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https://publisher.uthm.edu.my/ojs/index.php/japtt

e-ISSN: 2821-286X

Journal of Automotive Powertrain and Transportation Technology

Investigation The Influences of Electric Motor and Electric Go Kart Performance

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DOI: https://doi.org/10.30880/japtt.2022.02.02.003
Received 20 July 2022; Accepted 05 October 2022; Available online 31 December 2022

Abstract: This researcher focused at every type of electric motor and every force applied to a go kart. The goal of this research is to choose a prototype of an electric motor drive mechanism and test its performance on an electric go-kart. Furthermore, the purpose of this study is to establish the power requirements of an Electric Go-Kart, as well as its specific motion capabilities and performance specifications factors, in order to access the performance of the Electric Go-Kart motion. The benefit of developed electric go kart is to help decrease the pollution emitted and as a substitute to the typical combustion engine vehicle. However, due to its high congestion and pollution issue, a pollution with free vehicle created. In the first phase of the project, the researcher surveyed information related to the typical of electric motor that use in electric go kart. The second phase of the project is mainly on calculating the forces acted on the Electric Go Kart itself. Three main factor of movement behavior on go kart determined rolling resistance 54.88N, air resistance 28.4N and force gravity going uphill 552.98N. After that, the researcher selects drive system components with required specifications. The Brushless DC Motor was selected with 2000W 48V whose maximum output torque is 27.6Nm. Towards the end phase of the project, the electric go kart prototype was developed with actual size of go kart 1.94m length, 1.4m width and 0.5m height. Electric motor was analyzed on the motor speed, torque and power to make sure that the performance was approximately the set specifications. In conclusion, the project was success and it can produce a good performance at the go kart.

Keywords: Electric go kart, combustion engine, power, torque

1. Introduction

The electric go kart is a new eco-motorsport technology based on the electric car idea. Electric car technology is currently in its third century of development, and it is expected to improve quickly this year. Internal combustion engines and electric cars are comparable in operation [1]. The vehicle's instruments panel and electric control module are powered by an ignition key or a numeric keypad. The vehicle is engaged when the gearshift is in drive or reverse. The automobile may creep in an internal combustion vehicle-like way when the brake pedal is removed. When the driver depresses the accelerator pedal, a signal is sent to the ECM, which subsequently transfers current and voltage from the battery system to the electric motor according to the degree of depressing the accelerator pedal. The motor turns to transfers torque to the electric vehicle's wheels [2]. Because electric motor torque curves are considerably wider than those of internal combustion (IC) engines, an electric vehicle can accelerate much more quickly than a conventional vehicle. When the accelerator pedal is withdrawn or the brake pedal is pushed, most electric cars feature a built-in system called regenerative braking [3].

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In general, an electric motor is a device that transforms electrical energy into mechanical energy and then uses that energy to create rotational motion. Electric motors are divided into two categories: AC motors and DC motors [4]. DC stands for 'Direct Current,' and it's what a battery produces. It's just electricity, and it's far easier to regulate than an alternating current motor. The AC (Alternating Current) that comes out of wall socket is known as AC [5].

Cost of energy, energy independence, and environmental preservation are all significant factors pushing the revival of Electric Go-Karts. Due to the impending demise of petroleum goods, their high cost, and supply constraints, many are considering Electric Go-Karts as a possible replacement means of race transportation. Electricity can be produced from a number of different energy sources. Therefore, electric motor is the ideal variable fuel vehicle [6].

The objective of this study is to select a prototype of Electric Motor drive mechanism and verify their performance on the Electric Go-Kart. Electric Motor drive mechanism and their performance on the Electric Go-Kart is narrowed down based on Brushless DC Motor with output power 2000W and 48V. Besides, this project also needs to determine the power requirements of an Electric Go Kart base on motion capabilities and performance specifications parameters. The research is become more precise in order to provide a better view of the key aspects. Power requirements of an Electric Go Kart based on total mass on electric go kart 140kg including driver with average speed 40km/h and maximum output torque 28Nm.

2. Materials and Methods

The purpose of this research is to develop a prototype with a test Electric Motor Go-Kart driving mechanism and evaluate its performance. Before making a decision on the electric motor, there are a few things to consider about. A deeper look at motor power, voltage, current, and compatibility, among other things. Understanding these aspects in greater detail will aid in the selection of an appropriate go-kart motor and make the decision much easier. Figure 1 shows the methodology of this research.

