e-ISSN : 3047-4337
JOTECH, Vol. 2, No. 4, October 2025
Page 6-14

The Effect of The Number of Windings on Torque and Power of A 250W Electric Motor on An Electric Bicycle

Ajitiyo Dananjoyo[1], A'rasy Fahrudin[2]
[1,2] Muhammadiyah University of Sidoarjo, Indonesia

DOI : https://doi.org/10.61796/ipteks.v2i4.425

Sections Info

Article history:
Submitted: August 15, 2025
Final Revised: September 25, 2025
Accepted: October 05, 2025
Published: October 31, 2025

Keywords:
Electric Motor
Torque
RPM Speed
Power

ABSTRACT

Objective: *This study aims to investigate the effect of variations in the number of windings on torque and power output in a 250 W DC motor applied to electric bicycle propulsion, considering the growing demand for efficient, low-cost, and environmentally friendly ground transportation.* ***Method:*** *An experimental approach was employed by modifying the armature windings of a DC motor through both increasing and decreasing the number of coils. Motor performance was evaluated by measuring rotational speed (RPM), torque, and output power under standard winding conditions, additional windings, and reduced windings.* ***Results:*** *The standard winding configuration produced a torque of 0.55 Nm and power of 5.7 W at 100.4 RPM. Increasing the number of windings resulted in a torque of 0.55 Nm and reduced power of 4 W at 77.8 RPM. Conversely, reducing the windings increased rotational speed to 131.3 RPM, yielding a torque of 5.5 Nm and power of 7.5 W. The findings indicate that increased windings reduce RPM and power, while reduced windings enhance RPM and power output.* ***Novelty:*** *This study provides empirical evidence on how winding modification directly influences DC motor performance in electric bicycles, offering practical insights for optimizing motor design through winding configuration adjustments.*

INTRODUCTION

Transportation is a means used by individuals to travel from one location to another. Transportation is divided into three categories: land, sea, and air. For daily use and commuting, people tend to choose land transportation such as buses, cars, and bicycles because they are practical and efficient. As technology advances, transportation systems have evolved from fuel-based and manual systems to environmentally friendly electric systems [1]. According to Google Trends, the use of electric vehicles in Indonesia has increased by approximately 300%. Electric bicycles are one of the most actively developed electric transportation modes. An electric bicycle requires a DC motor to generate mechanical energy through electromagnetic interaction. The number of windings in the motor significantly affects torque and power output. Therefore, this study aims to analyze the effect of winding variation on the torque and power of a 250W electric motor [2].

RESEARCH METHOD

In this study, an experimental method was used, namely conducting research using an electric bicycle drive system with a 250 Watt electric motor as a driver [3]. By modifying the electric motor used, the modification of the work tools in this study focused on the number of coils on the electric motor [4], [5]. For this electric motor modification, by comparing the standard coils, then reducing the number of coils, then increasing the number of coils on the electric motor used as an electric bicycle driver [6].

In this study, the method uses experiments by giving a load to the wheel by braking and regulating the amount of load given to the electric motor to determine the power and torque on the electric motor [7]. The tools and materials used in this study are: 250 Watt DC motor, the DC motor here is used as a driver on an electric bicycle and as a material to be tested in this study, Torque and power test equipment The test equipment here is used to test power and torque [8]. The test equipment used by the author is a test equipment made and designed by the author himself to get maximum results [9]. Next there is copper, copper here is used to increase and decrease the number of turns to determine the effect of the number on the torque and power of the electric motor Tachometer In this study, the tachometer is used to collect RPM data on a 250 Watt DC motor Scales Scales are used to determine the load given to the DC motor [10].

Figure 1. Testing tools

The test equipment above uses a DC motor to drive the test equipment. The DC motor used has a standard 250-watt specification. It is connected by a chain to the test equipment wheel. This test equipment has a predetermined braking load, based on the weight of a digital scale [11], [12].

Testing Stages:

1. Determine the number of turns to be added and subtracted on the 250-watt DC motor.
2. Add and subtract turns on the 250-watt DC motor.
3. Vary the load during the test.
4. Collect data at the 250-watt DC motor rpm.
5. Process the test results and compare the results of the standard winding, the addition of turns, and the reduction of turns.

