The Performance of Electric Vehicles Converted from Combustion Motorcycles

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Keywords: Electric, Vehicle, Green, Convert.

Abstract: In this modern era, the availability of fossil energy is decreased but the pollution is increasing. Solving these problems is very important to increase of clean and green energy consumption, such as electric vehicles. Currently people are increasingly interested in electric vehicles, if this continues to grow used motorcycles will accumulate, so they need to be reused by converting them into electric motorcycles. This research is a descriptive quantitative study that discusses the calculation of the conversion process of a Yamaha LS3 combustion motorcycle into an electric motorcycle and observes its performance. This study resulted in converting a Yamaha LS3 motorcycle into an electric motorcycle by installing a 2,000 watts BLDC motor supported by a 4,800 watts controller and a 72 Volt 20 Ah battery. The performance of the converted motorcycle shows that the maximum speed is 54 Km/h, with an average Total load of 131 Kg, an average speed of 31.7 Km/h, a mileage of 3.43 km for an energy allotment of 100 watts hours. with a level of energy consumption reaching 29.27 watt hours/kilo meter. Utilization of used combustion motorcycles and converting them into electric motorcycles needs to be continuously developed.

1 INTRODUCTION

1.1 Problems Background

In this era of globalization, the need for electrical resources has become a primary need for every human being in the world (Hirsh and Koomey, 2015). Electricity actually has a very important role to support every human activity, including supporting the economy, especially tourism industry in Bali. The modern era need high technology to solve the current problems and future. The declining of fossil fuels availability is a major problem today. The growth of fossil fuels consumption will leave reserves only for next five decades. The unwanted climate change is the nature's warning to stop fossil fuels consumption. The best alternative for mobility & transportation is an green electric motorcycle.

Now day the electrical energy for transportation facilities has begun to be interested by the community. Electric vehicle is used for private and public transportation. The electricity vehiclefor transportation facilities is in line with to the Bali State Polytechnic as a centre of excellence for green tourism technology. The electric vehicle is the great choice because it does not cause noise pollution, low operating costs, and light vehicles (Mutyala and Tech, 2019). The increase of electric vehicle use, it can decrease the pollution, costs, and road damage because electric vehicle is lighter (Katoch and Rahul, 2019).

Now day the combustion engines vehicle have begun to be abandoned. The designs to get cheap batteries, small dimensions, light weight, with large capacities continue to be developed, as well as the capacity of the electric motor (Safoutin et. al., 2018). Now day in Indonesia the electric transportation facilities used is increase like electric bicycles, electric motorcycles, electric cars, electric bus and train. The public sentiment towards to electric transportation facilities is increasing. The predicted is the increase of electric transportation use will lead to a significant increase in electricity consumption, that are strategic actions are needed related to the development of generating capacity, distribution networks with charging infrastructure for electric transportation (Zhuk and Buzoverov, 2018).

Jondra, I., Sunaya, I., Arka, I., Parti, I., Sudiartha, I. and Widharma, I.
The Performance of Electric Vehicles Converted from Combustion Motorcycles.
DOI: 10.5220/0010947400003260
In *Proceedings of the 4th International Conference on Applied Science and Technology on Engineering Science (iCAST-ES 2021)*, pages 451-457
ISBN: 978-989-758-615-6; ISSN: 2975-8246

The development on electric transportation has received a large cost and investment from the government to support technology development and testing. As in Bali, electric buses have been operated for public transportation. The realized electric transportation so far is still below expectations, although it has grow up to a positive direction. The problems by potential users, including cost, range, reliability, and availability of electric transportation options (Knowles, 2013). Base on that problems, it is need some research to increase the competence of the technicians, so that a reliable, efficient and chipper assembly is obtained. Based on the results of this reliable assembly, modifications to the electric motor, controller, and battery to develop the electric transportation. The electric vehicle developments can be carried out if the current data or the latest up date of electric vehicle developments are known. With this research, the current data, development and characteristics of electric transportation blow up.

