Experimental Study of Performance Comparison of Lithium Iron Phosphate Batteries and Supercapacitors on Electric Motorcycles

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Abstract. Electric vehicles generally use batteries for energy storage, but currently there are designs for electric vehicle energy storage using supercapacitors (SC) or a combination of batteries and SC. In previous research, an electric motorcycle was made by converting Suzuki Shogun SP125 chassis, 800-1000 BLDC motor and controller. This research is to get a comparison between the use of Lithium Iron Phosphate (LFP) and SC batteries that installed on electric motorbikes using 2 passenger weight variables. The data taken are mileage, speed, acceleration, and battery charging time. The LFP battery pack used consists of a 51.2Volt 18Ah LFP HX32700 battery. The capacitor used consists of 18 pieces of 2.7v 500F arranged in series, resulting in a 48.6volt 27.78Farad. Tests were by installing LFP and SC alternately on electric motorbikes with variable passenger weights of 67 kg and 118 kg. One of result obtained that the acceleration data with SC is higher than that with LFP, this is because discharge power by SC is greater and faster than LFP. The disadvantage of SC in this research is that the power capacity is lower than that of LFP, resulting in a shorter electric motorcycle range.

Keywords: Lithium Batteries, Supercapacitors, Electric Motorcycles

1 Introduction

Recent years, electric vehicle technology has increased rapidly in line with environmental issues and global warming in recent years. Full-electric and hybrid electric vehicles of various types are already on the local and international market. At the same time, storage media such as batteries and fuel cells have been commercially launched and have been widely used.

In Indonesia, the movement of electric vehicles began around 2011, and Indonesia continues to move towards battery-based electric vehicles. The fulfillment of this pledge was accomplished through the execution of the inaugural introduction of battery-powered electric vehicles on December 17, 2020. This public launching aims to be able to disseminate Central and Regional Government programs and stakeholders in

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supporting the implementation of Presidential Regulation Number 55 of 2019 concerning the Acceleration of the Battery-Based Electric Motor Vehicle Program for Road Transportation [1].

It was discovered that the process of transforming a motorcycle into an electric one involves modern advancements and is still in a state of significant progress [2]. Banjarmasin State Polytechnic is currently developing the conversion of fossil fuel vehicles into EVs. Earlier research has utilized the Suzuki Shogun SP125 framework, a BLDC motor of 48 V and 800-1000 W, a controller of 800-1000 W, four 12V 20Ah lead-acid batteries, and static speed data indicating that motorcycles can travel at 30-40 km/h (Fig. 1). The batteries can be used for around one hour, and it takes 7-8 hours to charge them [3].

Fig. 1. Conversion of Suzuki SP125 Electric Vehicle (EV)

The battery is the main component of an electric vehicle, the battery price has a portion of 30% to around 50% of the price of an electric car [4]. Li-ion batteries are regarded as the technology that can assist in reducing carbon emissions in transportation, increase the usage of sporadic renewable energy sources, and provide a competitive advantage to the EU's industry in the Li-ion battery value chain. Batteries, such as Li-ion, are acknowledged as a vital technology that facilitates the energy transition[5].

Currently, a limited amount of rechargeable batteries are deemed appropriate for utilization in electric cars. These consist of Lead-Acid, Nickel-Metal Hydride, Lithium Polymer, Lithium Ion, and Sodium Metal Chloride. The LFP is a variant of lithium-based rechargeable batteries. Similar to all electrochemical devices that convert energy, the rechargeable lithium battery consists of an anode, cathode, and electrolyte. The lithium iron phosphate battery is suitable to work indifferent ambient conditions, guaranteeing almost the same performances in all the operating range defined by the manufacturer, showing a worsening of performances for low load current and low ambient temperature [6], [7].

To prolong the lifespan of batteries, it is necessary to discharge them periodically. This discharge process should be limited to approximately 10 percent of the entire capacity. It is not advisable to carry out a complete discharge as a regular maintenance procedure, as this can decrease the overall lifespan of the battery [8].

The technology of Lithium-ion offers superior power output, energy conservation, durability, charging speed, and requires minimal upkeep. In addition, supercapacitors enable a more efficient recuperation of energy while braking and descending, and enable a reduction in the strain exerted on the battery. In reality, due to the implementation of energy management, the RMS battery power can be decreased by 90% compared to using a solitary energy source, ultimately enhancing the lifespan of the battery [9].

In comparison to other battery packs within the lithium family, LiFePO4 battery packs are known for their high energy conversion efficiency, which can reach up to 95%. Additionally, they have a significantly longer life cycle, lasting up to 2000 times as opposed to the typical 400 to 500 times for other lithium family batteries. LiFePO4 battery packs are ideal for powering electric motors and managing power, making them suitable for use in electric scooters, pure electric scooters, hybrid cars, and other applications. In the future, they are expected to become the predominant choice for electric vehicles [10].

Until now, research related to energy storage media is still developing. One of them is supercapacitor which is also known by several other names such as EDLC (Electric/Electrochemical Double Layer Capacitor), electrochemical capacitor, or ultracapacitor. Unlike conventional capacitors, supercapacitors (SC) have very high capacitance values, up to thousands of Farads. The attributes of ultra-capacitors are supplementary to accumulators, such as elevated energy output and quicker charging time. The life of supercapacitors is also longer and the thermal risk is lower. This complementary nature causes supercapacitors to be often used with batteries to become a hybrid energy storage medium [11].

The amalgamation of lithium-ion batteries and supercapacitors enhances the effectiveness and dependability of the energy storage system for an electric automobile utilized in urban areas [12]. The advanced power management plan has enhanced the safety of hybrid electric vehicles (HEVs) by identifying and isolating issues in the vehicle's power sources. Additionally, the dependability and convenience of HEVs have been improved as both the SC and Fuel Cell can control the DC bus voltage, power the HEV independently, and function at varying power levels [13].

