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Experimental Study on the Conversion of Fuel Injection Motorcycles into Electric Vehicles Through Dynotest Performance Testing

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Abstract

This study aims to test the results of converting a gasoline-fueled motorcycle with an injection system into an electric bike in terms of horsepower and torque. The data from the unit conversion testing in this study used an experimental method with data analysis that compares the results of dyno tests on a gasoline-fueled motorcycle unit using variations of fuel octane values with dyno test data from the unit after being converted into an electric vehicle. The testing equipment and materials used in the study were Sportdyno 4.0, a 110 CC Injection Matic Motorcycle unit, and Pertamax Fuel. The results of this study show that the highest power and torque on the gasoline-powered motorcycle were 6.2 Horsepower (HP) at 6500 to 6600 rpm, and the highest torque was 6.8 N.m at 6400 rpm for the unit before conversion. After the conversion, the highest power achieved was 5.4 HP at an average of 2250 to 2500 rpm, and the highest torque was 28.48 N.m at 1100 rpm for the converted vehicle unit. Thus, it can be concluded from the average data analysis of the power and torque tests that the result of the electric vehicle conversion is 5.4 HP and 28.48 N.m.

Keywords: *Electric Vehicle, Motor Power, Motor Torque, Energy Conversion, Electric Motor.*

Abstrak

Penelitian ini bertujuan untuk pengujian hasil konversi unit sepeda motor berbahan bakar bensin dengan sistem injeksi menjadi kendaraan sepeda motor listrik terhadap hourspower dan torsi kendaraan. Hasil data pengujian konversi unit sepeda motor pada penelitian ini menggunakan metode eksperimental analisis data yang digunakan adalah analisis komparasi hasil *dynotest* konversi unit sepedamotor berbahan bakar minyak (BBM) menggunakan variasi bahan bakar nilai oktan, dengan data hasil *dyno test* unit setelah dilakukan konversi menjadi kendaraan listrik. Alat Uji dan bahan yang penelitian yang digunakan yaitu: *Sportdyno 4.0,* unit Sepeda Motor Type Matic Injeksi 110 CC dan Bahan Bakar Pertamax. Hasil penelitian ini menunjukan bahwa daya dan torsi tertinggi pada sepeda motor dengan menggunakan BBM sebesar 6,2 *Horsepower* (HP) pada 6500 rpm sampai dengan 6600, *Torque* tertinggi sebesar 6,8 (N.m) pada Rpm 6400, untuk unit sepeda motor sebelum dilakukan konversi. Pengujian kendaraan setelah di konversi didapat daya tertinggi sebesar 5,4 pada rata-rata 2250 sampai dengan 2500 rpm dan torsi tertinggi adalah 28,48 (N.m) pada 1100 rpm untuk unit kendaraan yang telah di konversi. Dengan demikian dapat disimpulkan dari analisis rata-rata data pengujian daya dan torsi yang dilakukan dari hasil konversi kendaraan listrik adalah 5,4 (HP) dan 28,48 (Nm).

Kata kunci: *Electric Vehicle*, Daya Motor, Torsi Motor, Konversi Energi, Motor Listrik

1. Introduction

The current era of mass transportation has received serious attention from the government through Presidential Regulation Number 55 of 2019 concerning the Acceleration of the Battery Electric Vehicle Program for Road Transportation (Perpres No. 55 of 2019). The issuance of this regulation is expected to create new opportunities for developing public transportation in Indonesia, promoting the use of electric vehicles for public transport. As of September 2020, the population of electric public vehicles in Indonesia totaled only 2,278 units, representing the number of electric vehicle certifications issued by the Ministry of Transportation **[1]**.

The Indonesian government continues to promote accelerating adoption of electric vehicle (EV) to support the transition to clean energy and reduce carbon emissions. Two key regulations governing EV conversion include: 1) Ministerial Regulation of Energy and Mineral Resources (ESDM) No. 03 of 2023: This regulation outlines the government assistance guidelines for converting internal combustion engine (ICE) motorcycles to battery-powered electric motorcycles. It includes provisions on the conversion process, eligibility criteria for assistance, and certification requirements for conversion workshops. 2) Presidential Instruction No. 7 of 2022: These mandates using battery-based electric vehicles as operational vehicles in government institutions to accelerate the adoption of battery technology. These policies are expected to accelerate the development of an inclusive EV ecosystem involving businesses, government, and the public **[2]**.

