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Design of the 3 kW Electric Motorcycle

H Helmi Rangkuti[1*], R Harahap[2] and S Suherman[3]

[1,2,3]*Electrical Engineering Department, Universitas Sumatera Utara, Indonesia.*

ABSTRACT

This paper presents an electric motor design by using a 3kW multiphase brushless direct current (BLDC). The research found that initial motor capacity is not easy to obtain because torque is affected by mechanic and passenger masses, and the rotation per minute (rpm) is affected by the gear arrangement. By using two gear arrangements, 48V 25AH battery source, and a commercial mechanical frame; the implementation results is 35km/h speed where the motorcycle only requires 0.3kW to travels for distance about 4.1km. The cost is much lower than the petrol based motor.

Keywords: Electric motor, Multiphase brushless direct current, battery, weather and environment, smooth working on any speed.

1. INTRODUCTION

As an essential transport mode, motorcycle is very common in tropical countries such as in Indonesia since the weather and environment are not friendly for pedestrian. The number of motorcycle runs in the Indonesian road reaches 85 million according to the AISI [1].

It can be said that all running motorcycle in Indonesia use petrol as the main power source. It was found that petrol requirement in Indonesia reaches approximately 1.6 million barrel per day [2]. It can be thought that the usage of the fossil energy is inefficient because it usage is greater than national product about 834 thousand barrel per day [2]. Therefore, alternative solutions such as a more friendly fuel are needed. The liquid based fuel public transport has been provided by the government. It can found that some buses available in Jakarta use liquid fuel. However, the secure of this fuel usage remains a problem. Despite this challenge, efforts to find alternative solutions should be a continuous effort because fossil energy source decreasing continuously.

The electric vehicles have been a hot issue in efficient renewable energy driven transports. Many researches have been conducted and more are coming. Electric car has been proposed in many ways. In addition, a number of competitions also have been conducted in various countries. For instance, Universitas Sumatera Utara as the oldest university in Sumatra island of Indonesia, had won the minimum energy usage car competition [3]. The electrical engineering within this university also participates in the electrical vehicle competition [4].

This paper focuses on electrical motorcycle design for student laboratory activities. Despite the absence of the novel method, the implementation is rather practical and useful for student experiment purpose. The more academic research has been conducted in [5] and [6]. The designed motorcycle is aim to operate at power source of 3kW. In order to do so, device components requirement is analyzed, starting from the battery to the mechanical frame.

*Corresponding Author: *helmitom@yahoo.com*

2. RESEARCH METHODS

In order to realize the expected electric motorcycle, Figure 1 shows the design steps involved in this research. Design starts with the power source calculation, determination of the electric motor specification, electric motor controller, electrical wiring, motor-wheel connection and transmission, and mechanical frame.

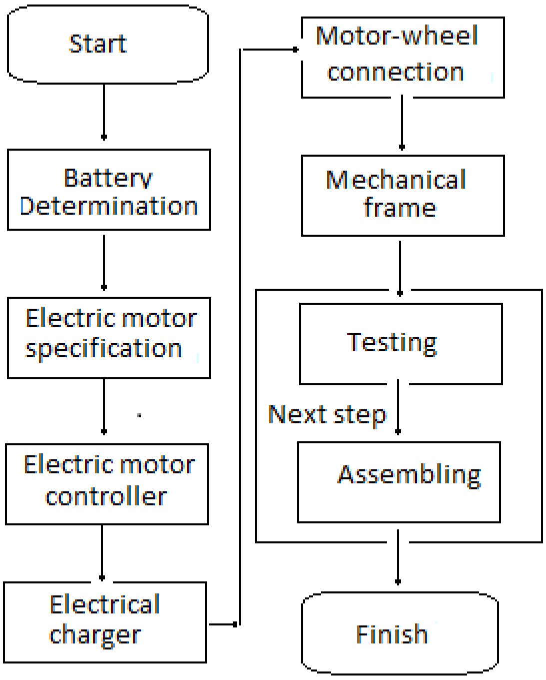


Figure 1. Research step.

The next step is component purchasing, and finally component assembly. By the time this paper was written, the designed electric motorcycle is not yet finished and tested.

