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Analysis Of Lithium Ion Battery Characteristics In Electric Motors

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ABSTRACT
Lithium-ion (Li-ion) batteries are one of the battery technologies widely used in electric motorcycles (EVs) because they have high efficiency and good durability. This battery functions as the main energy source for electric vehicles and is an important component in supporting vehicle performance. This study aims to analyze the characteristics of Lithium-ion batteries in electric motorcycles by considering factors such as operating temperature, voltage, and the influence of speed and terrain. Tests were carried out on flat and uphill tracks with speed variations of 10 km/h, 30 km/h, and 50 km/h. The results showed that Lithium-ion batteries tend to experience a faster increase in temperature when used at high speeds, but the battery voltage remains stable during the Discharge and Charging process without any significant spikes. These findings provide insight into the performance of Lithium-ion batteries in electric vehicles, as well as the importance of temperature management to maintain optimal battery performance.

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INTRODUCTION

The development of technology and the need for modern mobility have driven innovation in the development of energy-efficient and environmentally friendly vehicles. One alternative solution that is increasingly popular is the electric vehicle (EV), which reduces dependence on fossil fuels. The main component of an electric vehicle, namely the battery, is the main determinant of vehicle performance and efficiency. One of the most promising types of batteries is the lithium-ion (Li-ion) battery because it has high energy density, good durability, and superior efficiency compared to other types of batteries (Arfianto et al., 2016). Lithium-ion batteries offer various advantages, such as light weight, smaller size, long life cycle, and low self-discharge rate (Chen et al., 2012). In addition, this battery can be operated in a wide range of temperatures and has fast charging capabilities. However, in electric vehicle applications, lithium-ion batteries face major challenges, especially related to the increase in temperature during the charging process (discharge). This increase in temperature can affect the stability and safety of the battery, so an effective thermal management system is needed (Hardianto, 2019).

In daily use, the operational conditions of electric vehicles, such as road conditions and speed, have a significant impact on battery performance. On uphill or high-speed terrain, the battery tends to work harder, causing a faster voltage drop and a significant increase in temperature. Therefore, research on the characteristics of lithium-ion batteries under

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various operational conditions is important. By understanding how these batteries respond to various loads, the development of better power and temperature management strategies can be carried out to improve battery efficiency and life (Kaloko, 2009). This study aims to analyze the characteristics of lithium-ion batteries in electric motorcycles with various test scenarios, including speed variations (10 km/h, 30 km/h, and 50 km/h) as well as flat and uphill track conditions. Testing was carried out using a 15 Ah lithium-ion battery with measurements of parameters such as voltage, temperature, and capacity during the discharge process. The results of this study are expected to provide comprehensive insight into the performance of lithium-ion batteries in real conditions and become the basis for the development of more efficient and safe battery technology. With the increasing need for electric vehicles in various countries, including Indonesia, this research can make a real contribution to the development of the electric vehicle industry. Better battery management will not only improve vehicle performance, but also support global efforts to reduce carbon emissions and create a cleaner, more sustainable environment.

METHOD

This study uses an experimental approach to analyze the characteristics of lithium-ion batteries in electric motorcycles. Testing was carried out with speed variations of 10 km/h, 30 km/h, and 50 km/h on two types of tracks, namely flat and uphill. The independent variables include speed and type of track, while the dependent variable is battery performance as measured by voltage (V), current (A), temperature (°C), and capacity (Ah). Controlled variables include a battery capacity of 15 Ah and the type of battery used, namely lithium-ion. The tools used in this study include an electric motorcycle equipped with a 15 Ah lithium-ion battery, temperature sensor, current sensor, and voltage sensor, which function to measure battery performance parameters (Hardianto, 2019). A data logger is used to record data during testing, while a Bluetooth application allows real-time data monitoring via a mobile device (Chen et al., 2012).

The research procedure begins with the preparation of tools and materials, including sensor calibration to ensure data accuracy. Testing is carried out by riding an electric motorcycle on flat and uphill tracks with predetermined speed variations. During testing, parameters such as voltage, current, temperature, and battery capacity were recorded using a data logger. The data obtained were then sent to the device via a Bluetooth application to facilitate further analysis. The data obtained were analyzed descriptively to describe the battery performance pattern, such as mean, median, and standard deviation (Navidi, 2015). Graphs were used to visualize the relationship between speed, path, and battery performance parameters (Çengel & Boles, 2015). Comparison of test results on flat and uphill paths was carried out to understand the effect of terrain on battery performance.

