



## Performance Characteristics Of Brushless Direct Current (BLDC) Motor 350W 36V As The Driving Motor Of An Electric Bicycle

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### ARTICLE INFORMATION

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### ABSTRACT

This research aims to determine the performance characteristics of a BLDC motor 350W 36V as the driving motor of an electric bicycle at varying speeds of 10 km/hour, 20 km/hour and 30 km/hour. The distance traveled in this test is 1 km on flat road conditions with a load of 1 (one) rider of 75 kg. The test was carried out by recording the load value in the form of BLDC motor power and the duration of use of the battery when the electric bicycle was ridden. The test results show that at a speed of 10 km/hour an average motor load was recorded at 61.65 watts, at a speed of 20 km/hour an average load was recorded at 154.09 watts and at a speed of 30 km/hour an average load was recorded at 315.65 watts. The duration of use of the battery is that at a constant speed of 10 km/hour the battery can last for 4,2 hours, at a constant speed of 20 km/hour the battery can last for 1.68 hours and at a constant speed of 30 km/hour the battery can last for 0.82 hour

*Keywords: BLDC motor, electric power, electric bicycle*

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### 1. Introduction

Brushless Direct Current (BLDC) Motor is a type of synchronous motor where the magnetic field produced by the stator and the magnetic field produced by the rotor rotate at the same frequency. BLDC motors have several advantages over ordinary DC motors. These advantages include: does not use a brush, higher efficiency, almost no noise, long lasting, and many other advantages [1,2]. BLDC motors also have another characteristic where there is a controller whose job is to distribute current and voltage according to the needs for one rotation [3]. The main advantage of brushless or brushless motors is that they use semiconductor materials to change the direction of motor rotation, the motor rotation is smooth so the motor noise level is low [4]. BLDC motors have lower

torque compared to DC motors and induction motors [5,6].

Iqbal in his article explains that compared to DC motors, BLDC motors have a higher level of efficiency, performance and lower maintenance costs [7]. Rizky said that his test results showed that BLDC motors had the best efficiency of 83.29%, by producing power. amounting to 66,786 Watts at a speed of 332 rpm and a torque of 20,565 Nm [8].

Input parameters on the control unit are one way to improve the performance of the BLDC motor. The type of winding wire from the BLCD motor coil also influences the performance of the BLCD motor. Faisal explains that the Hellenic enamel wire type is better because it has a higher torsional strength (0.336 Nm) with low heat changes compared to Supreme enamel wire (0.24 Nm)

with high heat changes. The change in resistance of the enameled wire changes significantly during repeated testing which is influenced by changes in temperature [9,10].

Research that has never been carried out on BLDC motors is testing to determine the performance characteristics of BLDC motors when used to drive vehicles. This research includes tests to see what the average power load of a BLDC motor 350 W 36 V is when used at different speeds of the electric bicycle and its effect on how long the energy source from the battery can be used and how far the distance can be traveled until the battery energy runs out. It is hoped that this research will complement previous research data.

## 2. Methodology of Research

### 2.1 Exsperimental methods

The method used in this test is an experimental method in the form of direct recording of the performance of the BLDC motor when used to drive an electric bicycle. The performance characteristics of the BLDC motor are obtained based on speed variations when the electric bicycle is ridden at a constant speed of 10, 20 and 30 km/hour. The travel distance for each speed variation is 1 km. The road conditions chosen are flat and level with 1 (one) rider weighing 75 kg. The test data taken is the BLDC motor power load value. Data collection was repeated 3 (three) times for each speed variation and the average value was taken. Next, we calculate how long the battery will be used when the electric bicycle is ridden. A wattmeter is used during testing so that we can monitor the power load of the BLDC motor at any time. This research was carried out in the area around Merdeka University Malang, data collection was carried out on 14-16 July 2023.

### 2.2 Research Variables

The independent variables in this research consist of speed. The dependent variables in this research are voltage and current. Meanwhile, the control variable is the distance traveled as far as 1 (one) km and the data collection time every 14 seconds for a speed of 10 km/hour (25 data/test), 9 seconds for a speed of 20 km/hour (20 data/test) and 8 seconds for speed 30 km/h (15 data/test).