The performance of injection motorcycles with aging engines is no longer optimal due to wear and tear on engine components caused by prolonged usage. This results in increased fuel consumption, reduced power and torque output, and a significant rise in CO emissions in the vehicle's exhaust gases **[3]**. The fuel supply system technology mechanism used in motor vehicles to improve performance and reduce exhaust emissions currently relies on the Fuel Injection System technology **[4] [5]**.

A study on the conversion of motorcycles with internal combustion engines (ICE) indicates that electric motorcycles are the best alternative to replace ICE motorcycles, particularly from a sustainability perspective. Three main criteria need to be considered: 1) Net Present Value (NPV), 2) Payback Period (PP), and 3) Environmental impact. ICE motorcycles are one of the dominant vehicle types in this sector, and transitioning to electric technology is an effective solution to reduce carbon emissions **[6]**.

Several factors need to be considered in planning the conversion of an electric-powered system to be applied to a vehicle. These include the size and weight of the car, the required power, the achievable range, and the battery charging time. Additionally, selecting components such as the electric motor, battery, and motor controller is also conducted at this stage. Replacing the Internal Combustion Engine System with an Electric-Powered System In this phase, the internal combustion engine system currently installed in the vehicle will be removed and replaced with an electric-powered system. Components such as the electric motor, battery, motor controller, and battery charger will be installed on the vehicle **[7]**.

According to the vehicle conversion study, transitioning from conventional to electric vehicles increases the total vehicle weight due to installing electric motors and batteries. The system utilizes a 3-phase motor powered by a 150 AH battery with a total voltage of approximately 72 VDC, supplemented by an additional 12 VDC battery. This weight increase significantly affects the vehicle's center of gravity. The study primarily analyzes the performance of the transmission and electric motor in terms of power and torque delivery **[8]**.

The perspective of electric vehicle (EV) conversion technology focuses on improving energy efficiency and reducing pollution, which are the primary goals of EV technology adoption. It also explores the potential of using batteries as energy storage within electric power systems (EPS). Addressing issues such as *range anxiety* and minimum range thresholds can enhance driver participation in Vehicle-to-Grid (V2G) schemes **[9]**. This implementation requires advanced technologies, including bidirectional charging capabilities, intelligent battery management systems, and control systems that optimize energy usage for EVs. According to Kim et al. (2018), cited in the study by Ramadhani, S., & Yuliana, L. (2023), consumer perceptions of the economic benefits of EVs—such as energy cost savings, reduced maintenance costs and repair expenses—are key factors driving interest in EV purchases. However, challenges related to battery charging remain significant barriers for consumers considering EV adoption **[10]**.

A dyno test is a performance measurement tool used to determine torque and power values in vehicle performance testing. Regarding engine revolutions, vehicle speed has torque measured in Newton meters (N.m) and power measured in Horsepower (HP). The dyno test can assess These two performance metrics **[11]**.

The measure of an engine's ability to perform work is torque, making torque a form of energy. The magnitude of torque at a specific rotation can be calculated using the following equation:

$$T = 9549 \frac{N}{n_m}$$

Horsepower, commonly called HP, is the ability to carry a load within a particular period or time frame, measured in horsepower units (HP). Horsepower significantly affects the speed of a vehicle. [12]

$$HP = \frac{\text{Torsi (lbs.ft)x RPM}}{5252}$$

Explanation of meaning:
T = Motor torque (N.m)
N = Motor power (HP)
n = Motor speed (rpm)

The dyno test was conducted to measure the torque and power of the vehicle's primary drive based on variations in rpm. The testing was carried out by assessing maximum performance when the vehicle unit was spontaneously subjected to a full-throttle opening during the performance test, thereby achieving the desired optimal values. The researcher utilized power, torque, and rpm as variables for analysis. This study represents a developmental research effort that can serve as a reference for future research aimed at obtaining effective and efficient values in the performance testing of electric vehicles (EVs).