The formula used includes the calculation of average voltage $\tilde{\mathbf{v}} = \frac{\Sigma V i}{n}$ and temperature changes ($\Delta T = T_{akhir} - T_{awal}$) (Halliday et al., 2013). This analysis aims to provide comprehensive insight into the characteristics of lithium-ion batteries in supporting electric motorcycle performance under various operational conditions.

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RESULTS AND DISCUSSION

Analysis of Lithium Ion Battery Characteristics in Electric Vehicles

Horizontal Track

a. Battery characteristics on a horizontal track at a speed of 10km/h

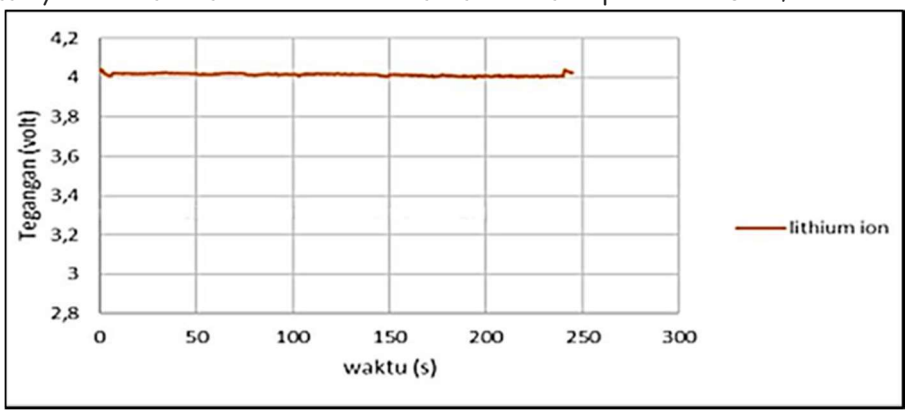

Figure 1. Battery characteristics on a horizontal track at a speed of 10km/h

In the test at a speed of 10 km/h, the Lithium-ion (Li-ion) battery showed stable characteristics even though there was a gradual decrease in voltage during the charging process (Discharge). At this speed, the Li-ion battery tends to maintain a more stable voltage. On the horizontal track temperature sensor at a speed of 10 km/h is explained in the following figure.

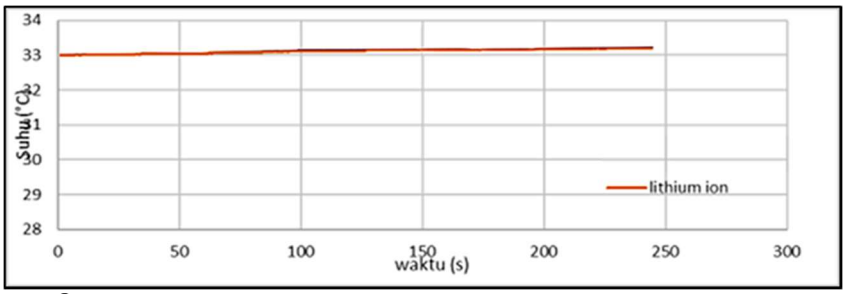

Figure 2. Battery characteristics on a horizontal track at a speed of 10km/h

In testing at a speed of 10 km/h on a flat track, Lithium-ion (Li-ion) batteries show a significant temperature increase characteristic during the charging process (Discharge). This is due to the nature of Li-ion batteries which tend to produce higher heat.

