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PROTOTYPE DESIGN OF E-BMX 2000 WATT ELECTRIC MOTORCYCLE

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Abstract. Limited supplies of fossil fuels such as gasoline, diesel and LPG resulting in vehicles that use internal combustion would be abandoned and replaced by electric vehicles. There have been many coverages that have reviewed the advantages of electric vehicles, where the advantages of electric vehicles include simple mechanical components, relatively low pollution, low noise levels, and could become a solution for future vehicles for an environmentally friendly life. This study aims to design and build a motorcycle prototype, a work which includes the design and manufacture of a BMX type motorcycle frame powered by a 2000 watt BLDC motor power, and testing the performance of the prototype using dynotest and compared to conventional motorcycles to compare the performance characteristics of both motorcycle. The frame is designed using Solidworks, then manufactured by cutting, bending, drilling, welding, and painting process. Mechanical components include frames that use mild steel pipes with diameter of 1.5 inches and thickness of 1.2 mm. Other mechanical components use components available on the market, such as headsets, front forks, disc brakes, hydraulic caliper brakes, and wheel assemblies. The electrical components used are 48V 2000-watt QS Motor, 60V 15 Ah Lithium battery, Yuyangking 80A controller and electric gas throttle with voltage indicator.
The results of the dynotest show that the maximum torque reaches 204 NM (roller) which is achieved at 976 rpm. The maximum speed reaches 69.7 Km/hour. The range of the single-charged battery could cover a distance of 30 km. The characteristic of 2000 Watt E-BMX is very powerful at low revs and stable at high revs, shown by achieving maximum torque at low RPM. To save battery life, it is necessary to limit the remaining voltage, which is done at 55 Volts, so that the battery do not completely run out. It could be concluded that electric motorcycle developed in this study is suitable for use in urban areas (paved tracks or light off-road) with determined mileage and the path travelled, and battery management is needed so the battery does not run out in the middle of a trip.

Keywords : electric motorcycle, e-BMX, 2000 Watt, dynotest, BLDC motor.

1. INTRODUCTION

Since fossil fuels such as gasoline, diesel and LPG will deplete over time, vehicles that use internal combustion (fuel oil, BBM) will also be increasingly abandoned and replaced by electric vehicles. In 2030, Indonesia targets to produce 3 million electric vehicles [1]. While in 2060, PLN targets electric vehicles and zero emissions, which is in line with electrical energy which is domestic-based energy [2]. The reason of why electric vehicles are the vehicles of the future is because of their many advantages, including simple mechanical components, easy maintenance, non-polluting, low noise levels and are solutions for future vehicles for an environmentally friendly life.

An electric motor is a device that can convert electrical energy into mechanical energy. It could be said that all types of electric motors have two basic components, namely the stator which is a stationary component, while the rotor is a rotating component. Through the role of these two basic components, electric motors can convert electrical energy, both direct (DC) and alternating (AC) electricity, into circular motion in the rotor which can be used for various purposes [3].

In principle, electric motors work by utilizing electromagnetic induction which can convert dynamic electrical energy into a magnetic field. With the help of permanent magnets, this induced magnetic field can produce a force that can move the rotor. This is due to the basic nature of magnets, where similar magnetic poles repel each other and opposite magnetic poles attract each other. The power of an electric motor is largely determined by the power of the electric current source, and also the configuration of the wire windings on the electromagnet. The more turns of wire on the electromagnet, the greater the power generated by the motor. To be able to produce circular motion, each type of magnet is placed on the stator and rotor. The electric circuit for the purposes of electromagnetic induction must be arranged in such a way that the magnetic polarity generated on the electromagnet can make the electric motor continue to rotate even though the magnet changes position due to the rotation of the motor.

The type of electric motor that will be used for this research is a brushless DC motor (BLDC) type electric motor. This motor uses a direct power source (DC). In conventional DC electric motors, the brush connects the electromagnet on the rotor with a DC power source so that the electric motor can move freely and an electromagnet polarity can be generated to rotate the motor. However, the use of this brush is known to generate friction which can cause noise and also reduce the component life. Therefore, in BLDC motor the brush is no longer used and the electromagnetic is placed on the stator, while the permanent magnet is placed on the rotor. Several electromagnets are placed on the stator in a radial configuration so that the rotor can move freely with the help of permanent magnets in all of the angular positions. Meanwhile, the function of controlling the direction of the electric current to control the direction of the magnetic field on the brush is replaced by a controller that can adjust the magnitude and direction of the electric supply for each electromagnet independently. The use of this controller system makes BLDC is advantageous when used as a motor for electric vehicles, where the motor torque and rotational speed can be easily controlled by the user as needed [4]-[9].

