Compares Design of the 3 KW with 350 Watt Electric Motor Cycle

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Abstract: This paper presents an initial design of the electric motor that employed maximum power source of 3 kW. The research found that initial motor capacity is not easy found as torque is affected by mechanic and passenger masses and the rotation per minute (rpm) is affected by gear arrangement. However, initial device collection has been conducted including a battery size determination, motor controller, mechanics, and speedometer as well as wiring requirement. Design is started by the power source calculation, the electric motor specification, electric motor controller, electrical wiring, motor-wheel connection and transmission, and mechanical frame. Further work will focus on the assessment of motor capability to move electric motorcycle with given passenger and motor weight.

1 INTRODUCTION

As the essential transport, motorcycle is commonly used in tropical country such as in Indonesia as the weather is not friendly for pedestrian as well as providing small transport capacity. Number of motorcycle runs in the Indonesian road reaches 85 million according to the AISI (AISI, 2018).

It can be said that all the running motorcycle in Indonesia use petrol as the power source. It was found that the petrol requirement in Indonesia reaches 1.6 million barrel per day (B. Migas, 2017). It can be thought that the usage of the fossil energy is inefficient as its greater than national product about 834 thousand barrel per day(B. Migas, 2017). Therefore alternative solutions are required. A more friendly fuel is needed. The liquid gas based public transport has been provided by the government. It can be found that some buses available in Jakarta use liquid gases. However, the secure of this fuel usage remains a problem. Despite, this challenge, efforts should be made continuously as fossil energy source decreases continuously.

The electric vehicles have been a warm issue in efficient renewable energy driven transports. Many researches exist and more are coming. Electric car has been proposed in many ways, and the competition challenges are also conducted in many countries. For instance, Universitas Sumatera Utara as the oldest University in Sumatra Island of Indonesia, has been the winner some minimum energy usage car competition (Ambarita; Siregarand Kawai, 2018). The electrical engineering within this university also participates in electrical vehicle competition (Howlader, A. H; Chowdhury, N. A; Faiter, M. M. K; Touati, F and Benammar, M. A, 2014).

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 (Buja, G; Bertoluzzo, M and Mude, K. N, 2015); (Paterson, S; Vijayaratnam, P; Perera, C and Doig, G, 2016). The designed motorcycle is aimed at power source of 3 kW. In order to do so, device components requirement is analyzed, starting from the battery to the mechanical frame.

2 RESEARCH METHODS

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

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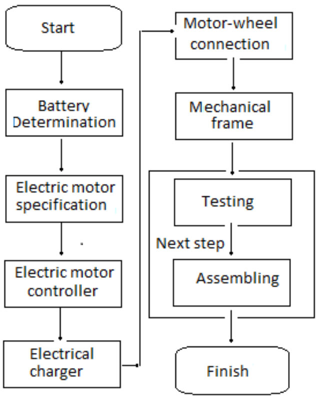

Figure 1: Research step.

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

3 COMPONENT SELECTION AND RESULTS

The next step is component purchasing and finally component assembly. By the time this paper written, the designed electric motorcycle is not yet finished and tested. The torsion moment (momen putir, MP) is calculated based on Equation 1 considering input power P and rotation per meter (n):

$$MP = \frac{60 \times P}{2\pi \times n} \qquad (1)$$

The output power 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.

$$P_{out} = W \; x \; V \qquad (2)$$

$$\eta = \frac{P_{out}}{P_{in}} \qquad (3)$$

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).

$$t = AH \; x \; V/P \qquad (4)$$

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

Multiphase brushless direct current (BLDC) (Salehifar, M; Moreno-Eguilaz, M; Putrus, G and Barras, P, 2016) is commonly motor used for electric vehicle. BLDC motor does not use brush for current supply. Permanent magnet (Figure 2) acts as rotor. In order to move phase current, the motor requires hall sensors to detect magnetic position. As s result, BLDC requires a specific controller. Some advantages of BLDC motor are, smooth torsion, high efficiency, long lifetime, smooth working on any speed.

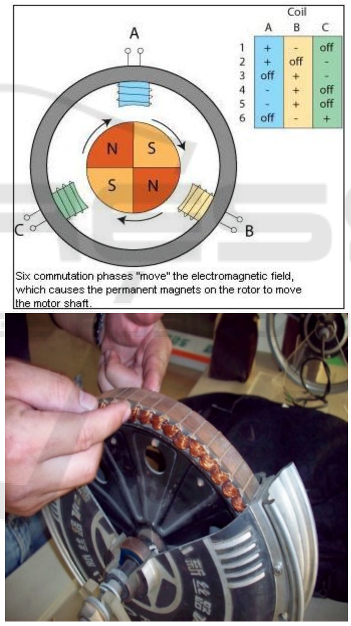

Figure 2: BLDC motor.

In order to determine the motor requirement, the power is calculated based on the approximated passenger and motor masses. In this case, the passenger mass is assumed to be one person with 65kg mass. The motor mass depends on the mechanic, motor and battery masses. After making a brief survey, this paper approximates the motor mass is 20 kg. As the selected mechanic frames as shown in Figure 3 with gear diameter 10 cm and 14 cm, 3 is about 51.3 kg, the total approximated motorcycle mass is 71.5 kg. There will be rotational per minute changes. The expected reduced rpm is 71.4%xRPM_{motor}.

