volume 2 2025 | DOI: 10.31603/biseeng.363
6th Borobudur International Symposium on Science and Technology (BIS-STE) 2024

UNIMMA PRESS
UNIVERSITAS MUHAMMADIYAH MAGELANG

Bicycle injection system design 4-stroke motorcycle

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Abstract

This research discusses the design of an injection system for 4-stroke motorcycles, aiming to reduce harmful substances in exhaust emissions by changing the conventional system to an EFI system. In addition, this study also aims to determine how much impact the application of the EFI system on a 4-stroke motorcycle has on torque and power, as well as how much exhaust emissions and fuel consumption are produced after the application of the EFI system. The method used in this research is experimentation. This activity was carried out in 3 test locations, namely at the FT UNP automotive workshop, Teqleck Speedshop, and the straight line of the Minangkabau Airport highway along 1 km. The results showed that the power generated by the designed EFI system decreased by 4.33% or 0.23 kW. Torque also decreased by 6.95% or 0.57 kW. In addition, the HC exhaust emission content decreased by 394.58% or 365.66 ppm, the CO content decreased by 39.13% or 0.63%, and the 〖CO〗_2 content in the exhaust emissions of the 4-stroke motorcycle converted to the EFI system increased by 68.99% or 2.67%. Finally, fuel consumption is more efficient, increasing by 31.85% or 21.98 Km/L.

Keywords

Injection system design, Power, Torque, Exhaust emissions, Fuel consumption

Introduction

As the number of vehicles is increasing, exhaust emissions containing harmful substances in motor vehicles are also increasing [1]. As a result, HC (Hydrocarbon) gas and Oxides of nitrogen agglomerate in the air so as to block sunlight and photochemical reactions occur and will form other chemical substances and oxygen, especially the ozone layer (O3) which is the most powerful oxidant, resulting in the phenomenon of smog [2]. It obstructs vision, irritates the eyes and causes cancer. In general, the impact caused by exhaust emissions on health is very much like causing itchy throat, coughing, triggering hypertension and others [3].

One of the causes of the high content of harmful substances in vehicle exhaust emissions is the large number of motorbikes that still use conventional or carburetor systems, where the level of fogging in the carburetor system is still not so perfect, resulting in less perfect combustion in the combustion chamber so that the exhaust

Published:
May 31, 2025

Selection and Peer-review under the responsibility of the 6th BIS-STE 2024 Committee

emissions generated from the carburetor system are so high [4]. These harmful exhaust emissions are caused by incomplete combustion in the vehicle, one of which is caused by incomplete fuel fogging from the carburetor, so that the resulting exhaust emissions contain high CO and HC substances [5].

As well as the results of research from [6] with the title comparison of fuel consumption of EFI and conventional motorcycle systems, with the results of his research that the HC and CO content of exhaust emissions produced in the carburetor system is higher than the EFI system. Then the results of research from [7] with the title exhaust gas analysis of EFI technology engines with premium fuel, with the results of their research, namely the CO and HC content in the exhaust gas of the carburetor system is higher than the EFI system. Then from the results of research by [8] with the title engine performance analysis study of EFI and carburetor combustion systems in gasoline engines. The results of his research are for the same engine speed of 3500 rpm, the power produced by the EFI engine is 2.37% greater than the carburetor engine of 44.179 kw.

Combustion is more efficient, meaning that more fuel is used and the engine produces more power. In addition, combustion also results in lower exhaust emission levels [9]. Therefore, with more effective fuel and air atomization, combustion will be complete, resulting in better exhaust emissions and fuel consumption. This results in better torque and power [10].

Research from [11] shows that an engine with an EFI system is able to produce more power than a carburetor system, even at the same engine speed. In addition, another study [12] revealed that the fuel consumption of the EFI system is more efficient compared to the carburetor system, which directly reduces the carbon footprint of the vehicle. However, previous studies have mostly focused on the efficiency and emission aspects under standard conditions, without considering its practical application under various operating conditions such as vehicle load, ambient temperature, and driving patterns in urban areas that tend to be irregular.

The novelty offered in this research includes a more in-depth analysis of the implementation of EFI technology on 4-stroke motorcycles under various operating conditions. This research also evaluates the potential of implementing EFI on older vehicles through retrofit technology, as an innovative solution to accelerate the transition to environmentally friendly vehicles without having to replace the vehicle entirely. With the increasing awareness of global emission standards and demands for energy efficiency, this research is expected to provide scientific and practical contributions in supporting the development of cleaner, more fuel-efficient and sustainable vehicle technologies.