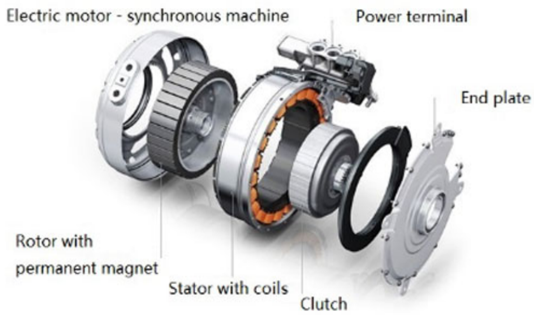


Figure 1. BLDC motor [10]-[13]

Generally, main components of electric motorcycles could be divided into 2 groups, namely electrical components and mechanical components. The electrical components consist of a BLDC motor which functions to convert electrical energy into mechanical energy, a lithium ion battery equipped with a charger to store electrical energy, a throttle handle and a controller which functions to adjust the speed of the BLDC rotation. Whereas, the mechanical components of an electric motorbike consist of a frame made of steel, a front fork which functions as a support for the front wheels, a brake set for the braking system on the front and rear wheels, a handle bar which functions as a steering system, a saddle for the driver seat and an electric box as a place to store electrical circuits.

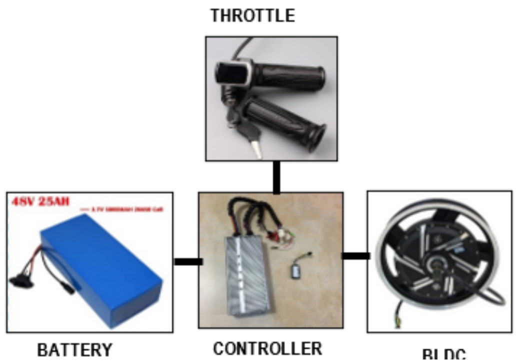


Figure 2. Electrical components

2. METHODS

Firstly, literature studies are needed to collect the references of frame design as base and comparison for the E-BMX frame.

Figure 3. Electric motorcycle frame references

From the existing references, a sketch is then made by considering the level of complexity, the capabilities of the existing production tool, and the availability of materials and working tools. Figure 4 shows the design sketch of an E-BMX that will be made. Mechanical components and electrical components are assembled into a single unit which is the basis of the electric motorcycle.

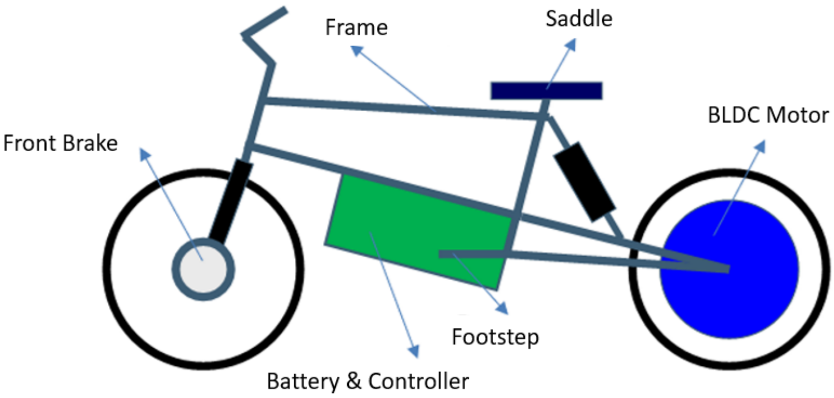


Figure 4. Design sketch

After the design sketches have been made and deemed feasible, the next step is to design the main frame with the predetermined concept, namely in the form of a BMX frame. The design process at this stage uses Solidworks software. This design step will produce technical drawing, which is ready for manufacturing processes. The 3D drawings of the frame are shown in Figure 5.

