



Analysis of The Effect of Drive Pulley Diameter Variation on Electric Motorcycle Performance

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Abstract

The primary objective of this study is to investigate how different sizes of drive pulleys influence the performance of an electric motorcycle equipped with a BLDC motor. This was approached using an experimental technique that combined dynotesting and road testing where three drive pulley diameters of 42T, 44T, and 46T were used. While the road tests were intended to measure the top speed of the motorcycle, the dynotests were aimed at acquiring the necessary data to calculate the torque and power. Based on the results of this study, an increase in the drive pulley's diameter will increase the speed of the electric motorcycle, although it will lower the torque. It was found that the 42T drive pulley offers the greatest torque, which is 16.54 Nm at a power of 5.2 HP, and the 46T drive pulley allows for the greatest speed of 63.37 km/h. It is thus apparent that for performance to be properly tailored to the motorcycle, a balance should be struck in line with the intended purpose, which can either be acceleration or the cruising speed.

Keywords: *Drive Pulley, BLDC motor, Maximum Speed, Power, Torque*

Abstrak

Tujuan utama dari penelitian ini adalah mengetahui bagaimana variasi diameter puli penggerak memengaruhi performa sepeda motor listrik yang dilengkapi dengan motor BLDC. Penelitian ini menggunakan metode eksperimen yang menggunakan dynotest dan uji jalan dengan variasi diameter drive pulley masing-masing sebesar 42T, 44T, dan 46T. Uji jalan dimaksudkan untuk mengukur kecepatan tertinggi sepeda motor, sedangkan dynotest ditujukan untuk memperoleh data yang diperlukan untuk menghitung torsi dan daya. Berdasarkan hasil penelitian ini, peningkatan diameter puli penggerak akan meningkatkan kecepatan sepeda motor listrik, meskipun akan menurunkan torsi. Hasil penelitian menunjukkan bahwa pada diameter drive pulley 42T menghasilkan torsi terbesar, yaitu 16,54 Nm pada daya 5,2 HP, dan diameter drive pulley 46T memungkinkan kecepatan tertinggi 63,37 km/jam. Dengan demikian, dapat disimpulkan bahwa penggunaan sepeda motor Listrik dapat disesuaikan jika ingin performa ataupun akselerasi maksimum yang ingin dituju, harus menyesuaikan dengan diameter pulley yang digunakan.

kata kunci: *Drive Pulley, motor BLDC, Kecepatan Maksimum, Daya, Torsi*



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1. Introduction

Technological developments, particularly in the field of transportation, are extremely rapid. This development is also linked to improved performance and reduced emissions from vehicles. Currently, the development of vehicle transportation has reached electric vehicles, which are an alternative to reduce the use of non-renewable fuels and emissions, particularly carbon emissions. Electric vehicles are also expected to reduce the cost of periodic maintenance for these vehicles [1] [2].

The electric motor in a vehicle functions to convert electrical energy into mechanical energy, which is motion. One type of electric motor that is commonly found is the Brushless Direct Current (BLDC) motor. This type has high efficiency, produces high torque at low speeds, and is also relatively easy to maintain [3-5]. This type of motor has a rotor consisting of permanent magnets and a stator with wire windings. The rotating magnetic field is generated from a three-phase alternating current supply that is electronically controlled, allowing for highly precise motor speed regulation.

One important component in the drivetrain of an electric motorcycle is the Continuously Variable Transmission (CVT) [6]. This component consists of a drive pulley and a driven pulley connected by a belt (V-belt). This working system transfers energy from the motor to the rear wheels without manual gear changes. The size of the pulley diameter affects the transmission ratio, which will subsequently influence the vehicle's performance, including torque, power, and maximum speed [7], [8].

Several studies have discussed the influence of changes in parameters found within a vehicle's transmission system on the vehicle's performance [9-13]. Research [4] shows that varying the primary pulley angle can increase vehicle power by up to 8.13%. Other research [12] investigates the effect of varying the driven pulley diameter on a vehicle's transmission system. The research results are as follows: the final torque and rotational speed are highly influenced by the difference in pulley diameter. Meanwhile, research [14] shows that pulley variations can affect the efficiency of CVT transmission in automatic motorcycles.

Based on previous studies, there is still limited research on the effect of varying the diameter of the drive pulley on electric motorcycles, particularly those using BLDC motors. Therefore, this study was conducted to analyze the effect of varying the diameter of the drive pulley on the performance of electric motorcycles, including torque, power, and maximum speed.

2. Method

The method used in this study is an experimental method involving variations in the drive pulley diameter of 42T, 44T, and 46T. The testing was conducted at the Automotive Engineering Technology Laboratory, Madiun State Polytechnic. The testing tools used are a SportDyno chassis dynamometer to test performance and a road test to determine the maximum speed of the electric motorcycle.

Testing was conducted using to obtain graphs of the relationship between engine power and revolutions per minute (RPM), as well as the relationship between torque and speed. The specifications of the electric motorcycle used include a 2000 Watt BLDC motor, a 72V 20Ah battery, and the standard CVT transmission from a carburetor Beat.