b. Battery characteristics on a horizontal track at a speed of 30km/h

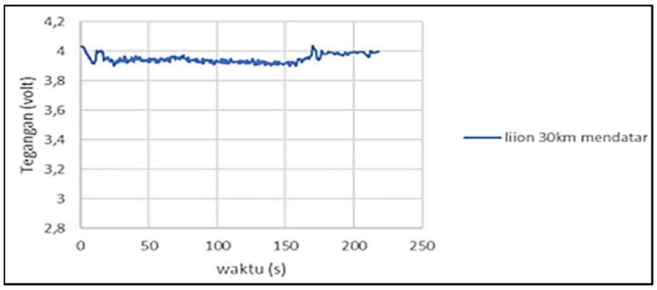

Figure 3. Battery characteristics on a horizontal track at a speed of 30km/h

In the test at a speed of 30 km/h, the Lithium-ion (Li-ion) battery showed a relatively faster voltage drop during the charging process (Discharge). This characteristic indicates

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that the Li-ion battery is more sensitive to the load given at that speed, so the battery voltage tends to drop more sharply. Although the capacity of the Li-ion battery is relatively high, the rapid voltage drop in this test indicates that battery performance may be affected at higher loads or at medium speeds. This reflects the need for better management of power usage and temperature management to maintain the stability of battery performance in electric vehicles using Li-ion batteries.

c. Battery characteristics on a horizontal track at a speed of 50km/h

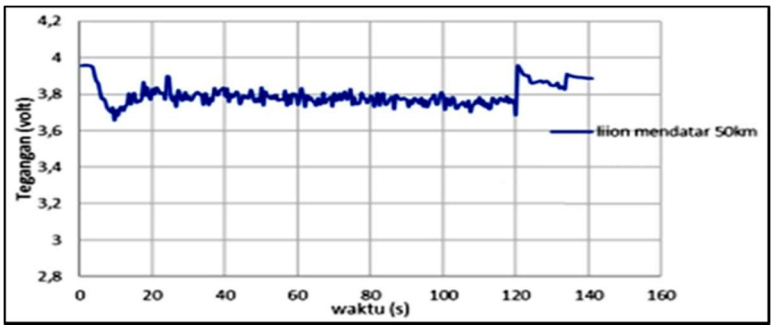

Figure 4. Battery characteristics on a horizontal track at a speed of 50km/h

In the test at a speed of 50 km/h, the Lithium-ion (Li-ion) battery showed a relatively faster voltage drop during the charge (Discharge) process. This characteristic indicates that the Li-ion battery is more sensitive to load fluctuations at high speeds, which causes the battery voltage to drop more sharply. The rapid voltage drop at a speed of 50 km/h indicates that the Li-ion battery tends to experience a greater performance decline at heavier loads or high speeds. This shows that although the Li-ion battery has a large power storage capacity, factors such as temperature management and load distribution are very important to maintain optimal performance at higher speeds. The temperature sensor on the horizontal track at a speed of 50 km/h is explained in the following figure.

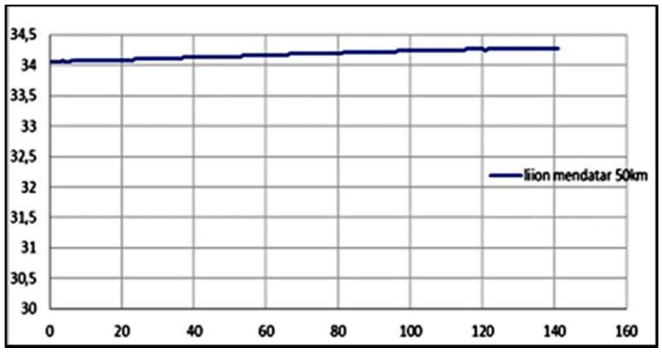

Figure 5. Battery characteristics on a horizontal track at a speed of 50km/h

In the test at a speed of 50 km/h on a flat track, the Lithium-ion (Li-ion) battery showed a significant increase in temperature during the charging process (Discharge). This increase in temperature is caused by the high current generated to meet the power needs at high speeds, which directly affects the operating temperature of the battery.