The torsion moment (momen putir, MP) is calculated based on Equation 1 considering the input power (P), and rotation per meter (n):

$$MP = \frac{60 \times P}{2 \times 3.14 \times n} \tag{1}$$

The output power (P_{out}) is determined by the work done by the electric motor and the speed achieved. Equation 2 shows the formula. The efficiency is given by Equation 3.

$$P_{out} = W \times V \tag{2}$$

$$\eta = \frac{P_{out}}{P_{in}} \times 100\% \tag{3}$$

The battery capacity is determined by the Equation 4 where the charging duration (t) depends on battery capacity (ampere hour, AH), battery voltage (V) and the required power (P).

$$t = AH \times V/P \tag{4}$$

Battery should be able to store enough charge to produce current for a specific time. Moreover, battery should not add significant mass to motor. In order to do so, this research arranges 13 series and 5 parallel Lithium battery of 3.7V 5AH to produce 48V 25AH. Figure 2 shows the packed battery. In order to allow charging, a commercial 48V 2A charger was purchased.

(a) **(b)**

Figure 2. (a) The packed Lithium battery, and (b) a commercial charger.

Charging the battery uses a commercial charger as shown in Figure 3.

Figure 3. Commercial charger.

The assumed total mass of passenger and motor is about 136.5kg. This mass and torque relation is difficult to found as the efficiency changes with load. However, by considering these problems and the expected average speed of 35km/h, the 400rpm, 3kW BLDC motor is purchased as shown in Figure 4.

Figure 4. The 3kW 48V BLDC motor.

Since BLDC requires hall sensor control, so IC 3525 which is a pulse width modulation (PWM) IC is employed according to the schematic given in Figure 5. Additional devices that have been purchased include a speedometer, motor cycle lighting and other components.

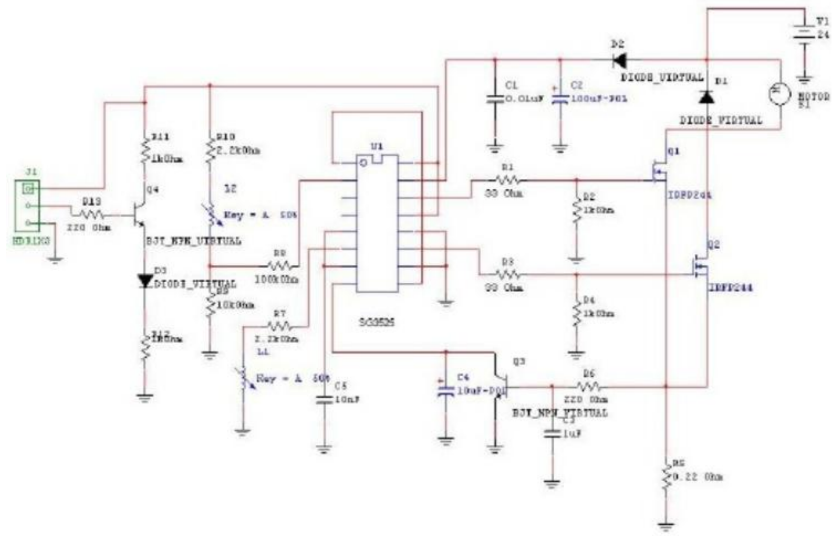
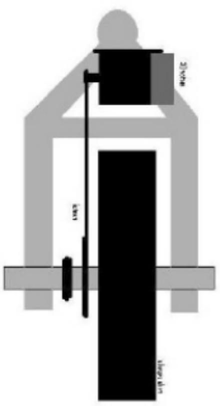
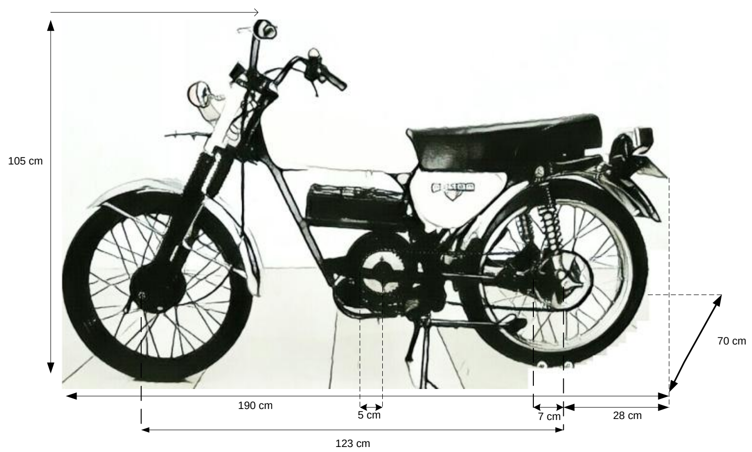


Figure 5. PWM circuit.

Motor is indirectly connected to wheel by using a chain as shown in Figure 6(a). The schematic of mechanical plan is shown in Figure 6(b).