2. Method

The research method used is quantitative with an experimental approach. This study demonstrates the impact of power and torque measurements on a 110 CC matic motorcycle unit by converting the same type of motorcycle into an electric vehicle. After obtaining the laboratory test data, hypothesis testing is conducted using data analysis.

This test aims to identify the efficiency and performance of electric vehicles compared to conventional vehicles. Its conclusions provide technical insights and recommendations for further development. This process demonstrates a thorough scientific approach to supporting innovations in renewable energy-based transportation technology.

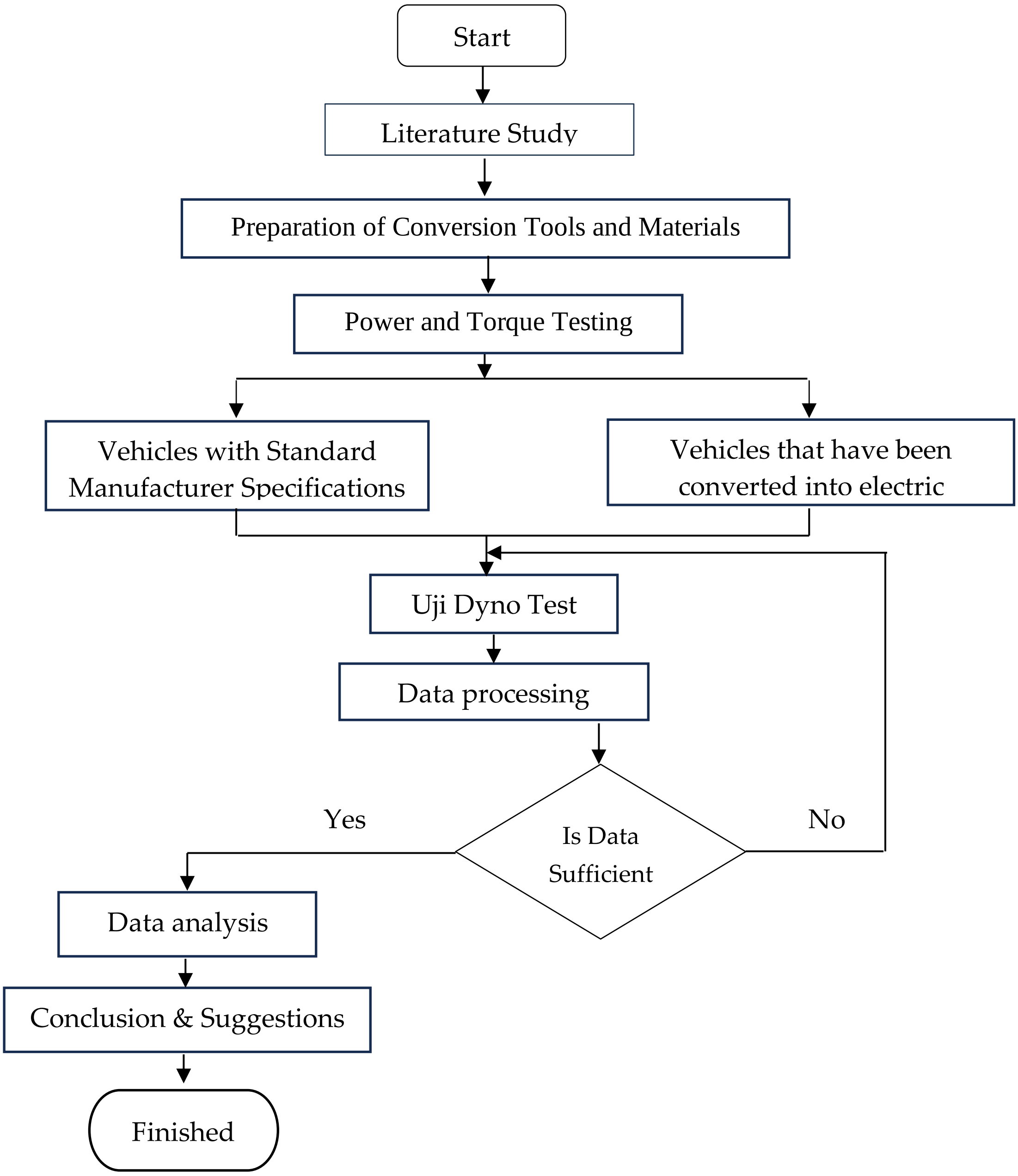

Figure 1. Research Flow Chart

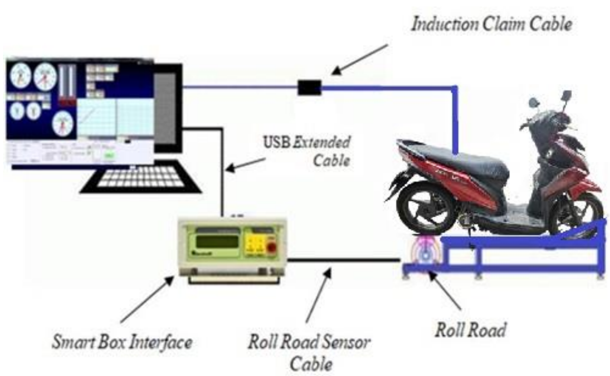

Figure 2. Power and Torque Test Scheme for EV Conversion Vehicles

The test using the dyno test specifications employed in this study is presented in the following **Table 1**.

Table 1. Dyno test Specifications

Measurment Items	:	Speed, rpm, Aceleration, Power, Gear Ratio, AFR, Tack, Wheather
Maximum Power	:	200 Hp / 147 Kw
Max Speed	:	300 km/hr
Max Rpm	:	20.000 rpm
Roll Road Diameter	:	6 inches
Weight	:	400 kg
Power Supply	:	Powerless (5volt)