Therefore, by updating the fuel system from carburetor to EFI, this research aims to support a significant reduction in exhaust emissions, reduce air pollution, and create a more efficient and powerful motor vehicle.

Method

This research uses an experimental method. The experimental research method can be interpreted as a research method used to seek the effect of certain treatments on others under controlled conditions [13]. This research will reveal the value of changes in exhaust emissions, fuel consumption, torque and power between Vega ZR motorcycles with carburetor fuel systems and those that have changed their fuel systems to EFI systems. Research flow can be seen in Figure 1.

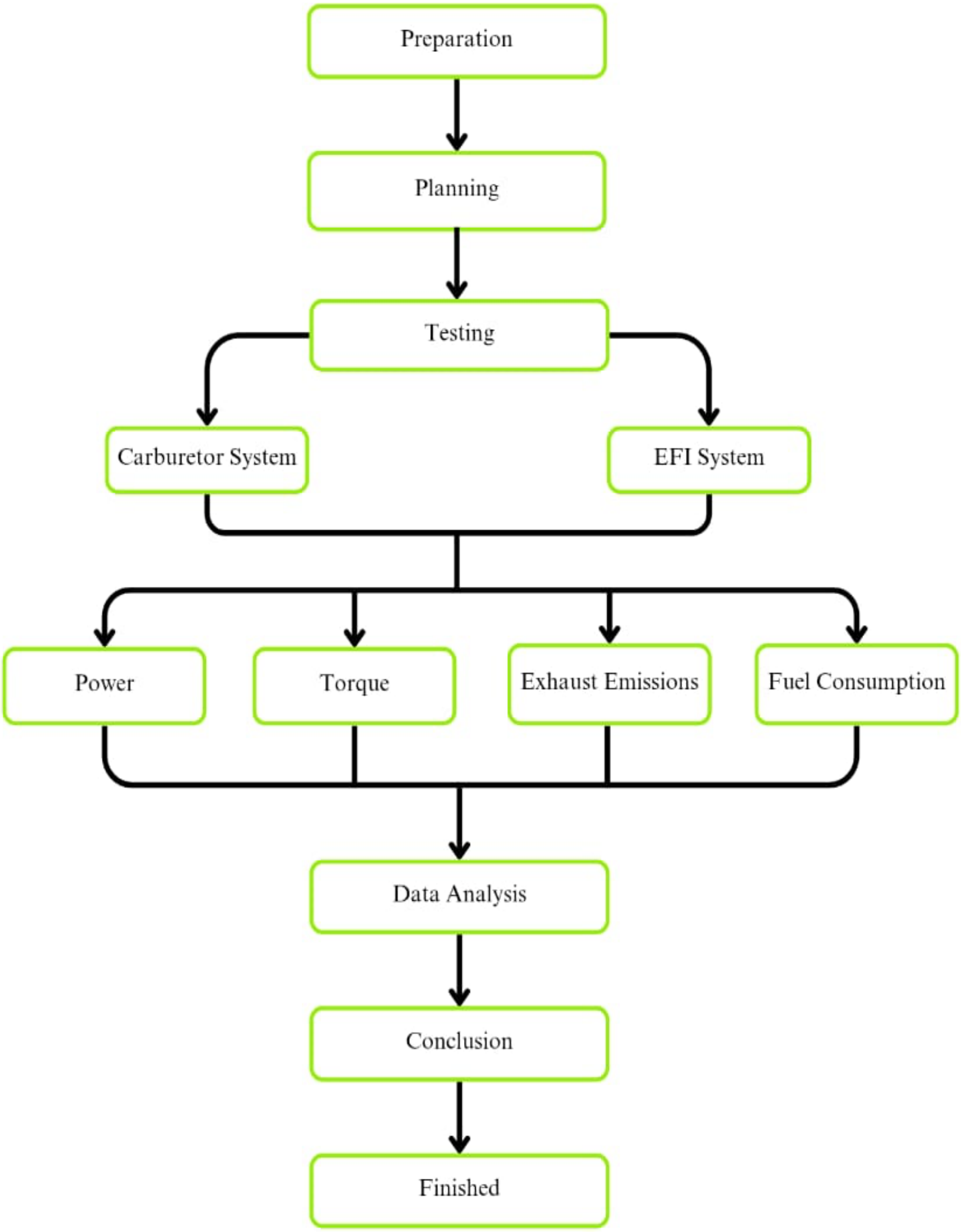


Figure 1. Research flow

This research object used is a Yamaha Vega Zr 4 stroke motorcycle in 2010 with a carburetor system. Table 1 are the specifications of the Yamaha Vega ZR used:

Table 1. Test vehicle specifications

Description	Specifications
Engine	4 stroke, SOHC, 2 valve
Cooling System	Air
Number of Cylinders	Single Cylinder
Cylinder Content	113.7 cc
Fuel System	Carburetor
Diameter x Stroke	50 x 57.9 mm
Compression Ratio	9, 3:1
Maximum Power	6 KW/7,500 rpm
Maximum Torque	8.3 Nm/4,500 rpm

The instruments in this study can be divided into 2, namely testing tools and research design designs.

a. Research tools

Table 2. Research equipment

Equipment	Function
Dynometer	Torque and power testing equipment
Gas Analyzer	Exhaust gas emission testing device
Burette	To measure the amount of fuel
I-max Rpm meter	To determine engine rpm

b. Research Design

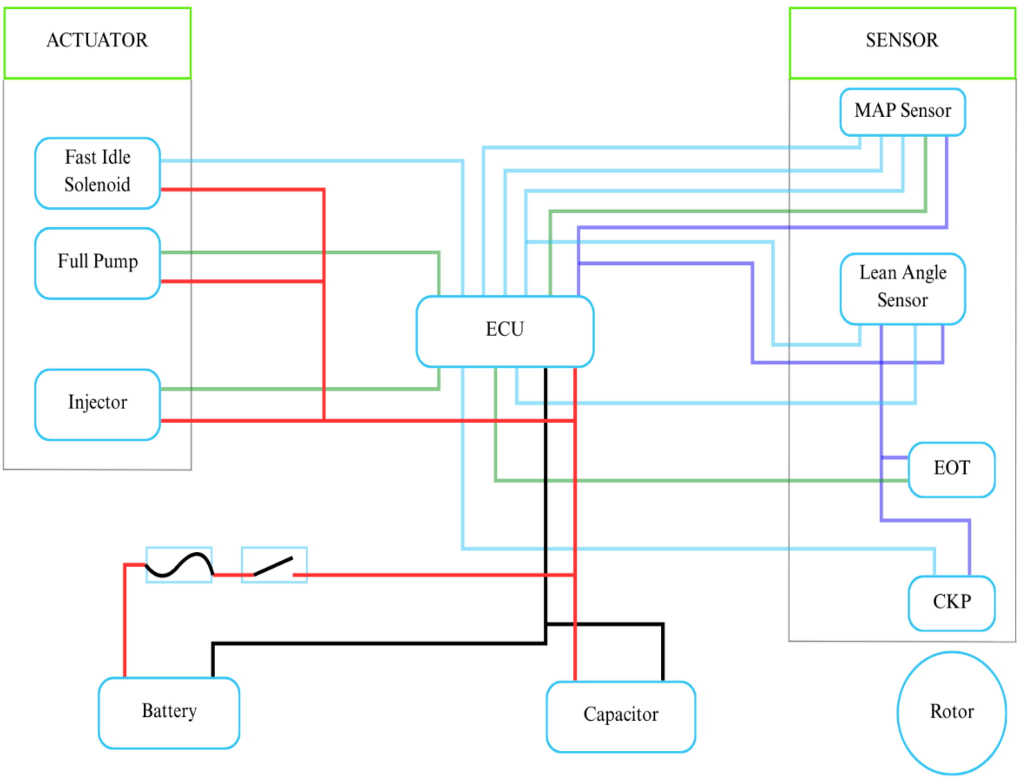
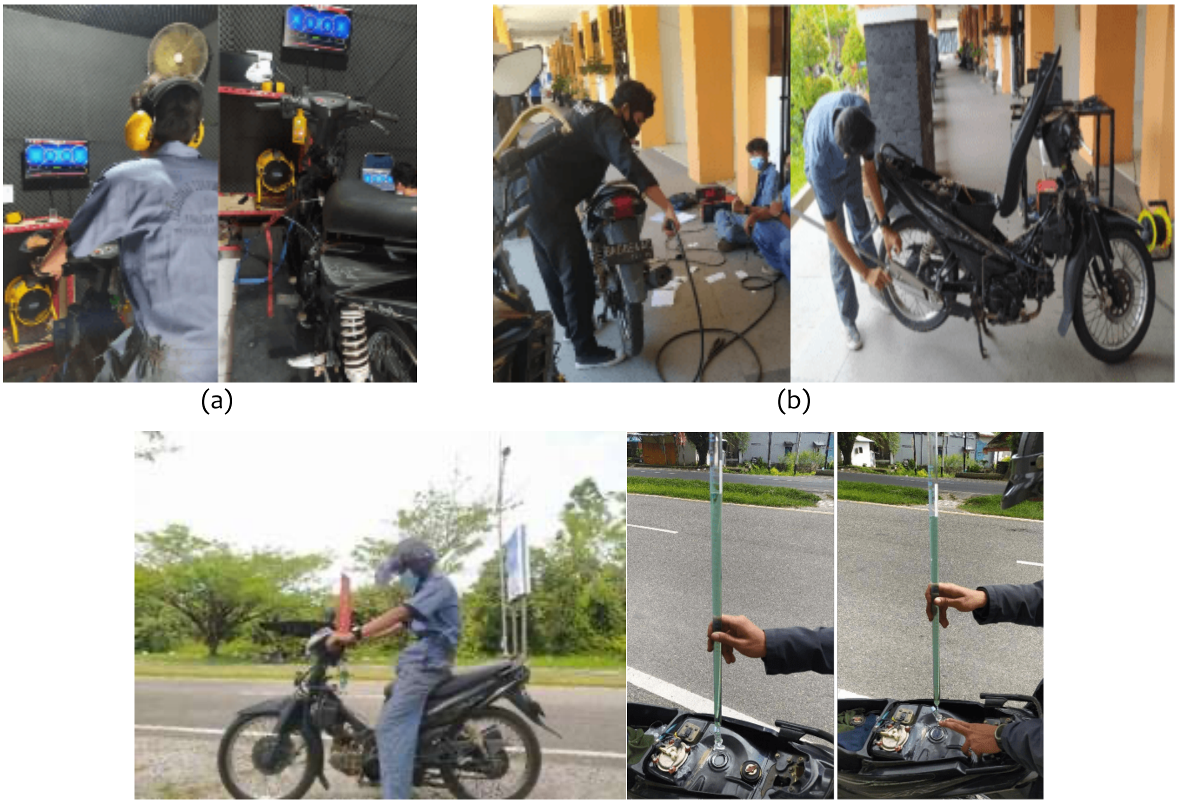