(a) Motor-wheel connection



(a) Mechanic plan

Figure 6. Mechanic design.

3. DESIGN RESULTS

A multiphase brushless direct current (BLDC) [7] is a common motor used for electric vehicle. BLDC motor does not use brush for current supply. Permanent magnet (Figure 7) acts as rotor. In order to move phase current, the motor requires hall sensors to detect magnetic position. As a result, BLDC requires a specific controller. Some advantages of BLDC motor are smooth torsion, high efficiency, long lifetime, and smooth working on any speed. The developed electric motor in this study is shown in Figure 8.

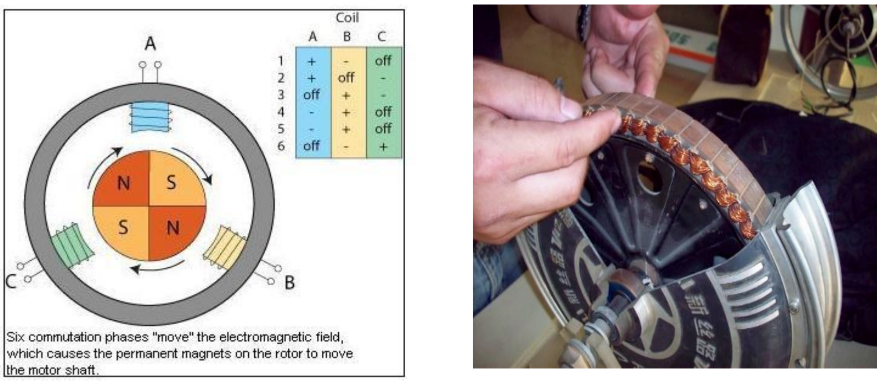


Figure 7. BLDC motor.

Figure 8. The designed electric motor.

In order to determine the motor requirement, the power is calculated based on the approximated passenger and motor masses. The motor mass depends on the mechanic, motor and battery masses. The approximated motor mass is 20kg. As the selected mechanic frames as shown in Figure 6 with gear diameter 10cm and 14cm, the total approximated motorcycle mass is 71.5kg. In order to achieve speed of 9.72m/s, the measured total work is 25.64N, at this speed, motor rotates up to 400rpm. The calculated average efficiency is 71.4%.

At motor evaluation, in order to travel 4.1km, the battery requires charging up to 1 hour 35 minutes which results 0.2025kWh of total energy. For 10km distance, battery charging runs for 3 hours 33 minutes with total energy of 0.499kWh. By comparing the total energy exhausted by the petrol based motor, the electric motor have lower cost expense of about Rp 5160 for 100km which is much lower compared to petrol motor, Rp 6650 for 35km.

4. CONCLUSIONS

This paper reported the design work of a 3kW electric motorcycle. BLDC motor is employed to drive 71.5kg motor mass. The designed motor achieves average efficiency of 71.4%. It requires about 0.2024kW for traveling up to 4.1km with maximum speed of 35km/h. The total expense is much lower than petrol motor.

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REFERENCES

[1] AISI, "Domestic Distribution in 2018," Indones. AISI - Asos. Ind. Sepedamotor.
[2] B. Migas, "Konsumsi BBM Nasional," (2017).
[3] Ambarita, H., Siregar, M. R., & Kawai, H., Study on aerodynamics characteristics an urban concept car for energy-efficient race. In IOP Conference Series: Materials Science and Engineering. IOP Publishing, **343**, 1 (2018) 012025.
[4] Howlader, A. H., Chowdhury, N. A., Faiter, M. M. K., Touati, F., & Benammar, M. A., Development of energy efficient battery electric car for Shell Eco-Marathon competition-Qatar University experience. In Ecological Vehicles and Renewable Ene, (2014).
[5] Buja, G., Bertoluzzo, M., & Mude, K. N., Design and experimentation of WPT charger for electric city car. IEEE Transactions on Industrial Electronics **62**, 12 (2015) 7436-7447.
[6] Paterson, S., Vijayaratnam, P., Perera, C., & Doig, G. Design and development of the Sunswift eVe solar vehicle: a record-breaking electric car. Proceedings of the Institution of Mechanical Engineers, Part D: Journal of Automobile Engineering **230** (2016).
[7] "Salehifar, M., Moreno-Eguilaz, M., Putrus, G., & Barras, P. Simplified fault tolerant finite control set model predictive control of a five-phase inverter supplying BLDC motor in electric vehicle drive. Electric Power Systems Research **132** (2016) 56-66.
[8] Torque calculation, Simple electric motor, (2018).