RESULTS AND DISCUSSION

This study used 3 variations in the number of turns and also variations in braking on a 250W electric motor. In the initial study, data was taken on standard turns and then given variations in braking. Braking was carried out three times, the first without a braking load, then given a braking load of 1 kg, then given a load of 2.8 kg. After collecting the standard turns data, the next step was to reduce the turns, followed by adding turns. The data needed is the RPM and the load given to the electric motor to calculate the torque and power on the electric motor. The formula used for the calculation is:

$$T = F \times L$$

T = Torque (N/M)
F = Applied Load (N)
L = Arm Length (M)

$$P = \frac{2\pi.N.T}{60} \quad (2)$$

P = Power (Watts)
N = Rotation (RPM)
T = Torque (N.M)

The following is an example of calculating the power and torque of an electric motor with a reduced winding size of 22 turns, under a load of 2.8 kg and at 125.2 rpm. The calculation results are as follows:

It is known that: F = 2.8 kg
F = 2.8 x 10
F = 28 Newtons
N = 125.2 RPM
L = 5.5 cm
L = 5.5 : 100
L = 0.055 Meters

Torque Calculation:
T = F X L
T = 28 N X 0.055
T = 1.54 N.M
Power Calculation
P = (2π.N.T)/60
P = 6.28x125.2x1.54/60
P = 1210.83/60
P = 20.1 Watts

This research focused on modifying the number of turns. The standard winding system has 29 turns. Seven turns were added to the total number of turns, bringing the total number of turns to 36. This increase was based on the maximum winding capacity of the motor. After the additional turns, the number of turns on the electric motor was reduced by seven turns. This reduction was also carried out by seven turns, from the original standard winding system of 29 turns to 22 turns.

Data collection yielded the following results:

Table 1. Data Collection Results

No	Number Of Load	Windings (KG)	Arm length (CM)	RPM	Torque (N.M)	Power (WATT)
1	29	0	5,5	103,8	0	0
2	29	1	5,5	100,4	0,55	5,7
3	29	2.8	5,5	96,3	1,54	15,5
4	22	0	5,5	137,2	0	0
5	22	1	5,5	131,3	0,55	7,5
6	22	2.8	5,5	125,2	1,54	20,1
7	36	0	5,5	81,4	0	0
8	36	1	5,5	77,8	0,55	4
9	36	2.8	5,5	74,6	1,54	12

The table above shows that the highest RPM for the standard winding is 103.8. After adding turns, the highest RPM reached 81.4. Subtracting the turns resulted in a maximum RPM of 137.2.

1. Effect of Standard Winding RPM on Torque and Power

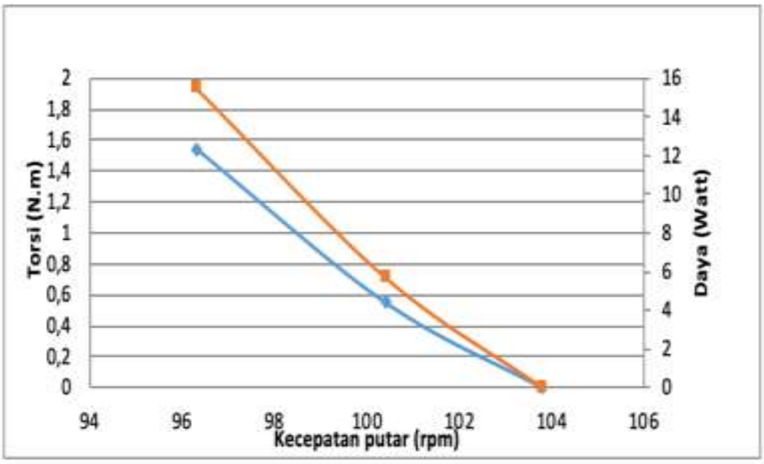

Figure 2. RPM on Torque and Power for Standard Winding

In the above-mentioned test, the winding power was compared, the goal being to determine the maximum power that could be generated by varying the winding power, starting with a standard winding power and increasing, decreasing, or adding more windings. The experiment could potentially yield the following data:

The graph above shows that when adding coils (coil 1), the highest power reaches 12 watts after calculations and load application in the experiment. With the standard coil, the highest power reaches 15.5 watts, and with the reduced coil, the highest power reaches 20.1 watts. Therefore, it can be concluded that the fewer coils, the greater the power produced, whereas if the number of coils is greater, the power produced will be smaller.