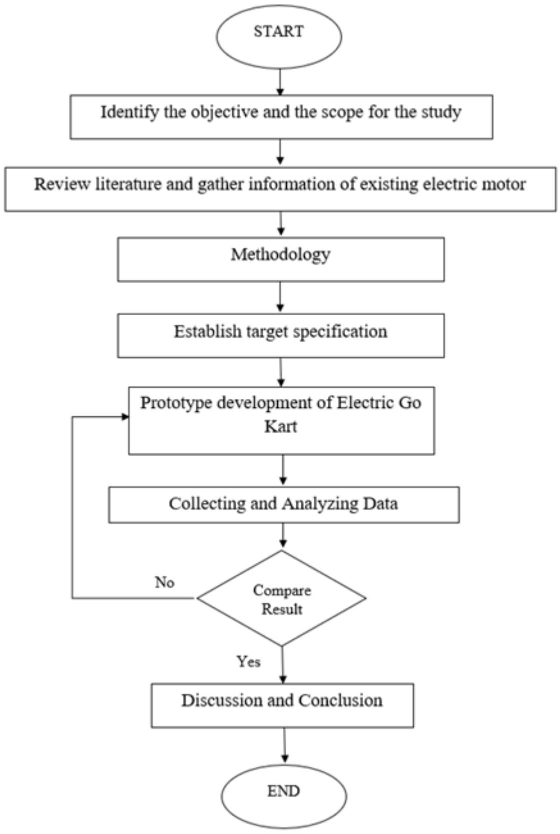

Fig. 1 - Methodology flowchart

2.1 Test Electric Motor Specification

For the test motor, using a Brushless DC Motor. Table 2.1 shows the specifications of the motor. The electric motor's parameters are based on research conducted in articles and journals. There is evidence that the requirements that were set are safe to run on the test road.

Table 1 - Test electric motor specification

Model	**KUNRAY MY1020**
Type	Brushless DC
Voltage	48V
Rate Speed	4300RPM
Rate Current	33Amp
Rate Torque	6.9N.m
Max Output Torque	400% rated value
Sprocket Driving	428 13T
Sprocket Driven	428 33T
Output Power	2000W
Weight	5800g
Dimension (Length*Width*Height)	134mm*118mm*108mm
Price	RM 689.61

2.2 Experiment Setup

The electric motor was mounted at the rear of the Go-Kart in the experimental arrangement, as illustrated in Figure 2. The output of the electric motor is directed to the go kart's rear tire through a chain and sprockets. The driven sprocket will be 33T, while the driving sprocket will be 13T. The electric motor is connected to the controller and battery, allowing the motor to be effectively operated. The experiment was carried out with three distinct electric motor rotational speeds of 573rpm, 1500rpm, and 2000rpm. The Tachometer measures the rotational speed, which is controlled by the throttle pedal. This control variable ensures that the researcher receives various data with three rotational speed tests, which are subsequently analyzed for electric motor performance.

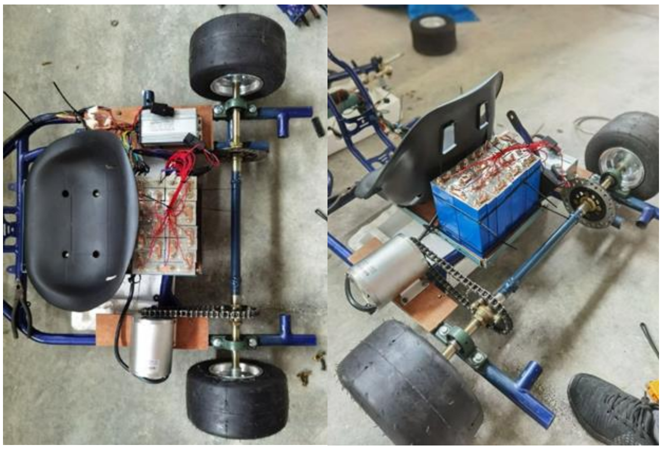

Fig. 2 - Position of electric motor on the go kart chassis

3. Results and Discussion

3.1 Powertrain Analysis

Some calculations are needed to determine how much power required by the motor in order to drive the PEV at the desired specification. Electric motor usually has mostly ideal speed-torque characteristic. The movement behaviour of a vehicle along its moving direction is completely determined by all the forces acting on it in this direction. The force of the rolling resistance is a function of the weight of the go kart multiplied by a coefficient of the rolling resistance. The total mass of go kart assumed as 140kg including the driver and coefficient of rolling resistance is 0.04. By using the Equation 3.1, rolling resistance at the go kart is 54.88N. The air resistance force is determined by using the Equation 3.2 which is considered the square of the speed, density of the air, and vehicle's drag coefficient. When a vehicle moves through the air at a certain speed, it encounters aerodynamic drag, which is made up of two elements shape drag and skin friction. The air resistance at the go kart is 28.4N. The angle of the slope and the force of gravity influence the force needed to lift a go kart uphill. The weight of a vehicle generates a downward-pointing component as it ascends or descends a hill. The gravity force uphill at the go kart is 552.98N by using Equation 3.3. According to the calculations, the highest potential forces will be used to calculate the maximum traction forces by using Equation 2.1 that the Electric Go-Kart faced, which is 890.2 N. All the force determination shown in Table 2.