This research is very interesting to do, the hope is researchers can design, assemble, operate and analyses the performance of electric vehicle converted from combustion engines motorbike so that old motorcycles are utilized continuously. The analysis carried out in terms of reliability and ability to become a means of transportation. With the results of this study, students can develop the technology of this electric vehicle mode. With this research, it will increase the contribution of the Bali State Polytechnic in developing electric vehicle.

1.2 Problems

How is the performance of electric vehicles converted from combustion motorcycles, regarding maximum speed, electrical energy consumption and distance travelled on 100 watt hours energy?

2 RESEARCH METHOD

2.1 Research Approach and Concept

This research is quantitative research. The formulation of the problem will be discussed by taking data about the performance of the converted electric motorcycle. The test results will be analysed statistically and mathematically to obtain the characteristic values of electric motorcycles. In selecting components, it is guided by: SNI 8608:2018 ISO/TR 13062:2015 about : electric cycle dan electric motor bike, Indonesian Minister of Transportation Regulation Number : 65/2020 About : Conversion of a Fuel Motorized Motorcycle into a Battery-Based Electric Motorcycle, designed and installed the electric motorcycle component, then conclusions and recommendations are drawn.

2.2 Total Sample

In this study, seven samples were taken related to the weight of the rider, from this weight variation, different mileage will be obtained in the same energy consumption.

2.3 Variable Operational Definition

The variables analysed in this study consisted of mileage length (L), Weight (W), Electrical Energy Consumption (W), maximum speed (Vmax), average speed (Vavg).

2.4 Tested

The mileage (L) is the distance that can be travelled by an electric motorbike for one research sampling, maximum speed (Vmax) is the maximum speed that can be achieved by an electric motorcycle with a certain weight of passengers, Average speed (Vavg) is the average speed achieved by an electric motorcycle with a certain weight of passengers during one sampling, this three data was measurement is carried out using a GPS-based speedometer in kilo meters per hour.

The test path taken in this electric motorcycle test is relatively straight, there are only 6 turning points, the others are straight, so measurements are chosen using a GPS-based speedometer. GPS data loggers are therefore accurate for the determination of speed over-ground in biomechanical and energetic studies performed on relatively straight courses (Witte & Wilson, 2004). This GPS-based distance and speed measurement is done by installing an android application on a smart phone. Many speedometer applications are available in the play store as shown in the figure 1 below.

I chose the GPS Speedometer application Version: 4:045 because its features are very complete. This speedometer can be selected in km/h or knots or mph, to improve accuracy for low speeds, for example, an electric bicycle can select a bicycle feature with a maximum speed of 65 km. In this speedometer application you can easily read travel time, trip distance, start time, maximum speed, altitude along the way, and location, more details can be seen in figure 2 below. What's more unique, this application has recording facilities during the trip, which can be sent via email or social media.

recordings of this journey in various forms, graphs, numbers, even in the form of tracks that ride on the google map application. With this recording, the travel history can be monitored anytime, anywhere and using a variety of devices that support it. This rigid and valid record is very supportive for researchers to analyse and draw conclusions.

Figure 1: Android speedometer GPS base.

Figure 2: Panel speedometer GPS base.

Weight (W) is the rider's body weight measured in kilograms, this weight measurement is done before they ride an electric motorcycle. To measure the weight of the rider is done using a digital scale with a maximum weight of 200 kilograms.

Electrical energy consumption (W) is the amount of electrical energy used in 1 experimental sample, this energy measurement is carried out using a DC watt meter in Watt Hour. Measurement of electrical energy consumption is carried out by an indirect measurement system using parallel resistance. From this parallel resistance, a digital KWH meter is installed as shown in Figure 3 below.

Figure 3: DC digital KWH meter.

This type of KWH Meter measurement circuit can be an indirect measurement, so it does not interfere with the voltage sent to the load. The shunt current sensing system was recommended as the best suited for simultaneous detection of DC injection accurate metering (Mironenko and Kempton, 2020). As for the installation circuit of this measuring instrument, it can be seen in Figure 4 below.

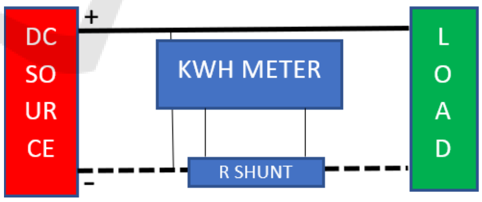

Figure 4: Installation circuit DC digital KWH meter.

