BIS ENERGY AND ENGINEERING

Volume 2 2025 | DOI: 10.31603/biseeng.366
6th Borobudur International Symposium on Science and Technology (BIS-STE) 2024

UNIMMA PRESS
Universitas Muhammadiyah Magelang

Effect of ignition timing variations using a programmable ECU on power and torque of FI motorcycle

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Abstract

This study examines the effect of changes in ignition timing on the power and torque of a 4 stroke engine, the object of research is a Honda Beat FI vehicle in 2015 with a BRT programmed ECU. The purpose of this study is to determine the impact of changes in ignition timing on the power and torque produced. The method used is experimental research, namely data collection through testing using Dynotest tools before and after changes in ignition timing to do.The results showed that the change in ignition timing advanced 2° resulted in the greatest increase in power from 5.56 kW to 5.58 kW (0.75% increase compared to standard conditions). While the change in the delayed ignition timing by 2° resulted in the greatest increase in torque from 8.21 N-m to 8.28 N-m (0.97% increase over the standard test).

Keywords

Power, Torque, Ignition timing, Programmable ECU

Published:
May 31, 2025

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

Introduction

The background of this research focuses on the development of automotive technology, especially in improving engine performance through fuel injection systems and electronic controls [1][2]. This research aims to answer the problem of the limitations of the factory standard ECU which cannot be reprogrammed to improve motorcycle performance [3]. With the existence of a programmable ECU, researchers try to optimize the ignition timing to make the combustion process more efficient and produce more power [4]. Problem identification includes how ignition timing variations can affect engine power and torque, as well as the importance of this research in the

context of automotive engineering education. The main objective of this research is to provide a better understanding of the effect of ignition timing on engine performance and to encourage the use of programmable ECUs among drivers and mechanics.

The development of technology has triggered a struggle in the automotive sector to create increasingly advanced technology [5]. These technologies include the development of engines that use a fuel injection system (EFI) with electronic control, namely the electronic control unit (ECU) [6]. One of the efforts to optimize the operation of a motorcycle engine is to implement an injection system, the injection system on a motorcycle is regulated by an ECU [7]. The ECU is an electrical device that functions to regulate the frequency and pulse width of the fuel injector as well as the ignition time and regulate the amount of fuel injected. so that in addition to modifying the engine mechanism [8]. The ECU is an electrical device used to regulate the operation of the ICE (Internal Combustion Engine). Many ways can be done to achieve good combustion on a motorcycle, one of which is by adjusting the ignition time so that the fuel in the combustion process uses timing [9]. The ignition time is right so that the entire fuel mixture that uses air can burn properly [10]. The ECU works digitally using a microcontroller whose function is to process data using a comparison process and calculate data according to engine needs [11]. Data processing comes from several sensors, namely the Throttle Position Sensor (TPS), Intake Air Temperature Sensor (IATS), Manifold Air Pressure (MAP), Camshaft Position Sensor and Engine Temperature sensor.

There are many ways to improve the performance of a vehicle, including increasing the cylinder volume (bore), changing the camshaft opening angle, and using pigtails [12], [13]. However, some of these treatments will have an adverse impact on the condition of the vehicle after a certain period of time. such as increasing the cylinder volume or replacing obsolete engine components, the ECU must be able to adapt to the needs of the engine, because the engine cylinder volume is modified to be large, an ECU is needed that can change the ignition timing according to the needs of the engine, so the standard ECU cannot be reprogrammed so a solution is needed to increase the engine cylinder volume [14].

One of the efforts that can be made to increase the power and torque of a vehicle includes modifications to the engine, air induction system, fuel system and ignition system for the combustion process [15][16]. To do this, a reprogrammable ECU system is required, as the various systems present in an injection engine can be programmed according to your needs. One type of reprogrammable ECU that has been widely circulated in the aftermarket is the ECU [17]. Programmable, with this type of ECU it is possible to reprogram the drive system. In this research, the reprogramming that will be carried out relates to the ignition timing system required in the combustion process. With this programming variation, it can be used to find the required performance based on engine power and torque. To meet the desired needs, it is necessary to modify the ignition timing variation using the Beat FI 110 2015 computer that can be programmed.

Method

This research uses an experimental method with the object of research in the form of a Honda Beat FI motorcycle in 2015. The ignition timing variations include forward and backward settings of 1° and 2°. Data collection was carried out using Dynotest test equipment at the Kawasaki GREENTECH workshop, Pekanbaru. The data obtained includes power and torque measurements before and after ignition timing modification. Data analysis was carried out descriptively by comparing the test results carried out under standard conditions and after ignition timing variations. Thus, this study aims to identify the significant effect of changes in ignition timing on engine power and torque and provide an overview of the effectiveness of programmable ECU in improving vehicle performance [18]. The following is the research flow chart:

This research is an experimental study. In this context, experiments were conducted to observe the effects of ignition timing variations on engine power and torque. Experimental research allows researchers to control variables and observe results directly [19].