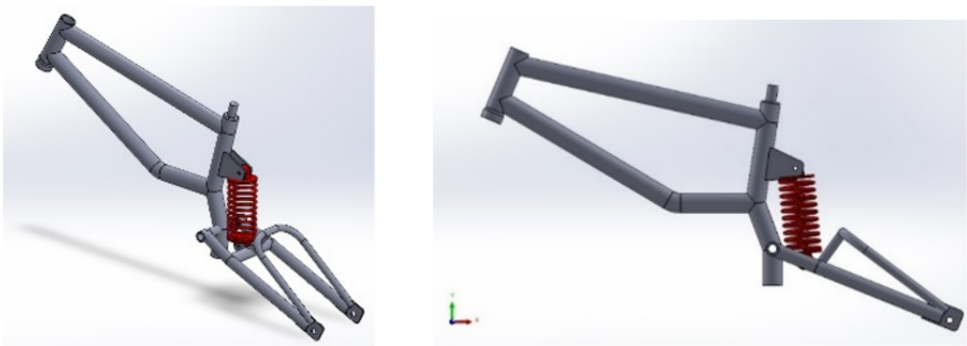


Figure 5. E-BMX frame design

The production and manufacturing process of the E-BMX frame consists of the cutting process, bending process, drilling and welding process and continued with the coating and finishing/painting process. After the manufacture of the frame is complete, the process of assembling the electrical and mechanical components is continued. The final result of the prototype is shown on Figure 6.

(a) (b)

Figure 6. E-BMX Prototype (a) side view, (b) isometric view

3. RESULTS AND DISCUSSION

3.1 Dynotest Testing

Power testing or commonly called dynotest on two-wheeled vehicles is intended to determine the maximum torque compared to RPM (wheel rotation). This test is also utilized to find out the characteristics of motorcycle performances such as the performance at low rpm up to high rpm. From the results of the tests conducted, it is shown that the E-BMX has the character of being immediately powerful at low rpm, then stable up to high rpm. In contrast to gasoline motorbikes, which tend to increase torque as the wheel RPM increases [14][15].

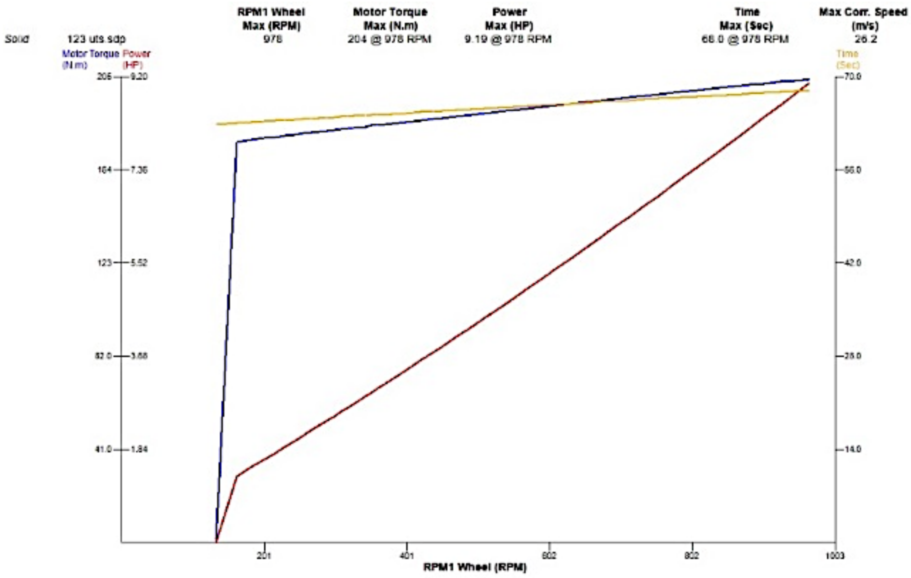
The equipment required for the dynotest test includes a set of test equipment consisting of two cylinders/rollers to support the rear wheel of the motorcycle being tested. Rotation input from the rear wheel of the motorcycle will rotate the roller which is then displayed in graphic form through software that can be read on a computer monitor screen. The tested E-BMX is placed on the test roller, as shown in Figure 8.