Dimentional	:	2110 x 1000 x800 mm
Optional	:	Notebook

Table 2. Vehicle Specification Data

Tipe Mesin	Spesifikasi
Machine Type	4 Stroke, 2 Valve OHC, Air-Cooled, PGMFI
Cylinder Volume	110 CC
Ignition System	Full transistor, Battery
Spark Plug	NGK / CPREA9-9, DENSO U27EPR9
Bore and Stroke	52,4 x 57,9 mm
Maximum Torque	8,68 N.m / 6500 rpm
Compression Ratio	9,5: 1
Fuel System	Fuel Injection
Dimension	1863 x 678 x 1072 mm
Transmision	Full Automatic
Battery	MF Battery 12V 3 Ah
Oil Capacity	Total : 0,84 L ; Periodic : 0,80 L ; Replace Oil Filter : 0,80 L

Source from: Honda Beat 110 FI Service Manual. PT. AHM **[13].**

Table 3. Conversion Vehicle Specification Data

Unit Type	Specification
Energy source	Electric DC
Drive Motor Type	BLDC 2000 Watt
Battery	Lithium Ion 72V
Controller	BRT Juken 10 EV, For Electric Motorcycles BLDC 0.8KW-3KW with Voltage 48V-72V
Transmision	Automatic/Fix With Belt Gear

3. Results and Discussion

The driving motor on the converted 110 CC automatic motorcycle produced three test results for power and torque performance testing. Before conversion, with the unit in standard factory condition, the maximum power and torque values of the motor can be observed in the test result data Table 4.