The object of research is the vehicle used as the object of research, here is Honda Beat FI 2015. The selection of this vehicle is based on its popularity among motorcycle users in Indonesia, as well as its ability to be modified with a programmable ECU.

Research Variables:

a. Independent Variables: Ignition timing (advanced and delayed).
b. Dependent Variable: Engine power and torque produced.
c. Control Variables: Engine condition, fuel type, and test environment.

Operational Definition of Variables:

a. Ignition Timing: Refers to the degree angle at which the spark plug ignites the spark to burn the fuel and air mixture.
b. Engine Power: A measure of an engine's ability to perform work, measured in kilowatts (Kw).
c. Engine Torque: A measure of the rotating force produced by an engine, measured in Newton meters (N.m).

Research Instruments:

a. Dynamometer: This tool is used to accurately measure engine power and torque.
b. ECU Programmable BRT: Used to vary the ignition timing.
c. Other Test Equipment: Includes software for data analysis.

Place and Time of Research:

The test was conducted at GREENTECH's Kawasaki testing workshop, Jl. Soekarno-Hatta, Labuah Baru, Payung Sekaki District, Pekanbaru City,

Riau.Research Time: The research was conducted during a certain period with a predetermined schedule to ensure consistency in testing.

Data Source:

a. Primary Data: Data obtained directly from the results of power and torque testing using a dynamometer.

b. Secondary Data: Additional information from related literature on ignition and engine performance.

Research Procedure:

a. Preparation of Tools and Materials: Ensure all test equipment is ready for use.

b. Programmable ECU Setup: Performing initial settings on the ECU for standard conditions.

c. Basic Testing: Measuring power and torque under standard conditions without ignition timing variations.

d. Ignition Timing Variation:

- Varies the ignition timing by advancing 1° and 2°.
- Performing ignition timing variation with 1° and 2° backward.

e. Measurement of Power and Torque After Variations: Using a dynamometer to measure power and torque after each treatment.

Data Collection and Analysis:

The research scheme can be seen in Figure 1.

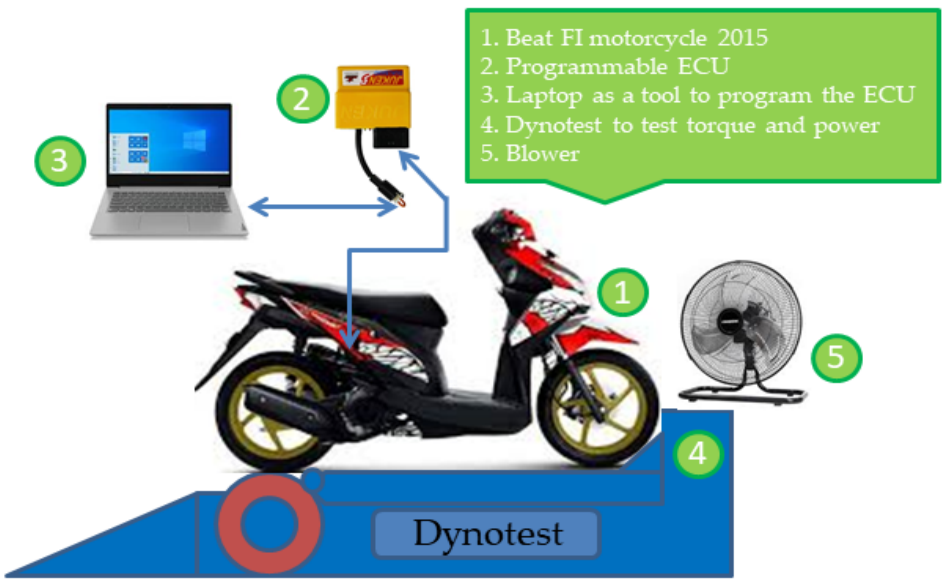

Figure 1. Scheme of research

Results and Discussion

The results showed that variations in ignition timing can increase the power and torque of the Honda Beat FI engine. The highest power increase occurs at the ignition timing that is advanced by 2°, while the highest torque increase occurs at the ignition timing that is set back 2°. The test results show that proper ignition timing can have a positive impact on engine performance, with an increase in power by 0.75% and torque by 0.97% compared to standard conditions. The discussion of the results also includes an analysis of how ignition timing relates to combustion efficiency and engine power output [20]. This study emphasizes the importance of ECU programming to achieve optimal performance and provides recommendations for the use of programmable ECUs among motorcycle users. Test results can be seen in Table 1-6.