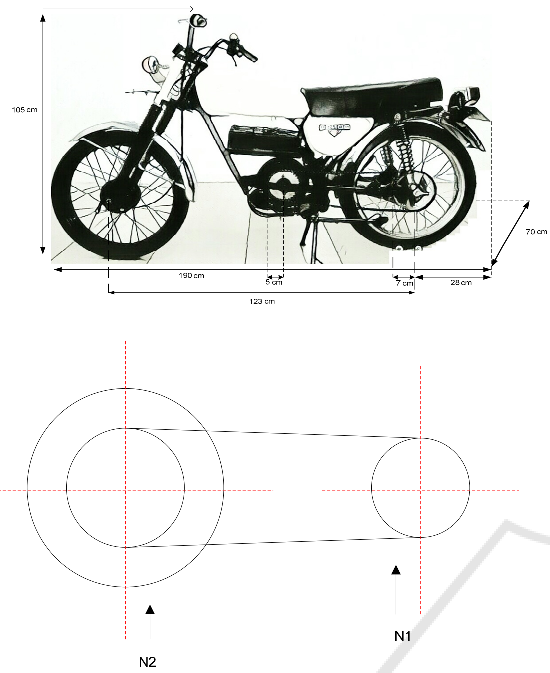

Figure 3: Motor mechanics.

The torque required [Nm] at the wheels is Maximum force[N] x radius of the wheel [m]

T(wheel) = F x r

This has to be converted to the torque required at the machine side, which is a ratio. Ignoring all losses, power in = power out, but one can generally allow for a loss of about 2% therefore,

T(motor) x w(motor) = T(wheel) x w(wheel)

where T is in Nm and w (angular velocity) is measured in radians per second.

To include gearbox efficiency of 98% this becomes

0.98 T(motor) x w(motor) = T(wheel) x w(wheel)

(you will need more torque at the motor side to overcome the inefficiencies)

To convert rpm to radians per second: w = rpm x 2Pi / 60.

Without considering the weight of the motor mechanics and the gear, the torque offered by BLDC can be approximated as (Torque calculation, 2018):

$$Torque = CurrentxVoltagexEfficiency /(RPMx2\pi) \tag{5}$$

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

Figure 4: The 3 kW 48 V BLDC motor.

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

Figure 5: The packed Lithium battery and a charger.

Since BLDC requires hall sensor control, the pulse width modulation controller in purchase to enable duty cycle controlling as depicted in Figure 6. Additional devices that have been purchased, include a speedometer, motor cycle lighting and other components.

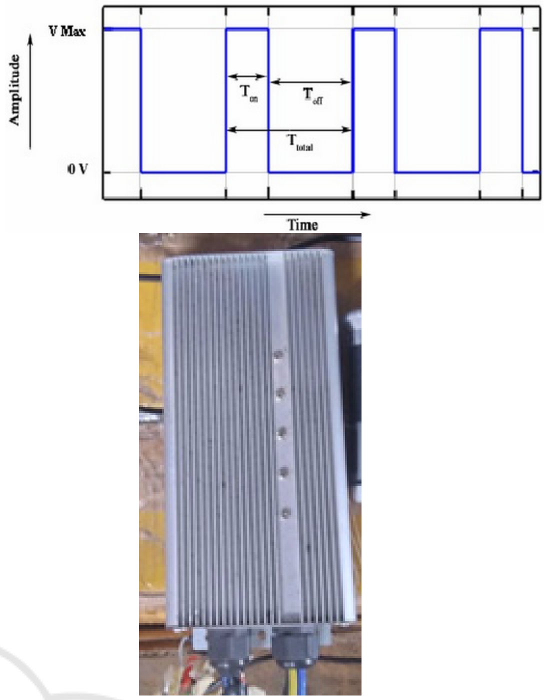

Figure 6: BLDC controller.

BLDC motor control A BLDC motor can overcome the shortcomings of the DC motor. The basic structure of BLDC motor is different as compared to DC motor because it has no mechanical commutator (brush). In a BLDC motor, the coil is wound on the stator, the rotor has surface-mounted permanent magnets, and the brush commutator is replaced with the electronic commutator. The external rotor (some motors are internal) has four pole pairs and consists of the permanent magnet. The stator consists of three-phase windings (A, B, and C). It is easy and intuitive to analyze magnetic field of the stator using this schematic.The MCU and the control circuit is the commutator.

The stator windings can generate the magnetic field when powered, which will attract or repel the permanent magnet (rotor), as a result of which the rotor spins. See the following figure. Basic theory of motor control BLDC Motor Control with Hall Sensors Based on FRDM-KE02Z, Rev 0, 07/2013 Freescale Semiconductor, Inc. 5 Figure 6. Internal magnetic force The following figure shows how to generate the magnetic field in the stator. Here, the positive current is defined as the current flowing into a specific phase, or coming out of a specific phase. Figure 7. Magnetic field generation Similar to the DC motor, if the MCU and control circuit in a BLDC motor do not change the direction of the magnetic field generated by the stator windings in time, the rotor won't spin. In BLDC motor, a rotating magnetic field should be generated by the windings. Therefore, there must be a way to conform the position of commutation and change the direction. For this purpose, the Hall sensor method is discussed in this application note. 3 Basic theory of six-step commutation method

4 CONCLUSIONS

This paper has reported the initial work on designing a 3kW electric motorcycle. Initial motor purchased BLDC is based on approximation as mathematical analysis effected by the load and mechanical masses. Battery, controller and mechanics have also been collected. Further work will focus on the assessment of motor capability to move electric motorcycle with given passenger and motor weight.

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