Table 4. Vehicle Power Test Results Data Before Conversion

Engine Rotation (Rpm)	Power (HP)			
	Test 1 (HP)	Test 2 (HP)	Test 3 (HP)	Average Value
6300	5,6	6,2	6,2	6,0
6400	5,7	6,2	6,1	6,0
6500	5,8	6,2	6,1	6,0
6600	5,8	6,1	6,0	6,0
6700	5,9	6,1	6,0	6,0
6800	6,0	6,0	5,9	6,0
6900	6,1	6,0	5,9	6,0
7000	6,0	6,0	5,8	5,9

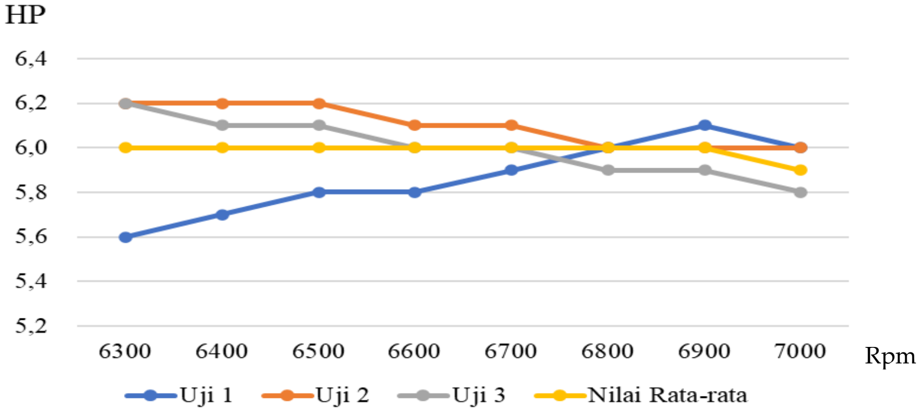

Figure 4. Power test graph (HP) before conversion

From the power test results of the motorcycle before being converted into an electric motorcycle, within the range of 6300–7000 Rpm, the average power remained relatively stable at 6.0 HP, with only a slight drop at 7000 Rpm to 5.9 HP. The maximum average power was 6.0 HP, achieved across almost the entire Rpm range (6300–6900 Rpm). The three tests (Test 1, Test 2, and Test 3) showed very similar results, with a slight variation of 0.1–0.3 HP, indicating the stability of the testing system and engine performance. The 6300–6900 Rpm range is the optimal range for engine power, where the average power remained stable at 6.0 HP. At 7000 Rpm, there was a slight decline in average power to 5.9 HP, indicating that the engine's efficiency decreased at the highest rotational speed.

Table 5. Data of Power Test Results After Conversion

Engine Rotation (Rpm)	Power (HP)			
	Test 1 (HP)	Test 2 (HP)	Test 3 (HP)	Average Value
1000	3,9	4	3,8	3,9
1100	4,3	4,4	4,2	4,3
1250	4,8	4,7	4,6	4,7
1500	5,2	4,9	5	5,0
1750	5,3	5,2	5,1	5,2
2000	5,4	5,2	5,3	5,3
2250	5,4	5,4	5,4	5,4
2366	5,4	5,4	5,4	5,4
2500	5,4	5,4	5,4	5,4
2750	5,3	5,3	5,3	5,3
3000	5,1	5,2	5	5,1
3250	5	5	5,1	5,0
3500	4,8	4,8	4,7	4,8
3750	4,7	4,8	4,6	4,7
4000	4,7	4,7	4,5	4,6
4250	4,5	4,5	4,4	4,5