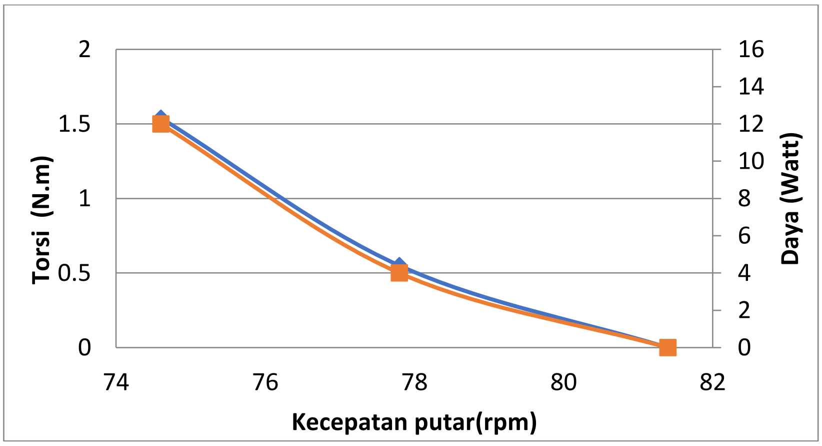

Figure 3. RPM versus Torque and Power After Adding Windings

As seen from the table above, the torque generated is 1.54 and the power required is 12 watts at an rpm of 74.6. With a braking load of 0 kg, the peak RPM of the standard winding is 81.4. As a result, the motor speed decreases as the motor torque increases due to the interaction of braking force and motor power.

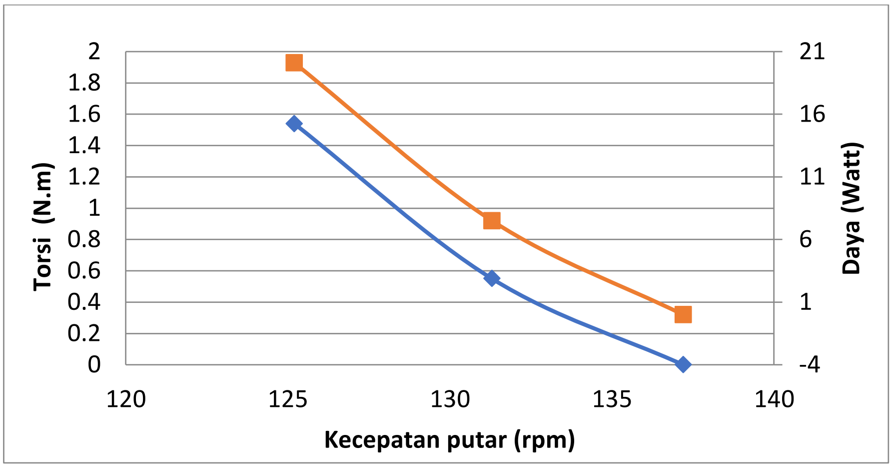

Figure 4. RPM versus Torque and Power After Winding Reduction

The graph above shows that at 125.2 rpm, 1.54 lb-ft of torque is produced and 20.1 watts of power are required. With a brake load of 0 kg, the highest RPM of the standard reel is 137.2. Consequently, motor speed decreases as motor torque increases due to the interaction of braking force and motor power.

In the above-mentioned test, torque and windings were compared. The goal was to determine the maximum torque that could be produced by varying the windings, starting with a standard winding and increasing, decreasing, or adding more turns. The experiment could potentially yield the following data:

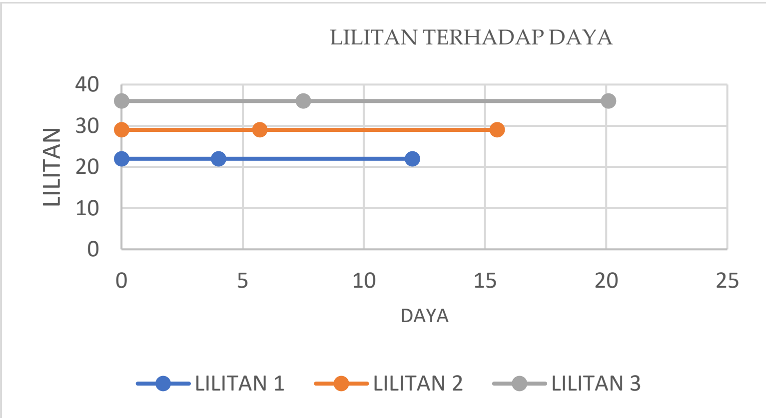

Figure 5. Torque on Coils

In the above-mentioned test, the winding power was compared, the goal being to determine the maximum power that could be generated by varying the winding power, starting with a standard winding power and increasing, decreasing, or adding more windings. The experiment could potentially yield the following data:

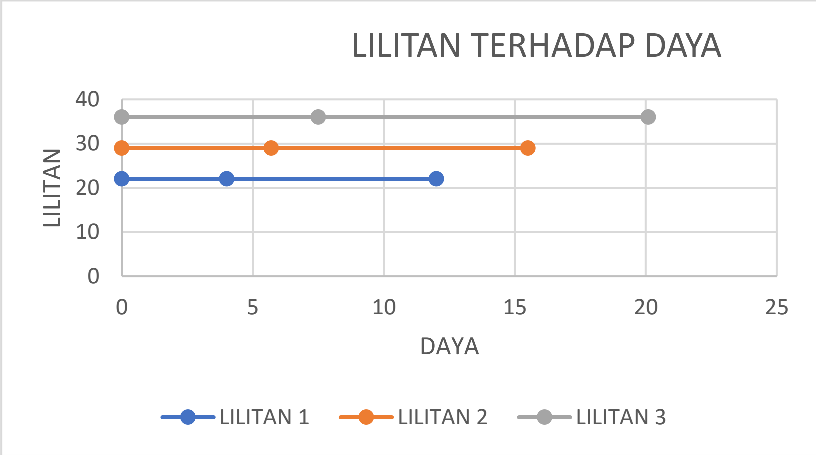

Figure 6. Coils versus Power

The graph above shows that when adding coils (coil 1), the highest power reaches 12 watts after calculations and load application in the experiment. With the standard coil, the highest power reaches 15.5 watts, and with the reduced coil, the highest power reaches 20.1 watts. Therefore, it can be concluded that the fewer coils, the greater the power produced, while if the number of coils is greater, the power produced will be smaller [13], [14], [15].

CONCLUSION

Fundamental Finding : The results demonstrate that variations in the number of coils significantly influence the performance characteristics of a DC electric motor, particularly rotational speed (RPM), torque, and power output. An increase in the number of coils leads to a decrease in RPM and power, while coil reduction results in higher RPM and power output, indicating an inverse relationship between coil quantity and motor speed–power performance. **Implication :** These findings provide practical implications for electric bicycle motor design, suggesting that coil configuration can be strategically optimized to achieve desired performance characteristics, such as higher speed or greater efficiency, depending on application requirements. **Limitation :** This study is limited to a single 250 W DC motor and focuses solely on coil variation without considering other influencing factors such as thermal effects, load variations, long-term durability, or efficiency losses. **Future Research :** Future studies should examine the combined effects of winding configuration with load conditions, efficiency analysis, thermal performance, and energy consumption, as well as extend the investigation to different motor capacities and real-world electric bicycle operating conditions to enhance generalizability and applicability.

REFERENCES

[1] В. О. Бржезицький, Я. О. Гаран, and І. М. Маслюченко, “Detailing of the transformer equation to the single winding turns (groups of the winding turns),” *Technology audit and production reserves*, vol. 1, no. 1(27), p. 32, Jan. 2016, doi: 10.15587/2312-8372.2016.59101.

[2] M. Pane, B. C. W. Dwisanda, and R. Samosir, “Thrust Analysis of 250 Watt DC Motor With 12 Volt And 24 Volt,” *VANOS Journal of Mechanical Engineering Education*, vol. 7, no. 2, Nov. 2022, doi: 10.30870/vanos.v7i2.16772.

[3] L. H. Liyun Hu and Z. Z. Zhiming Zhang, “New approach for normalization and photon-number distributions of photon-added (-subtracted) squeezed thermal states,” *Chinese Optics Letters*, vol. 10, no. 8, pp. 82701–82704, 2012, doi: 10.3788/col201210.082701.