Uphill Track

a. Battery Characteristics on Uphill Track at 10km/h Speed

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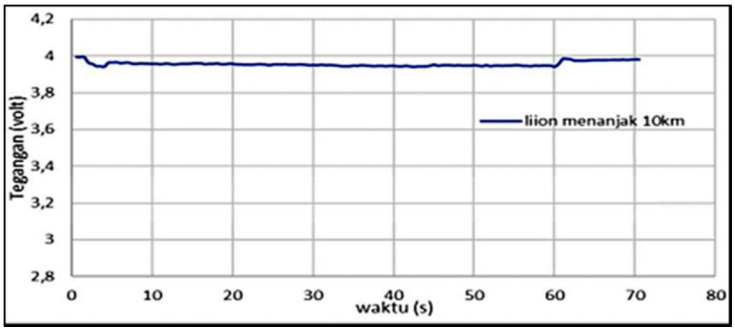

Figure 6. Battery characteristics on Uphill Track at 10km/h Speed

In the test at a speed of 10 km/h on an uphill track, the Lithium-ion (Li-ion) battery shows a voltage drop characteristic during the loading process (Discharge). The additional load generated by the uphill condition affects battery performance, resulting in a more significant voltage drop compared to flat track conditions. The temperature sensor on the uphill track at a speed of 10 km/h is explained in the following figure.

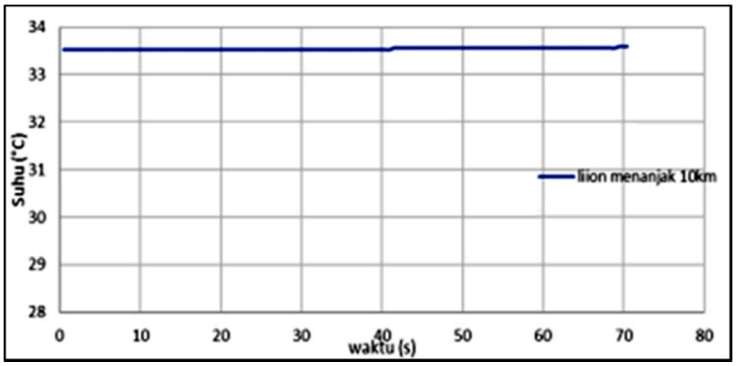

Figure 7. Battery characteristics on Uphill Track at 10km/h Speed

In the image above, the temperature of the lithium-ion battery tested during loading (discharge) on an uphill track at a speed of 10 km/h is recorded. The temperature of the lithium-ion battery shows a relatively rapid increase during the energy discharge process at higher load conditions, especially on uphill terrain. This temperature increase is influenced by the intensity of use and the operational characteristics of the lithium-ion battery which produces heat when operating at more challenging speeds and terrain.

b. Battery Characteristics on Uphill Track at 30km/h Speed

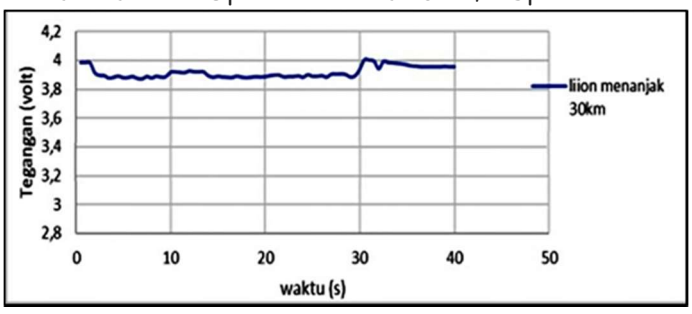

Figure 8. Battery characteristics on Uphill Track at 30km/h Speed

In the test at a speed of 30 km / h on an uphill track, the Lithium-ion (Li-ion) battery

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showed a significant voltage drop during the loading process (Discharge). Uphill conditions that provide additional loads affect battery performance, so that the voltage tends to drop faster. The temperature sensor on the uphill track at a speed of 30 km / h is explained in the following figure.

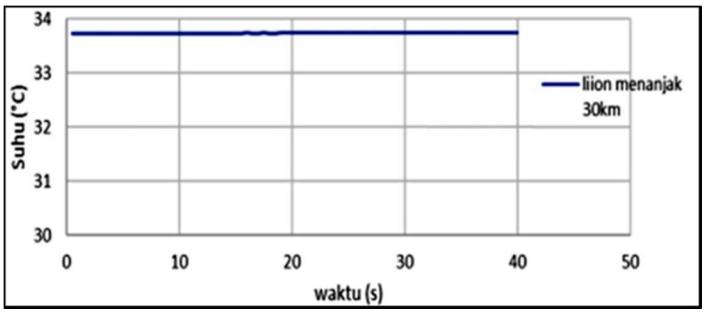

Figure 9. Battery characteristics on Uphill Track at 30km/h Speed

In the test at a speed of 30 km/h on an uphill track, the Lithium-ion (Li-ion) battery showed characteristics of increasing temperature during the charging process (Discharge). This increase was influenced by the additional load due to uphill terrain conditions that require greater power.