Figure 7. Roller used on dynotest

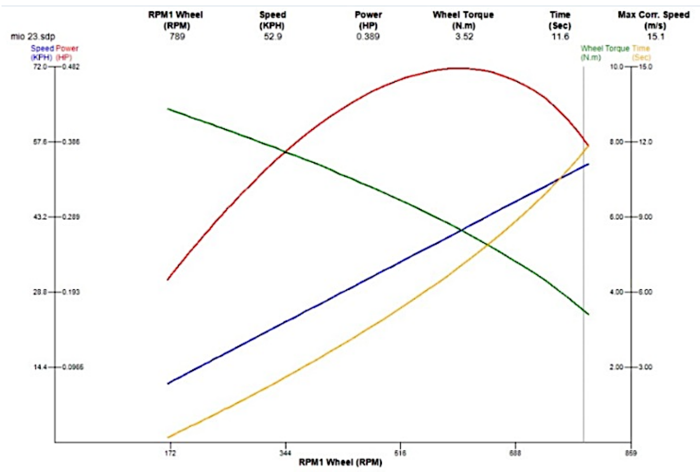
Figure 8. Testing setup process

3.2 Dynotest Result

The Dynotest carried out in this study produced a graph of Torque, RPM and Power (power) of the motor. The dynotest result of the E-BMX is shown in Figure 9 (a). As comparison, the dynotest also performed on a conventional motorcycle (Yamaha Mio), which the result is shown in Figure 9 (b).



(a)



(b)

Figure 9. Dynotest result plot of (a) 2000 watt E-BMX and (b) Yamaha Mio

3.3 Discussions

From dynotest test results for the 2000 Watt E-BMX, it is known that the character of an electric motorbike has a spontaneous torque increase at low rpm, while the character of a conventional motorbike (gasoline motorbike) is that the torque will reach its maximum as the rpm increases. The character of such an electric motor also depends on the setup and settings of the controller, in the sense that the controller can adjust the torque desired by the rider.

In this study using test equipment on a laboratory scale, the validity of the data still needs to be validated again, because it is indeed used for research. But from the existing dynotest equipment, the characteristics and performance of the 2000 watt E-BMX could be obtained.

3.4 Prototype Specifications

The technical specifications of the 2000 watt E-BMX prototype are shown in Table 1.

Table 1. 2000 watt E-BMX specifications

Component	Specifications
Driving motor	QS Motor 48V 2000 Watt
Battery	Lithium Ion 60V 15 Ah
Controller	Yuyangking 80A
Frame	Mild steel pipe, D 1.5 inch, t=1.2 mm
Maximum speed	69,6 Km/hour
Maximum distance	30 km (fully charged once). Maximum voltage: 67V Cut Off : 55V
Charging time	5-6 hours
Performance (dynotest)	Maximum torque 204 NM (roller) at 976 rpm
Wheelbase	1300 mm
Rear suspension	monoshock
Rear brake	Suzuki Satria FU 150 disc brake
Front brake	Yamaha Vega ZR disc brake
Head set	Honda Grand
Tire	Front: 2.25 x 17 Rear: 2.50 x 17

4. CONCLUSION

Conclusions that could drawn from this research are as following:

1. In the process of designing and designing the E-BMX frame, the software used is Solidworks. Details of the specifications for the frame material are 1,5 inch diameter mild steel pipe with the thickness of 1.2 mm, monoshock type suspension, and 1300 mm wheelbase. Other mechanical components used motorcycle components available on the market. Among them are head set bearings (Honda Grand), front forks (Yamaha Vega ZR), front disc brakes (Yamaha Vega ZR), handle bars (United Bike), rear disc brakes (Suzuki Satria FU 150), etc.
2. The result of the Dynotest conducted at the laboratory of Automotive and Electronical Engineering, Polinema shows that the maximum torque is 204 NM (roller) at 976 rpm.
3. The 2000 Watt E-BMX is very suitable for use on paved urban tracks or light off-road, and with a distance of up to 30 km for one full-charging, Hence it is also suitable for everyday use.
4. Battery management for the rider is needed in order to prevent the run out of the battery in the middle of a trip.

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