Table 1. Test results using a standard ECU

Standard ECU					
Test	**Power (Kw)**	**RPM**	**Test**	**Torque**	**RPM**
I	5,58	7590	I	8,22	5890
II	5,57	7590	II	8,21	5890
III	5,57	7590	III	8,2	5890
Mean	5,57	7590	Mean	8,21	5890

Table 2. Test results using programmable ECU without treatment

Programmable ECU without treatment					
Test	**Power (Kw)**	**RPM**	**Test**	**Torque**	**RPM**
I	5,6	7370	I	8,17	6140
II	5,63	7250	II	8,17	6080
III	5,59	7480	III	8,18	5850
Mean	5,6	7366	Mean	8,17	6023

Table 3. Test results using programmable ECU with ignition timing advanced 1°

Programmable ECU with advanced 1°					
Test	**Power (Kw)**	**RPM**	**Test**	**Torque**	**RPM**
I	5,63	7440	I	8,17	5810
II	5,65	7260	II	8,25	5830
III	5,59	7370	III	8,18	5970
Mean	5,62	7356	Mean	8,2	5870

Table 4. Test results using programmable ECU with ignition timing advanced 2°

Programmable ECU with advanced 2°					
Test	**Power (Kw)**	**RPM**	**Test**	**Torque**	**RPM**
I	5,68	7520	I	8,17	6170
II	5,66	7540	II	8,18	6180
III	5,66	7530	III	8,17	6210
Mean	5,67	7350	Mean	8,17	6186

Table 5. Test results using programmable ECU with ignition timing delayed 1°

Programmable ECU with delayed 1°					
Test	**Power (Kw)**	**RPM**	**Test**	**Torque**	**RPM**
I	5,63	7350	I	8,17	5810
II	5,63	7390	II	8,18	5880
III	5,62	7600	III	8,21	5810
Mean	5,63	7446	Mean	8,18	5833

Table 6. Test results using programmable ECU with ignition timing delayed 2°

Programmable ECU with delayed 2°					
Test	**Power (Kw)**	**RPM**	**Test**	**Torque**	**RPM**
I	5,65	7540	I	8,28	6100
II	5,62	7490	II	8,21	6010
III	5,56	7420	III	8,25	5750
Mean	5,61	7483	Mean	8,25	5953

The results show that ignition timing variations have a significant effect on engine power and torque. The following is a summary of the results obtained:

a. Power Increase:

   The highest power increase occurred in the 2° advance ignition timing treatment, with an increase in power from 5.56 kW to 5.58 kW, or an increase of 0.75% compared to the standard condition of the Juken ECU.

b. Torque Increase:

   The highest increase in torque occurred in the 2° delayed ignition timing treatment, with the average torque produced increasing from 8.21 N-m to 8.28 N-m, or an increase of 0.97% compared to the torque data from the standard ignition timing test.

Proper ignition timing is very important in the combustion process in the engine cylinder. When the ignition timing is advanced, the fuel and air mixture has more time to burn completely before the piston reaches top dead center (TDC). This leads to more efficient combustion and an increase in the power produced by the engine. Conversely, if the ignition timing is too advanced or retarded, it can lead to incomplete combustion, thereby reducing the power produced by the engine.

Effect of Ignition Time on Torque, torque is a measure of the rotational force produced by the engine. The increase in torque in the delayed ignition timing treatment indicates that under certain conditions, ignition timing adjustments can improve combustion efficiency at low engine speeds. This is especially important in the context of everyday use of motorcycles, where higher torque at low revs can improve vehicle acceleration [12].

Although this study provides valuable insights into the effect of ignition timing variations on engine performance, there are some limitations. First, the study was only conducted on one type of vehicle (Honda Beat FI 2015), so the results may not be

generalizable to other types of vehicles. Secondly, other factors such as fuel quality and engine condition may also affect the results obtained but were not examined in depth in this study.

Conclusion

Based on the results of the search on the 2015 Honda Beat FI motorcycle got an increase in power with the ECU programmable. During the standard ECU programmable ignition test, the power generated was 5.59 kW to 5.63 kW, while in the highest power test scores were generated during the temporary process. advanced ignition 20 with an increase in power of 5.66 kW to 5.68 Kw, an increase of 0.75% compared to the power generated under standard Juken ignition conditions.Finding Torque Using Programmable Calculator Standard Programmable Ignition Test ECU Generated Torque from 8.17 N.M to 8.18 N. M, while the paired test results of the highest score were obtained when the ignition time was delayed by 20%. with the resulting average torque of 8.21 N.m to 8.28 N.m. there was an increase of 0.97% compared to the torque data produced by the Standard ECU programmable ignition time test. Based on the search results on the 2015 Honda BeatBeat FI Motorcycle Power and Torque Test with Standard ECU, with changes in ECU ignition timing, the ratio of power and torque can be programmed, having an increase in power at the test time of Ignition advance by 2^0 or 1^0 (1.79%). Meanwhile, in the paired test results, there is no increase with the ECU programmable at the time of ignition or advanced or reverse [13].

Acknowledgement

I am expresses highest gratitude to the Almighty Allah SWT for blessing, love, opportunity, health and mercy, so that I could finish this, Thank you for all Lecturers of Automotive Engineering Department who have given their knowledge and information. The researcher expresses gratitude to the UNP Rector and the Department of Automotive Engineering for their financial support and facilities throughout the completion of this research.

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