c. Battery Characteristics on Uphill Track at 50km/h Speed

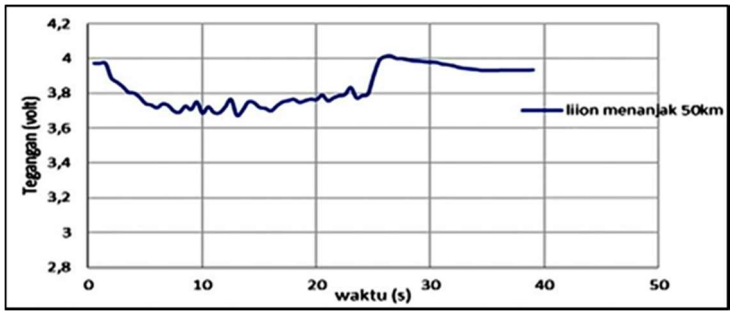

Figure 10. Battery characteristics on Uphill Track at 50km/h Speed

In the test at a speed of 50 km / h on an uphill track, the Lithium-ion (Li-ion) battery showed significant voltage drop characteristics during the loading process (Discharge). The condition of the uphill track at high speed provides a greater load, which has an impact on battery performance and causes the voltage to drop rapidly. This characteristic indicates that the Li-ion battery has a higher sensitivity to increased loads on rough terrain. The temperature sensor on the uphill track at a speed of 50 km / h is explained in the following figure.

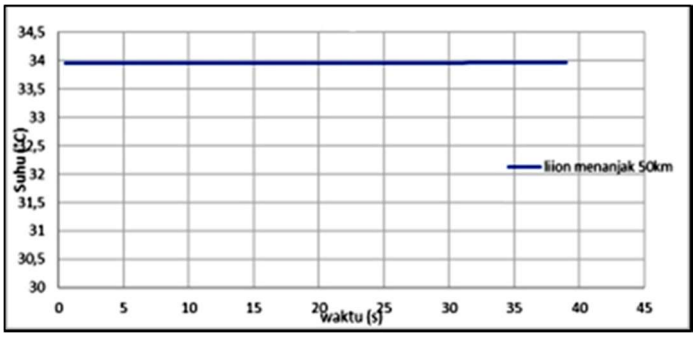

Figure 11. Battery characteristics on Uphill Track at 50km/h Speed

In the test at a speed of 50 km/h on an uphill track, the Lithium-ion (Li-ion) battery

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experienced a significant increase in temperature during the charging process (Discharge). This is due to the need for greater power to pass through uphill terrain at high speed, resulting in higher heat.

CONCLUSION

Based on the test results conducted on flat and uphill tracks with speed variations of 10 km/h, 30 km/h, and 50 km/h, it can be concluded that Lithium-ion batteries show temperature characteristics that tend to increase rapidly during the charging process (Discharge). This indicates that Lithium-ion batteries are more sensitive to temperature increases at higher load conditions. Although the temperature increases significantly, the battery voltage remains stable, both during the Discharge and charging processes. There is no significant voltage drop during Discharge, and there is no large voltage spike during the charging process, indicating the battery's ability to maintain its performance well under the test conditions carried out. Based on the research findings, several suggestions that can be conveyed are as follows: first, it is important to improve the temperature management system to prevent overheating and maintain stable battery performance, considering that the temperature tends to increase during loading. Second, although there is no significant voltage spike, the charging process needs to be continuously monitored so that the voltage remains stable and charging efficiency can be improved. Third, further testing with more extreme conditions, such as higher charging cycles and different temperatures, is needed to obtain more comprehensive data on battery life. Fourth, the accuracy of the battery condition monitoring system through BMS and Android-based applications needs to be improved so that the data obtained is more accurate and real-time, making it easier for users to manage battery performance.

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