### 2.3 Experimental Setup



**Figure 1.** Series of test objects

Information:

1. Chiiwee 6-DZF-20 battery, 12 Volt, 12 Ah (3 pcs) (3 pcs)
2. ON/OFF switch
3. Wattmeter
4. Controller
5. Speed throttle handle
6. BLDC Motor 350W 36 V

## 3. Result and Discussion

The following tables are a summary of average data from the results of tests carried out at varying speeds of 10, 20 and 30 km/hour.

**Table 1.** Wattmeter data for electric bicycle speed 10 km/hour.

Table Speed of Electric Bicycle (10 km/jam)			
Number	Voltage	Ampere	Watt
1	36.87	0	0
2	35.43	2.32	821,976
3	35.85	2.41	863,985
4	35.93	1.83	657,519
5	35.52	1.81	642,912
6	35.73	1.89	675,297
7	35.9	1.96	70,364
8	35.68	1.8	64,224
9	35.91	1.28	459,648
10	34.68	1.87	648,516

11	35.9	1.79	64,261
12	35.78	1.96	701,288
13	35.67	1.76	627,792
14	35.84	1.38	494,592
15	35.71	1.46	521,366
16	35.7	1.55	55,335
17	35.83	1.38	494,454
18	35.79	1.52	544,008
19	35.76	1.68	600,768
20	35.67	1.74	620,658
21	35.77	1.44	515,088
22	35.68	1.64	585,152
23	35.34	1.54	544,236
24	35.79	1.67	597,693
25	35.82	1.78	637,596
Average	35.7	1.73	61.65

**Table 2.** Wattmeter data for electric bicycle speed 20 km/hour

Table Speed of Electric Bicycle, 20 km/jam			
Number	Voltage (V)	Ampere (A)	Watt (W)
1	36.72	0	0
2	35.36	2.34	827,424
3	35.85	5.31	1,903,635
4	34.72	4.24	1,472,128
5	34.59	4.45	1,539,255
6	34.48	4.62	1,592,976
7	34.41	4.68	1,610,388
8	34.97	4.78	1,671,566
9	34.49	4.47	1,541,703
10	34.65	4.96	171,864
11	34.42	4.22	1,452,524
12	34.29	4.96	1,700,784
13	33.91	4.61	1,563,251
14	33.98	4.74	1,610,652
15	34.55	4.51	1,558,205
16	34.57	4.16	1,438,112
17	34.72	4.45	154,504
18	34.7	4.04	140,188
19	34.58	4.56	1,576,848
20	34.87	4.45	1,551,715
Average	34.64	4.45	154.09

**Table 3.** Wattmeter data for electric bicycle speed 30 km/hour

Table Speed of Electric Bicycle (30 km/jam)			
Data Number	Voltage	Ampere	Watt
1	36.78	0	0
2	36.58	8.7	318,246
3	34.67	7.82	2,711,194
4	34.45	9.83	3,386,435
5	35.65	8.67	3,090,855
6	34.34	9.87	3,389,358
7	34.47	8.89	3,064,383
8	34.76	8.45	293,722
9	35.58	9.35	332,673
10	34.69	8.62	2,990,278
11	35.73	8.79	3,140,667
12	34.21	9.32	3,188,372
13	35.89	9.71	3,484,919
14	34.63	8.45	2,926,235
15	35.68	9.45	337,176
Average	35.1	8.99	315.65

**Calculation**

Is known:

- Battery voltage (V) = 12 volts
- Battery capacity (I) = 12 Ah
- From each table, the average BLDC motor power load is 61.65 Watts for a speed of 10 km/hour, 154.09 Watts for a speed of 20 km/hour and 315.65 Watts for a speed of 30 km/hour.