2.5 Data Analysis

In converting this Yamaha LS3 into an electric motorcycle, it will use mathematical and physical calculations, the results of these calculations will be compared with regulatory standards regarding the conversion of electric motorcycles. In determining the power of the electric motor of an electric motorcycle, it is influenced by the weight of the vehicle including the rider, the speed to be achieved and the time of achieving that speed which can be explained by the formula below.

$$W = 1/2 \times mV2 \quad (1)$$

$$P = Wt \quad (2)$$

ware:
W : work (Joule)
m : Weight (kg)
v : speed (m/dt)
P : Power (watt)
T : time (dt)

The working ability of an electric vehicle controller measured in watts is influenced by the magnitude of the power source or battery voltage and the nominal current that can flow in the controller. To analyse the workability of the controller can be calculated by the formula below.

$$P = V \times I \quad (3)$$

ware:
P : Power (Watt)
V : Source voltage (Volt)
I : Nominal current flowing to controller (Amper)

3 RESULT AND DISCUSSION

The results of this study are expressed in the figure of an existing figure of a motorcycle combustion by the brand: Yamaha (type: LS3), component figure, circuit diagram, final figure of the converted motorcycle. The results of this study are also equipped with tables, graphs, and information related to the object of research.

3.1 Result

Yamaha LS3 is a combustion engine vehicle, year of manufacture 1973, with an engine capacity of 100 cc. This motorcycle is classified as antique and rare. Its unique design as shown in the figure below makes this motorbike still a collection of old motorbike collectors. So it is very interesting if it is converted into an electric motorcycle without changing the major design.

Figure 5: Yamaha LS3 with combustion engine.

The results of measuring the weight of the Yamaha LS3 combustion motorcycle, it was 85 kilograms, my weight as a rider was 74 kilograms, bringing the total weight to 159 kilograms. Based on the regulation of the minister of transportation Number: 111/2015 it is determined that on the highway the maximum speed of a motorcycle is 80 km/h. Based on these two types of data and using formula (1), it can be calculated the power of the electric motor needed to drive the converted electric motorcycle, as in the calculation below.

$$\begin{aligned} W &= \tfrac{1}{2} \times m\, v^2 \\ &= \tfrac{1}{2} \times 159 \times (80 \times 1000/3600)^2 \\ &= \tfrac{1}{2} \times 159 \times (22.22)^2 \\ &= 39{,}252 \text{ Joule} = 39{,}252 \text{ watt seconds} \quad (4) \end{aligned}$$

If the time required to reach a speed of 80 km/h is 10 seconds, using formula (2) it can be calculated the need for an electric motor for the conversion of a Yamaha LS3 combustion motorcycle into an electric motorcycle as shown in the calculation below.

$$\begin{aligned} P &= W/t \\ &= 39{,}252/10 \\ &= 3{,}925.2 \text{ watts} \quad (5) \end{aligned}$$

In the specifications of the Yamaha LS3 motorcycle, it is stated that the engine capacity of this motorcycle is 100 cc. Based on the Regulation of the Minister of Transportation of Indonesia Number: 65/2020 article 12 paragraph 4 section c.1 it is determined that for motorcycles with a maximum engine capacity of 110 cc, the conversion is to an electric motorcycle with an electric motor with a maximum power of 2,000 watts. To comply with the regulations, converting a Yamaha LS3 motorcycle is done using an electric motor with a maximum power of 2,000 watts as shown in the figure at below, thus the calculation results with a motor power of 3,900 watts cannot be applied.

Figure 6: Brush less direct current motor 2,000 watt.