[4] E. Malecki, “Su003 GASTROENTEROLOGY TRAINEE PERCEPTIONS OF COGNITVE LOAD DURING ENDOSCOPY VARY BY CLINICAL SITE,” *Gastroenterology*, vol. 160, no. 6, p. S-586, May 2021, doi: 10.1016/s0016-5085(21)02097-7.

[5] A. Eikani, B. M. Mosammam, M. Mirsalim, and A. Khorsandi, “Six Degrees of Freedom Wireless Power Transfer by Crossed Dipole Transmitting Coils and the Minimum Number of Receiving Coils,” in *2022 13th Power Electronics, Drive Systems, and Technologies Conference (PEDSTC)*, IEEE, Feb. 2022, pp. 587–591. doi: 10.1109/pedstc53976.2022.9767219.

[6] Y. Ma, J. Zhao, and Y. Xia, “The Law of Winding Connection Sequences for Multiphase Series Winding Inverters Considering Reverse Connection of Windings,” *IEEE Trans Power Electron*, pp. 1–12, 2025, doi: 10.1109/tpel.2025.3640357.

[7] C.-M. Hwang, J.-H. Park, and Y.-G. Kim, “Study on the low voltage DC short-circuit test and DC test equipment,” in *2015 3rd International Conference on Electric Power Equipment – Switching Technology (ICEPE-ST)*, IEEE, Oct. 2015, pp. 492–494. doi: 10.1109/icepe-st.2015.7368339.

[8] R. Abdollahi, “Induction motor drive based on direct torque controlled used multi-pulse AC-DC rectifier,” *International Journal of Applied Power Engineering (IJAPE)*, vol. 10, no. 2, p. 89, Jun. 2021, doi: 10.11591/ijape.v10.i2.pp89-96.

[9] C. Ma *et al.*, “Effects of static eccentricity on the no-load back electromotive force of external rotor permanent magnet brushless DC motor used as in-wheel motor,” *IET Electr Power Appl*, vol. 13, no. 5, pp. 604–613, Jan. 2019, doi: 10.1049/iet-epa.2018.5394.

[10] S. Kuznetsov, “High speed 5000 hp superconducting propulsion motor for marine electric drives utilizing YBCO field coils,” in *IEEE International Electric Machines and Drives Conference. IEMDC’99. Proceedings (Cat. No.99EX272)*, in IEMDC-99. IEEE, pp. 743–745. doi: 10.1109/iemdc.1999.769229.

[11] A. Marcus and O. Pinkus, *Characterization Study of an Electric Motor-Transmission System for Electric Vehicles*. 1977. doi: 10.2172/12133186.

[12] A. Dananjoyo and A. Fahrudin, “Effect of Number of Turns on Torque and Power of 250w Electric Motorcycles on Electric Bikes: Pengaruh Jumlah Lilitan terhadap Torsi dan Daya Motor Listrik 250w pada Sepeda Listrik,” Jan. 2024, doi: 10.21070/ups.3697.

[13] F. Kong and X. Liu, “Sustainable Transportation with Electric Vehicles,” *Foundations and Trends® in Electric Energy Systems*, vol. 2, no. 1, pp. 1–132, 2017, doi: 10.1561/3100000016.

[14] R. D. Stevens, “Transportation and Land Use — Is There a Relationship?,” in *Transportation, Land Use, Planning, and Air Quality*, American Society of Civil Engineers, Jul. 2009, pp. 131–140. doi: 10.1061/41059(347)12.

[15] G. Gunawan, “PENGEMBANGAN PERANGKAT PEMBELAJARAN FISIKA PENDEKATAN SAINTIFIK DAN PEMBELAJARAN KOOPERATIF DALAM UPAYA MENINGKATKAN KOMPETENSI PENGETAHUAN, SIKAP DAN KETERAMPILAN PROSES SISWA SMK,” *Vidya Karya*, vol. 33, no. 2, p. 131, Jan. 2019, doi: 10.20527/jvk.v33i2.5643.

Ajitiyo Dananjoyo
Muhammadiyah University of Sidoarjo, Indonesia

***A'rasy Fahrudin (Corresponding Author)**
Muhammadiyah University of Sidoarjo, Indonesia
Email: arasy.fahrudin@umsida.ac.id