**1. Battery Energy (E)**

$$E = V \times I \times n \text{ (Wh)}$$

Where :

V : Voltage (Volts)

I : Current (Ah)

n : Number of batteries used

$$E = 12 \times 12 \times 3 = 432 \text{ Wh}$$

Note: the maximum battery energy recommended for use is 60% (Efficiency Factor) so:

$$E_{\text{use}} = E \times 60\%$$

$$E_{\text{use}} = 259.2 \text{ Wh}$$

**2. Battery energy runs out for a long time**

a. Speed 10 km/h

If the average load is 61.65 watts at a speed of 10 km/h. So if an electric bicycle is used at a constant speed of 10 km/hour the battery lasts =  $259.2/61.65 = 4.20$  hours or is identical to the ability to cover a distance of 42 km.

- b. Speed 20 km/h  
If the average load is 154.09 watts at a speed of 20 km/h. So if an electric bicycle is used at a constant speed of 20 km/hour the battery lasts =  $259.2/154.09 = 1.68$  hours or is identical to the ability to cover a distance of 33.6 km.
- c. Speed 30 km/h  
If the average load is 315.65 watts at a speed of 30 km/hour. So if an electric bicycle is used at a constant speed of 30 km/hour the battery lasts =  $259.2/315.65 = 0.82$  hours or is identical to the ability to cover a distance of 24.6 km.

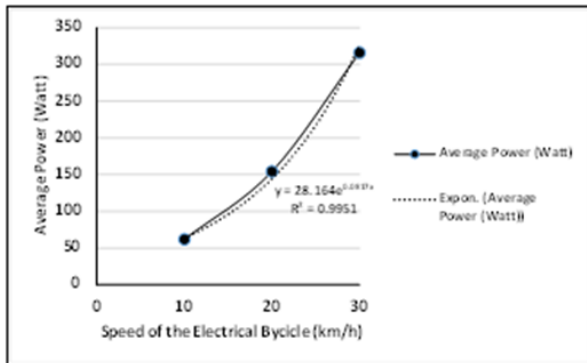


Figure 2. Graph of BLDC motor power load based on speed variations

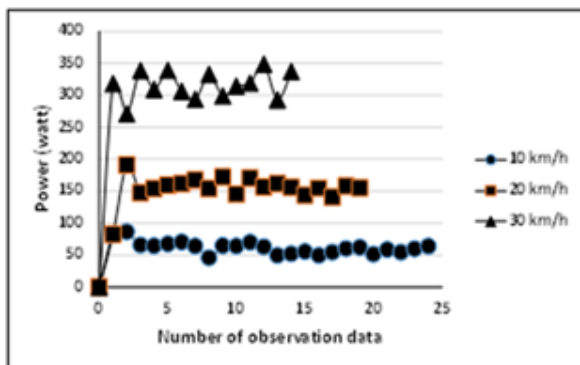


Figure 3. The relationship between speed variations and the increase in BLDC motor power load

The The time span between data taken during testing cannot be the same for variations in electric bicycle speed because the faster the electric bicycle is ridden, the more difficult the recording process is when the data is taken. Researchers are only trying to take as much data as possible from each speed variation so that the average power load of the BLDC motor is more accurate and credible.

Based on tables, calculations, Figures 2 and 3 show that the relationship between the increase in bicycle speed and the average power load of the BLDC motor follows an exponential equation  $y = 28.164e^{0.0817x}$ , not a linear equation.. This means that the faster the speed of an electric

bicycle, the electricity consumption required for the BLDC motor's power load increases exponentially, much greater than the increase in speed itself. Thus, for the same distance and carrying load, the faster the electric bicycle, the more wasteful the use of electrical energy from the battery will be. This can be seen from the calculation results, for a constant speed of 10 km/hour, the battery can be used for up to 4.2 hours or is identical to the ability to cover a distance of 42 km. Meanwhile, if the constant speed is increased to 30 km/hour, then the battery can only used for up to 0.82 hours or identically only able to cover a distance of 24.6 km

#### 4. Conclusions

1. The relationship between increasing the speed of an electric bicycle is not directly proportional to increasing the power load of the BLDC motor but rather follows the exponential equation  $y = 28.164e^{0.0817x}$ .
2. The best battery usage efficiency in this experiment was obtained at the lowest constant speed, 10 km/hour where the battery can be used for 4.20 hours or is identical with the ability to cover a distance of 42 km.

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