Figure 2. EFI system design

Testing scheme



(a) (b) (c)

Figure 3. (a) Torque and power testing of carburetor system and EFI system, (b) Exhaust gas emission testing of carburetor system and EFI system, (c) Fuel consumption testing of carburetor system and EFI system

Data analysis technique

This data analysis is used to determine the torque and power values as well as exhaust emissions and fuel consumption between the carburetor system and the EFI system.

$$P = \frac{n-N}{n} \times 100\% \qquad (1)$$

Description: P as Percentage result (%); n as Average value of test results (treatment/EFI system); N as Average value of test results (no treatment/carburetor system)

Then conduct a t test to see the significance of the data obtained.

$$Sx = \sqrt{\frac{\Sigma(x_i-\tilde{x})^2}{n-1}} \qquad (2)$$

Description: x_i as Data value; $\tilde{x}$ as Average value; n as Amount of data
The standard deviations of samples 1 and 2 that have been obtained are entered into the t formula:

$$t = \frac{(\tilde{x}-\tilde{y})}{\sqrt{\frac{(nx-1)Sx^2+(ny-1)Sy^2}{nx+ny-2}} . \sqrt{\frac{1}{nx}+\frac{1}{ny}}} \qquad (3)$$

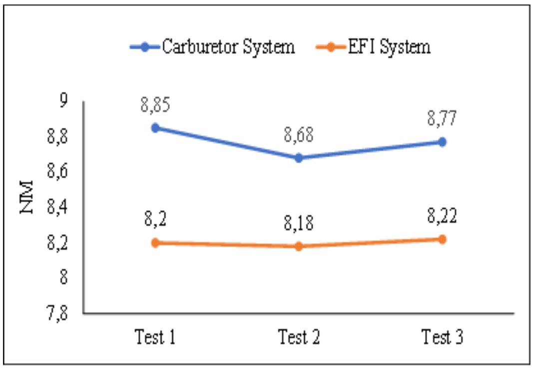
Description: t as Test results; $\tilde{x}$ as 1st sample average; $\tilde{y}$ as 2nd sample average; ${S_x}^2$ as Standard deviation of the 1st sample; ${S_y}^2$ as Standard deviation of the 2nd sample; nx, ny as Number of samples; The df price used for t_{table} is.