Based on the selected motor capacity, proceed with the selection of the controller. This controller is an electric vehicle component as a DC to DC converter (Matey, 2017). To support the performance of a brush less direct current motor (BLDC motor), a controller with a minimum capacity of twice the motor capacity is needed (Mutyala and Tech, 2019). In this study, the capacity of the BLDC motor is 2,000 watts, so a controller of at least 4,000 watts is needed to anticipate the starting current. The controller found on the market is a controller with the following specifications: input voltage: 48-72 Volt DC, Output current: 100 Amperes. Based on the controller specifications, the controller capacity can be calculated by formula (3) as below.

$$\begin{aligned} P &= V \times I \\ &= 48 \times 100 \\ &= 4{,}800 \text{ Watts} \end{aligned} \tag{6}$$

Based on the calculation results above, it can be explained that with a 48 Volts battery this controller can produce an output power of 4,800 watts, or about 240% of the capacity of the installed BLDC motor. After identified the capacity of the BLDC motor and controller, then the battery can be determined to be used. Data controller states that the controller will be able to work well at least with a 48 Volt DC power supply, or it can also be operated for a 60 Volt or 72 Volt DC power supply. The greater voltage of the battery affect to the greater the power can be generated by the controller. In this study, a 72 Volt battery with a capacity of 20 Ampere hour was selected. with these specifications, the battery performance can be calculated by formula (4) as described below.

$$\begin{aligned} W &= V \times I \times t \\ &= 72 \times 20 \times 1 \\ &= 1{,}440 \text{ Watt hour} \end{aligned} \tag{7}$$

Figure 7: Battery lithium polymer 72 Volts 20 Ah.

BLDC motors have lower efficiency compared to alternating current induction motors, BLDC at nominal speed has an efficiency of about 80% while AC induction motors reach 85% efficiency (Miyamasu and Akatsu, 2013). Thus, 20% of the electrical energy sent to the BLDC motor is lost in the form of heat, iron loss, copper loss, friction loss and so on. Not 100% of the energy that goes into the BLDC motor is used to rotate the rotor.

The main component in the controller circuit is the microprocessor. This microprocessor is programmed how to drive the mosfet in order, provides PWM execution based on the throttle input, and also has other features such as brake, reverse, self study, speed control, communication port, led indicator, etc (Kumar et. al., 2010). In its working process, the controller also requires electrical energy to operate the electronic components installed in the circuit board. Not all of the energy entering the controller is output to the BLDC motor. The controller has a maximum efficiency of 75.6% (Hirave et. al., 2015). As a chemical material, the battery should not be used until its capacity is exhausted, operation like this will accelerate battery damage (Chen et. al., 2021). especially lithium polymer batteries, it is not permitted to discharge up to 10% capacity (Dimitrios et. al., 2020) (Ranjbar et. al., 2011). thus the lithium polymer battery can be operated to a minimum of up to 20%, maximum usable 80% of capacity. Thus the maximum mileage of an electric motorcycle as a result of this conversion can be calculated as described below.

$$\begin{aligned} t &= W \times 80\% \times 75{,}6\% \times 80\%/2000 \times 60 \text{ minute} \\ &= 20.54' \end{aligned}$$

If the maximum speed is 65 km, in 20 minutes 54 seconds, then the distance that can be covered with the maximum speed for a single charge is a maximum of 22.25 kilo meters.

The performance of the electric motorcycle as a result of the conversion from the Yamaha LS3 combustion motorcycle is carried out on the same route, with the same energy, namely 100 watt hours for each observation. Each time the observation is climbed by different riders with different weights. Tracking speed, distance is done using a GPS-based speedometer application, with output as in Figure 8 below.

Figure 8 explains that the observations were made on June 24, 2021 at 10:40. The observations were carried out in the Ketewel area, Sukawati, Gianyar Regency, Bali Province with latitude coordinates: -8.636685 and longitude: 115.284870. Observation time lasted for 5 minutes 47 seconds, with a distance of 3,036 km, a maximum speed of 54 km / h and an average speed of 31.5 km/h. Observations were made from the start, the maximum speed was 54 km/h, on the contour of the road varying up and down between 17.30 meters to 30.70 meters above sea level.

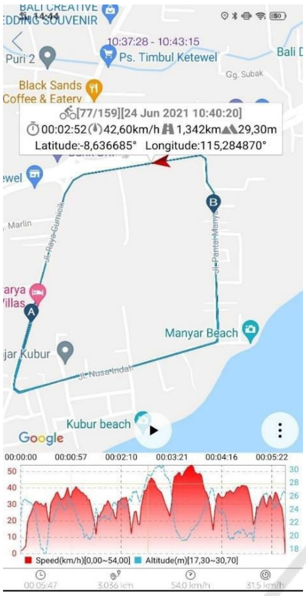

Figure 8: Tracking speed.