2 Method

2.1 Vehicle Specification

The conversion specifications for the Suzuki SP125 used in this research are outlined in Table 1. Additionally, the primary characteristics of the Suzuki SP125 can be observed on the website of the producing firm. The purpose of this study is to determine the performance of Suzuki SP125 EV using LFP and SC batteries with two passenger weight variables. The performance data taken are acceleration speed, maximum speed, mileage, temperature, power output and charging time. We conducted an experiment by installing the LFP and SC in alternately on a Suzuki SP125 EV.

Table 1. Specification of Suzuki SP125 Conversion

Item	Specification
Motor	1000 Watt
Motor Type	BLDC
Battery	4x Sealed Lead Acid 12V 20A
Dimensions	1,905 x 705 x 1,075 mm
Seat Height	770 mm
Wheel Axis Distance	1,220 mm
Lowest Distance to Ground	135 mm

2.2 LFP battery Assembling anda Testing

Assembling 16 LFP batteries arranged in 16 series and 3 parallel using a battery holder, nickel plate and Battery Management System (BMS) as a safety for charging and discharging. Spot resistance welding, along with its process variations, is a versatile technology that can be utilized for welding all types of battery cells, as the welding process takes place locally at the points of contact [14]. The LFP battery pack made has a voltage of 51.2 Volts with a current of 18Ah (Fig. 2)

Fig. 2. LFP assembling

2.3 Supercapacitors Assembling and Testing

This research used 18 pieces of 2.7 Volt 500 F SC assembled in series. 6 pieces of SC are assembled in series so that it becomes 16.2 Volts 83.33 F. Then this circuit is connected again in series to produce 48.6 Volt and drop SC value to 27.77 Farad. SC Value in series was calculated using Eq (1) and the SC circuit can be seen in Fig. 3.

$$\frac{1}{Ctotal} = \frac{1}{C1} + \frac{1}{C2} + \frac{1}{C3} + \cdots + \frac{1}{Cn} \qquad (1)$$

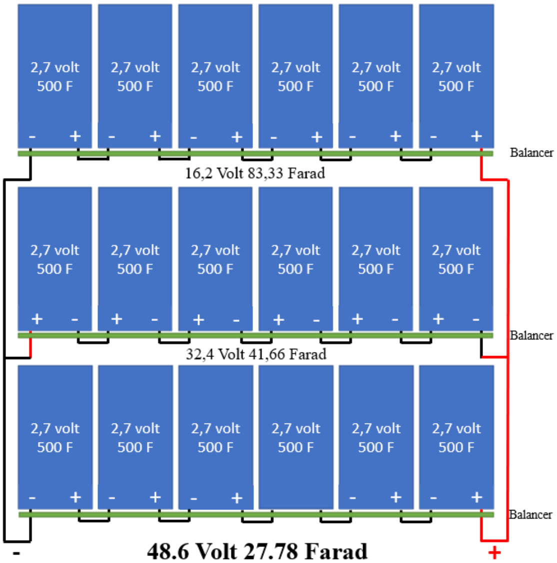

Fig. 3. Supercapacitors Assembling

3 Result and Discussion

The experimental results using LFP on Suzuki SP125 EV can be seen in Table 2.

Table 2. Experiment results with LFP Battery

Parameters	Value	Unit
Load	67 Kg (1 person)	118 Kg (2 person)
Acceleration (0-100 meter)	10.3 second	14 second
Max Speed (km/hour)	42	41
Miliage (km)	35.34	28.23
Max Power Output (watt)	828.67	884.67
Max Temp (C°)	32.2	33.7
Charging Time (minutes)	240-300	240-300

From Table 2 we can see a slight difference in the performance of EV with 2 passenger weight variables. Performance comparison is seen in the weight of 118 kg passengers, that is, the acceleration of the vehicle becomes 4 seconds slower and the mileage becomes shorter to 28 Km compare to 67 kg.

The experimental results using SC on Suzuki SP125 EV can be seen in Table 3. It can be seen LFP pack batteries have a longer travel distance than SC. With a load of 1 person, the LFP is able to cover 34.5 km compared to 1.75 km for the SC. This is due to the reduced Farad value in SC because of the series circuit. The Maximum Speed of electric vehicles using SC is slightly higher than that of LFP. With a load of 1 person, the maximum speed using SC is 44 km/h, while using LFP the maximum speed is 42 km/h. Likewise with a load of 2 people The acceleration of electric vehicles using SC is higher than that of LFP. With a load of 1 person, the acceleration of 0-100 meters in 9.6 seconds using SC, compared to LFP in 10.3 seconds. SC charging time is very short compared to using LFP. SC only takes 2 minutes to charge, while LFP takes 4 to 5 hours fully charge.

Table 3. Experiment results with supercapacitors

Parameters	Value	Unit
Load	67 Kg (1person)	118 Kg (2person)
Acceleration (0-100 meter)	9.6 Second	11.4 Second
Max Speed (km/hour)	44	4.,2
Miliage (km)	1.73	1.27
Max Power Output (watt)	967.61	970.43
Max Temp (C^o)	33.7	33.8
Charging Time (minutes)	120	120

4 Conclusion

Currently, the LFP battery is still the best choice for electric vehicles with a high level of safety. The supercapacitor is able to improve the acceleration of the vehicle well. We still cannot fully use supercapacitors as the main energy source for electric vehicles. This is because supercapacitors disadvantage such as its density and the ability to discharge high electrical energy. This research may be continued on how to combine the battery pack and SC to get the best performance of electric vehicles with high efficiency.

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