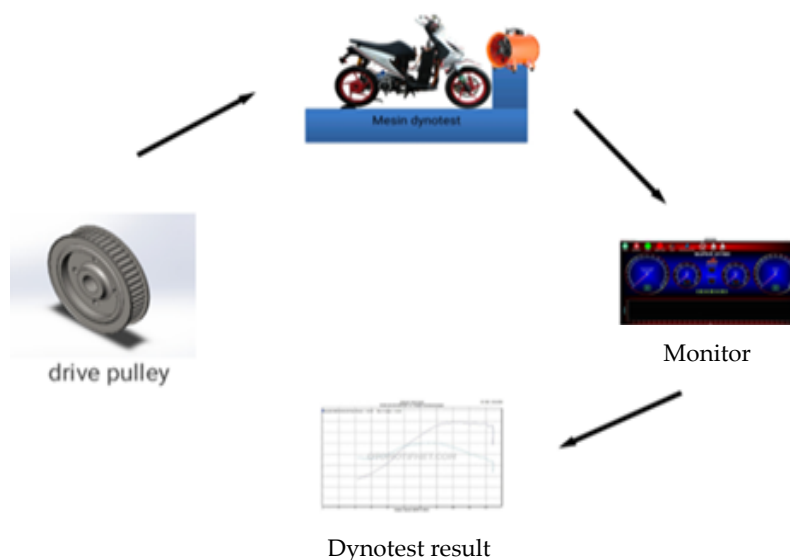


Figure 1. Research Testing Design

The stages in this research include two phases, namely:

1. Preparation Phase In this phase, the motorcycle to be tested is checked, including the battery, controller, electrical system, electric motor, and transmission system. Next, prepare the testing equipment, which is a sport chassis dynamometer.
2. Data collection stage After all the tools and materials are ready, the testing and data collection process begins. The steps are as follows:
 - a. Raise the vehicle onto the dynotest equipment.
 - b. Install safety devices for the vehicle.
 - c. Install measuring instruments and other additional equipment on the vehicle.
 - d. Start the electric motorcycle for 5 minutes.

- e. Perform the test by accelerating from idle to the maximum RPM determined by looking at the dynotest monitor screen.
- f. Release the throttle when the specified RPM is reached to determine maximum power and torque.
- g. Save the test results displayed on the dynotest monitor layer.
- h. Repeat steps a-g for other variations of the drive pulley diameter.

3. Results and Discussion

Power Analysis

The maximum power for each variation of the drive pulley is relatively the same in figure 2, which is 5.2 HP. This value indicates that changes in pulley diameter do not significantly affect the peak power of the BLDC motor because the main power is more determined by the motor specifications and the battery voltage used [1], [4].

Figure 2. Power Testing Graph

However, differences are seen in the characteristics of the power curve against rotational speed. With the 42T pulley, maximum power is reached faster because the large transmission ratio allows the motor to work optimally at low speeds. In contrast, with the 46T pulley, maximum power is reached at higher speeds due to the smaller transmission ratio [7].

Torque Analysis

Figure 3. Torque Testing Graph

Dynotest results show at figure 3 that the 42T drive pulley produces a maximum torque of 16.54 Nm, the 44T drive pulley produces 14.9 Nm, and the 46T drive pulley produces 14.1 Nm. The highest torque value was obtained with a drive pulley diameter variation of 42T. This is because a smaller diameter increases the reduction ratio in the CVT.

A smaller diameter drive pulley will result in greater torsional force. This force is what will be transmitted to the vehicle's rear wheels. The torque value will decrease as the diameter of the drive pulley used increases. This is because the reduction ratio in the transmission becomes small [10].

Top Speed and Overall Performance

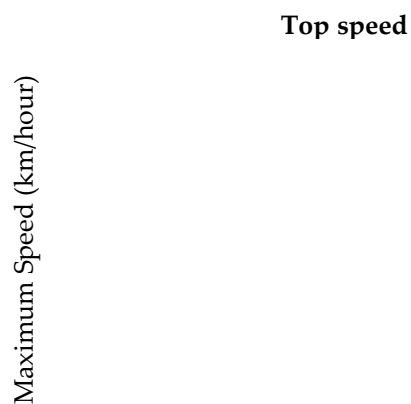


Figure 4. Top Speed Testing Graph

Road test results show that variations in pulley diameter affect the maximum speed of an electric motorcycle. The 42T pulley produced a maximum speed of 55.20 km/h, the 44T pulley 57.18 km/h, and the 46T pulley reached 63.37 km/h.

The image above shows the results of road testing on an electric motorcycle. The greater the variation in the diameter of the drive pulley used, the higher the maximum speed produced. This is evident in the top speed testing graph, where the maximum value is 63.37 km/h with a drive pulley diameter of 46T. This increase in maximum speed is due to the change in the final transmission ratio of the electric motorcycle. The larger the drive pulley diameter, the closer the transmission ratio will be to 1:1. This will cause the wheels to rotate faster relative to the engine speed [15].

4. Conclusion

Variations in the diameter of the drive pulley significantly affect the performance of an electric motorcycle with a BLDC motor. A small drive pulley (42T) produces the greatest torque, while a large drive pulley (46T) results in the highest maximum speed. The maximum power value is relatively constant at 5.2 HP.

Generally, increasing the drive pulley diameter leads to a decrease in torque but an increase in maximum speed. Therefore, the selection of pulley size must be adjusted to the vehicle's performance needs.

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