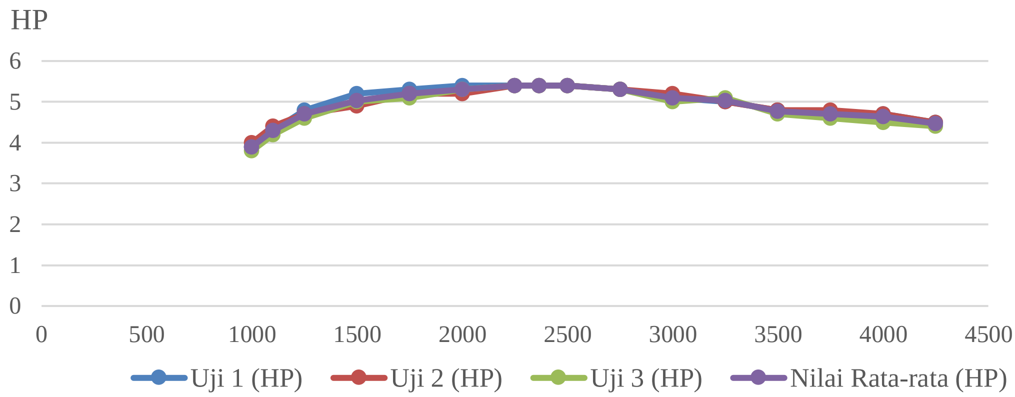

Figure 5. Power test graph (HP) after conversion

Based on the power test data of the motorcycle after conversion, the power increases as the rpm goes from low to mid-range, with power (HP) rising as engine speed (rpm) increases from 1000 to around 2250 rpm. The highest power value is achieved at rpm 2250-2500 with an average power of 5.4 HP. The converted electric motorcycle shows the best power efficiency at mid-range rpm (2250–2500 rpm). The power increases at low to mid-range RPM, but at high RPM, there is a performance decline, indicating possible limitations of the motor at higher speeds.

Table 4. Torque Test Results Data Before Conversion

Putaran Mesin (Rpm)	**Torsi (N.m)**			
	Test 1 (N.m)	Test 2 (N.m)	Test 3 (N.m)	Average Value
6300	6,97	6,68	6,88	6,84
6400	6,87	6,86	6,82	6,85
6500	6,64	6,87	6,35	6,62
6600	6,39	6,86	5,78	6,34
6700	6,14	6,81	5,49	6,15
6800	5,93	6,61	5,43	5,99
6900	5,70	6,28	5,30	5,76
7000	5,45	5,87	5,00	5,44

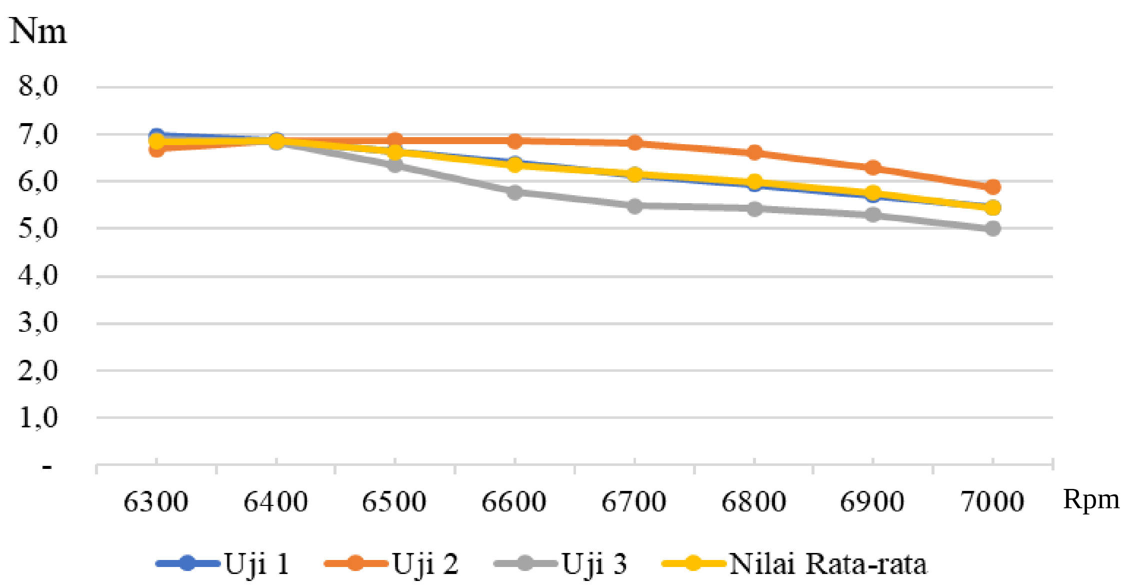

Figure 6. Torque test graph (N.m) before conversion

The motorcycle's torque test before conversion shows that the maximum torque is reached at 6400 rpm with an average of 6.85 N.m. This indicates that the motor efficiently generates torque within that rpm range. After 6400 rpm, the torque gradually decreases. At 7000 rpm, the average torque reaches its lowest point at 5.44 N.m. There is a significant decrease in torque from 6.84 N.m (at 6300 RPM) to 5.44 N.m (at 7000 rpm).