$$df = nx + ny - 2 \quad (4)$$

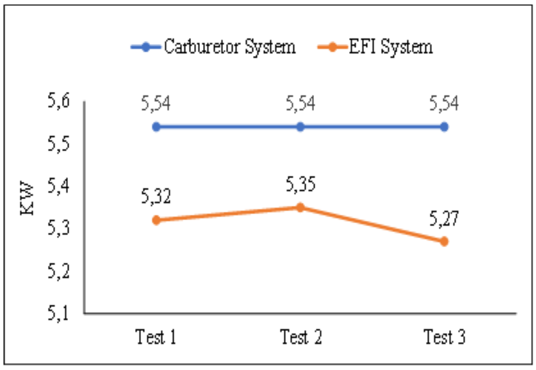
Results and Discussion

Results

The results of torque and power testing are shown in Figure 4, conducted without utilizing the specified configuration. The first vehicle was tested without the use of Needle Thrust Bearings, while the second vehicle had the Needle Thrust Bearings installed to enhance its performance. The comparative performance of the carburetor and EFI (Electronic Fuel Injection) systems is presented through a series of figures and tables. Table 3 displays the T-test results for torque and power, indicating differences in engine performance between the two systems. Emission characteristics are illustrated in Figure 5, where part (a) shows the levels of CO and CO_2, and part (b) presents HC emissions for both systems. These emission differences are statistically supported by the data in Table 4, which outlines the T-test results for exhaust gas emissions. Fuel efficiency comparisons are shown in Figure 6, which graphs the fuel consumption results of the two systems, and further confirmed by Table 5, presenting the T-test results of their respective fuel consumption values.



(a)



(b)

Figure 4. (a) Graph of torque testing results of carburetor system and EFI system, (b) Graph of power testing results of carburetor system and EFI system

Table 3. T-test results of torque and power between carburetor system and EFI system

Test	System	N	Mean	S	S2	df	t_{Count}	t_{table}	Description
Torque	Carburetor	3	8.77	0,085	0.007	4	11.284	2.776	Significant
	EFI	3	8.2	0.020	0.0004				
Power	Carburetor	3	5.54	0	0	4	9.85578117	2.776	Significant
	EFI	3	5.31	0.040	0.0016				

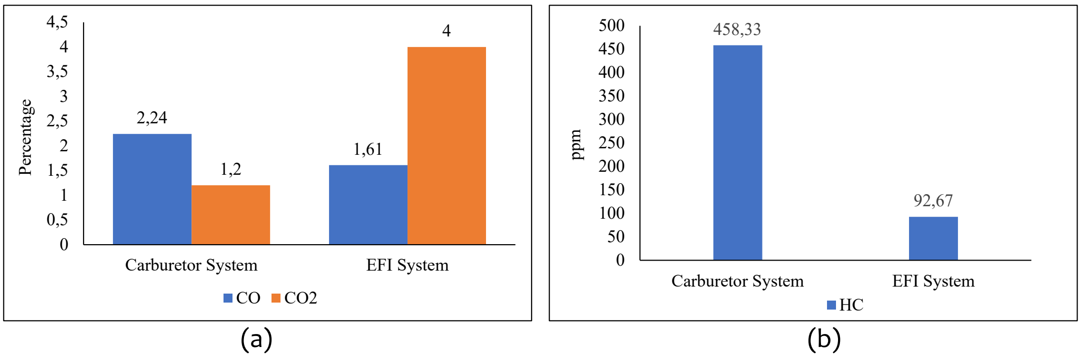


Figure 5. (a) Graph of test results of exhaust gas emissions content of CO and CO_2 carburetor system and EFI system, (b) Graph of test results of exhaust gas emissions HC content of carburetor system and EFI system

Table 4. T-test results exhaust gas emissions between carburetor system and EFI system

Test	System	N	Mean	S	S2	df	t_{Count}	t_{table}	Description
HC	Carburetor	3	458.33	98.997	9.800.406	4	6.377360	2.776	Significant
	EFI	3	92.67	7.572	57.335				
CO	Carburetor	3	2.2433	0.29535	0.8723	4	2.486	2.776	Not Significant
	EFI	3	1.6133	0.32470	0,1054				
CO_2	Carburetor	3	1.2000	0.100		4	30.340	2.776	Significant
	EFI	3	3.8667	0.11547					