The data in Figure 8 is loaded and added to the total weight value which is the weight of the vehicle (76 kg) plus the weight of the driver, energy for one observation of 100 watt hours and is analysed in table 1 below.

Table 1: Performance electric motorbike.

NO	BRUTO WEIGHT	AVG SPEED	MILE AGE	ENERGY CONSUM PTION
1	(KG)	(KM/H)	(KM)	(Wh/KM)
2	150	31,5	3,04	32,94
3	149	31,2	3,09	32,40
4	138	32,1	3,29	30,39
5	128	31,8	3,50	28,57
6	124	31,4	3,58	27,93
7	120	31,8	3,68	27,20
8	120	31,5	3,65	27,43
9	119	32	3,66	27,31
Average	131	31,7	3,43	29,27

The data in table 1 is statistically processed to produce an illustration in the form of a graph as shown in Figure 9 below.

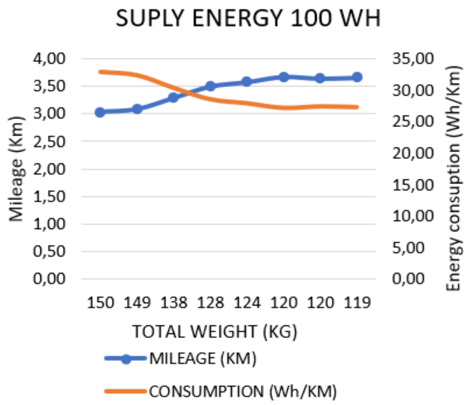

Figure 9: Performance of electric motorbike converted from combustion engine motorbike.

3.2 Discussion

In choosing a BLDC motor is influenced by the total weight as well as the maximum speed and acceleration to the maximum speed. The calculated that the required BLDC motor capacity is 3,925.2 watts. Based on confirmation of regulations for Yamaha LS3 with a 100 cc combustion engine capacity the maximum converted is a 2,000 watt BLDC motor.

Other equipment must be able to a 2,000 watt BLDC motor. The controller capacity is minimum of twice the capacity of the BLDC motor, the choice is a controller with a voltage 48-72 Volts by nominal current of 100 amperes at least 4,800 watts. The battery is selected is according to the controller voltage, the choice is a 72 Volts 20 Ah battery, it can supply 1,440 watt hours of energy, ultra fast charger needed for recovery energy (Tong and Groesbeck, 2012).

Observations on the performance of the converted motorcycle were carried out with varying rider loads. The data in table 1 shows that the heavier the rider's load, the shorter the distance that this electric motorbike can cover with an energy allotment of 100 watt hours.

4 CONCLUSIONS AND SUGGESTIONS

4.1 Discussion

To convert a yamaha LS3 with a 100 cc combustion engine, the regulations limit it based on the existing engine capacity up to 110 cc, converted with maximum 2,000 watts BLDC motor. To support the performance of the 2,000 watts BLDC motor, a controller with a capacity of 4,800-7,200 watts was chosen in a working voltage of 48-72 Volts. The battery options on the market are 72 volts with a capacity of 20 Ah. The performance of the converted motorcycle shows that the maximum speed that can be achieved is 54 Km/h, with an average gross load of 131, an average speed of 31.7 Km/h, a mileage of 3.43 km for an energy allotment of 100 watt hours. , with a level of energy consumption reaching 29.27 watt hours/kilo meter.

4.2 Suggestions

To prevent the accumulation of used combustion motorcycle, the conversion into an electric motorcycle is very important because the components are available and the energy consumption is more efficient and pollution-free. Further researchers can develop the conversion of combustion motorcycles into electric motorcycles by making alternative components that are more efficient and perform better.

ACKNOWLEDGEMENTS

This research was funded by DIPA Politeknik Negeri Bali Year 2021. We thank Director of Politeknik Negeri Bali for his support to this research.

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