Table 5. Torque Test Results Data After Conversion

Engine Rotation (Rpm)	Torque (N.m)			
	Test 1 (N.m)	Test 2 (N.m)	Test 3 (N.m)	Average Value
1000	28,64	28,62	28,54	28,6
1100	28,77	28,55	28,67	28,7
1250	27,66	27,55	27,52	27,6
1500	24,63	24,63	24,53	24,6
1750	19,09	19,07	19,05	19,1
2000	21,44	21,33	21,44	12,4
2250	17,01	17,05	17,01	17
2366	16,26	16,2	16,36	16,3
2500	15,46	15,64	15,22	15,4
2750	13,83	13,98	13,8	13,9
3000	12,61	12,33	12,22	12,4
3250	11,26	11,28	11,13	11,2
3500	10,2	10,02	10,3	10,2
3750	9,21	9,24	9,25	9,2
4000	8,39	8,59	8,59	8,5
4250	7,58	7,34	7,68	7,5

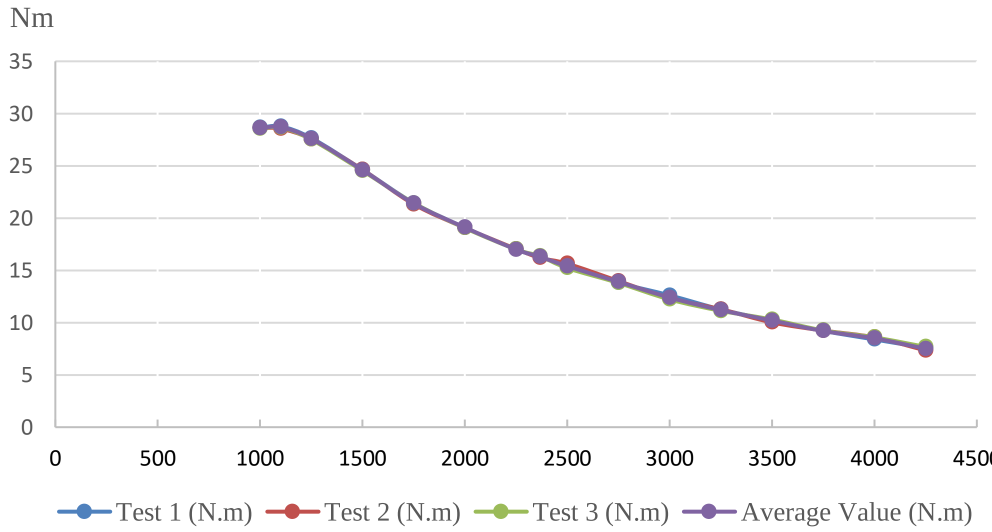

Figure 7. Torque test graph (N.m) after conversion

The torque test of the converted motorcycle shows that the maximum torque is recorded at 1100 rpm with an average of 28.48 N.m, indicating that the electric motor performs optimally at low rpm. The torque consistently decreases as the engine speed increases. At 4250 rpm, the average torque is only 7.57 N.m, a significant drop compared to the peak torque at low rpm. The test results show fairly consistent values, with slight differences between test results (Test 1, 2, and 3). This indicates that the motor maintains stable performance after the conversion. The electric motor, after conversion, delivers the best performance at low to medium rpm (1000–1500 rpm), where the torque is at its highest, reaching up to 28.48 N.m.

4. Conclusion

Based on the data analysis conducted in this study, the investigation results on the converted motorcycle unit indicate the differences in power and torque between the electric vehicle conversion and the original unit. The maximum power and torque produced by the converted electric vehicle were 5.4 (HP) and 28.48 (N.m), respectively. The gasoline-powered motorcycle with an injection system technology showed a maximum average power of 6.0 HP, stable in the 6300–6900 RPM range, and then slightly decreased at high RPM (7000) to 5.9 HP. The converted electric motorcycle achieved a maximum average power of 5.4 HP at the 2250–2500 RPM range. After this RPM, the power gradually decreased at a higher RPM.