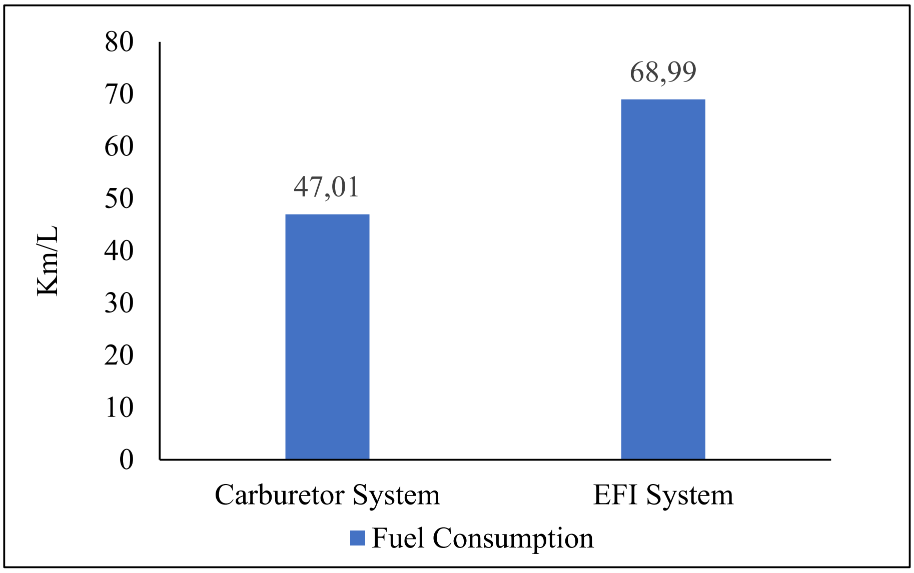


Figure 6. Graph of fuel consumption testing results of carburetor system and EFI system

Table 5. T-test results fuel consumption between carburetor system and EFI system

System	N	Mean	S	S2	df	t_{Count}	t_{table}	Description
Carburetor	3	47.01	0.254	0.0645	4	3.09128304	2.776	Significant
EFI	3	68.99	12.3080	151,4868				

Discussion

This research is about updating the fuel system from conventional to EFI system on Yamaha Vega ZR motorcycle. This research aims to reduce exhaust emissions or cleaner exhaust emissions in vehicles so as to reduce air pollution generated from the results of vehicle exhaust emissions and fuel consumption is economical and can increase torque and power. This research has not existed before, previous research compared exhaust emissions, torque and power and fuel consumption with 2 different types of vehicles.

After applying the injection system design to this 4-stroke motorcycle whose specifications have been determined by the researcher, the motorcycle in this study is easier to start in cold engine conditions, unlike the initial condition when the motorcycle is using a carburetor system, when the engine is cold it is difficult to start. The exhaust emissions produced by this EFI system are cleaner than the conventional system based on the data that the researchers analyzed.

By using this EFI system, the fuel consumption traveled by this 4-stroke motorcycle increases considerably so that it can be said that it is more economical in fuel consumption. More efficient combustion means that the fuel used is more efficient and the engine produces more power. In addition, combustion also produces lower levels of exhaust emissions [10]. However, in this study the torque and power produced decreased very little, this is useful as a reference for future researchers so that this research is developed so that torque and power are expected to increase properly.

Conclusion

The results of this 4-Stroke Motorcycle Injection System Design according to percentage analysis are that there is an increase in testing the HC, CO, and 〖CO〗_2 content in exhaust emissions and fuel consumption, so that the resulting mileage increases further and the torque and power produced decrease by a small difference.

This research only discusses the design of the EFI system on a 4-stroke motorcycle with specifications determined by the researcher and analyzes the output or results of the Power, Torque, Exhaust emissions and Fuel consumption generated between the Carburetor system and the Design of the Injection System (EFI), for future research to be developed again with other specifications.

Acknowledgement

The authors would like to thank the Department of Automotive Engineering and Padang State University for the funding support provided for this research. This support made it possible to carry out research on the design of injection systems on 4-stroke motorcycles. Thanks also go to the reviewers and proofreaders for their constructive and valuable input in improving the quality of this article. Thanks to the colleagues and lecturers who have helped this research well. Hopefully the results of this research will provide significant benefits for the development of automotive technology in the future.

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