After conversion, the electric motor performs better at low to medium RPM and has a higher maximum torque than the gasoline engine at low RPM. The electric motor is suitable for use in environments requiring power efficiency and acceleration at low speeds, such as urban areas. However, at high RPM, the electric motor shows a significant drop in torque, similar to the performance of the gasoline engine, which loses efficiency at higher RPM. Further research could be conducted to improve performance by adjusting the motor controller or using a larger, more efficient battery.

References

[1] Nur, A. I., & Kurniawan, A. D. (2021). The future projection of electric vehicles in Indonesia: An analysis of regulatory perspectives and the management of climate change impact in a sustainable manner. *Indonesian Environmental Law Journal*, *7*(2), 197–220.

[2] Agus Surya Adi, I. P., Satya Kumara, I. N., & Raka Agung, I. G. A. P. (2021). Status perkembangan sepeda listrik dan motor listrik di Indonesia. *Jurnal SPEKTRUM*. Program Studi Teknik Elektro, Fakultas Teknik, Universitas Udayana.

[3] Bani, T. C. (2013). The study of the effect of travel distance and engine age on the concentration of carbon monoxide (CO) and nitrogen oxide (NOx) emissions in four-wheeled motor vehicles. *Ejournal3.undip.ac.id, Undip, 2013*

[4] Sya'bani, A. A., Dantes, K. R., & Wiratmaja, I. G. (2022). The effect of camshaft lobe separation angle variations on torque, power, and fuel consumption in 4-stroke gasoline engines. *Jurnal Pendidikan Teknik Mesin Undiksha, 10*(2), August 2022.

[5] Aryadi, A. (2020). Experimental study on the effect of electric fuel pump pressure variations on engine power, torque, exhaust emissions, and fuel consumption of fuel-injection motorcycles. *Teknobiz: Journal of the Master's Program in Mechanical Engineering, 10(3), 2020.*

[6] Habibie, et al. (2021). Sustainability evaluation of internal combustion engine motorcycle to electric motorcycle conversion. *Evergreen, 8*(2), 469–476. Transdisciplinary Research and Education Center for Green Technologies, Kyushu University. **https://doi.org/10.5109/4480731**

[7] Zainuri, F et al (2023). Electric Vehicle Conversion Study for Sustainable Transport, Electric Vehicle Conversion Study for Sustainable Transport. Recent in Engineering Science and Technology, 1(02), 18–24. https://doi.org/10.59511/riestech.v1i0 2.15

[8] Zainuri, F. (2021). Analysis and optimization of electric vehicle conversion performance. *Journal of Mechanical Engineering Research and Developments*, 44(3), 128–137. **https://doi.org/10.59511/riestech.v1i02.15**

[9] Popović, V., Jereb, B., Kilibarda, M., Andrejić, M., Keshavarzsaleh, A., & Dragan, D. (2018). Electric vehicles are used as electricity storage in electric power systems. *Logistics & Sustainable Transport, 9*(2), 57–72. **https://doi.org/10.2478/jlst-2018-0010**

[10] Ramadhani, S., & Yuliana, L. (2023). The Influence of Consumer Perception on Purchase Intention of the Mercedes-Benz EQS Electric Car. *Journal of Business Orientation and Entrepreneurship*, 4(1), 35–44. **https://doi.org/10.33476/jobs.v4i1.3614**

[11] Siregar, R., Persada, U. D., Sumarsono, D. A., & Zainuri, F. (2019). Dynotest design analysis for electric converted vehicles. *Recent in Engineering Science and Technology, 1*, 5. Retrieved from www.mbi-journals.com/index.php/riestech.

[12] Zainuri, F., & Tullah, M. H. (2022). Performance of electric vehicle conversion through dyno test testing. *Jurnal Mekanik Terapan, 3*(2), 044-049. https://doi.org/10.32722/jmt.v3i2.4621.

[13] Astra Honda Motor. (2015). *Manual service book Honda Beat 110 FI*. PT. AHM.