Table 2 - Force determination

Force Determination	Force Required
Rolling Resistance	54.88N
Air Resistance	28.40N
Gravity Force going Uphill	469.70N
Tractive Force	552.98N

3.2 Minimum Motor Torque Required

From the definition of torque, the torque applied at wheel is calculated with multiply the torque on motor with gear ratio which is number of teeth on driven per number of teeth on drive. Rated torque on the motor get 70Nm. To ensure that the motor can moved the go kart, mechanical torque was calculated. Total mechanical torque on wheel determined by using value of total tractive torque multiple with radius on rear wheel and resistance factor for the frictional losses between the caster wheels and their axles and the drag on the motor bearings. Typical values range between 1.1 and 1.15 (or 10 to 15%). The value of mechanical torque is 73Nm. Rated torque of the motor is assumed similar with mechanical torque on the wheel. The maximum output torque is 27.6Nm on BLDC motor with rated power 2000W at 4500RPM. To calculated the wheel speed, rated motor rpm divided with gear ratio and the speed is 1771.65rpm. In experiment test for this maximum rated speed without load, BLDC motor with 2000W 48V can achieve speed 2000rpm. This value is measured by using digital tachometer.

3.3 Voltage, Current and Power at Electric Motor

The flux resistance was calculated using the DC electric motor test, and a voltage is delivered to the flux at the DC electric motor. The current that flows through the flux as a result is a direct current. As a result, there is no voltage induced in the rotor circuit, and the motor reactance is zero. The single circuit parameter restricting current flow is flux. Sixteen pieces of 3.2-V 25AH LiFePo4 batteries were required to provide the power source, which became 51.2-V when applied to the DC motor. In order to regulate DC current to the rated value, a group of light bulbs is inserted in the circuit as a resistive load. The flux current and voltage across the motor are measured. The motor rating that was employed in this study is indicated in the table 3.

Table 3 - Specification of BLDC Motor

Power	2000	W
Voltage	48	V
Speed	4500	rpm
Current	33	Amp
Weight	6	kg

The no-load test was used to quantify copper losses at stator windings, core losses, and mechanical losses. The motor was tested at rated voltage and frequency without a load connected to the rotor shaft.

Table 4 - Power consumption of BLDC Motor

Throttle	Voltage (V)	Current (A)	Power (W)
Low	48.8	33	1610.4
Medium	50.5	33	1666.5
hard	52.6	33	1735.8

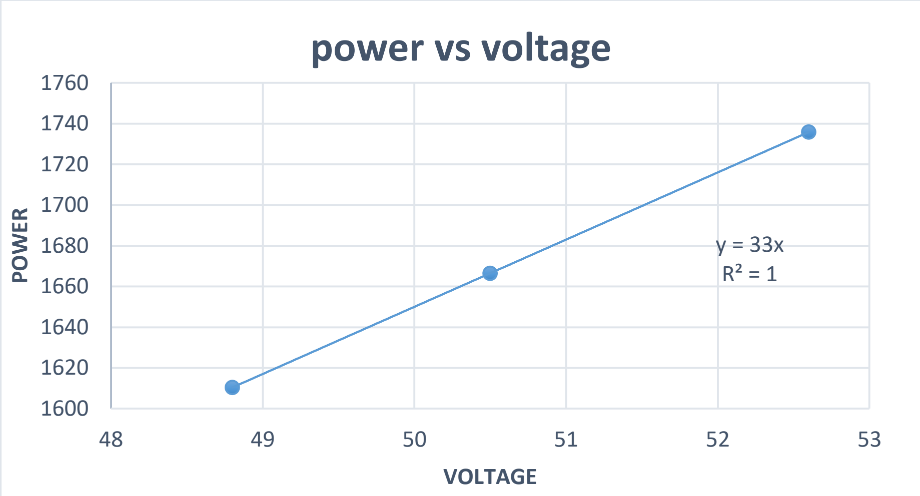

Fig. 3 - Graph Power Vs voltage

Using the data that was obtained, the Power (W) vs Voltage (V) graph was plotted as shown in Figure 3. Because of the Voltage, the graph displays that the trend is increasing and linear. The graph's equation is y = 33x, which implies that the gradient of the graph is 33 and the graph's intersection is 0. (0,0). The intersection shows that the Voltage is 0V when the Power is 0W. As a result, the energy efficiency of brushless DC (BLDC) motors may provide the same mechanical power for the same electrical power need. BLDC motors are thought to be more efficient in terms of energy consumption. For the same input power, a BLDC motor will convert more electrical power into mechanical power than a brushed motor due to the absence of brush friction. The improved efficiency is greatest in the no-load and low-load regions of the performance curve of the motor.

3.4 Speed Test

On-table speed test for the Brushless DC Motor, which is competent for the rear tyre and axle by using sprocket ratio 33/13 and chain 428. The rating for the motor that was used in this study as shown in the table 5.

Table 5 - Specification of BLDC motor 2kW 48V

Power	2000	W
Voltage	48	V
Max Forward Speed	2000	rpm
Reverse Speed	573	rpm
Current	33	Amp

Table 6 - Performance of BLDC motor 2kW 48V

Throttle	Speed (rpm)	Power (W)	Torque (Nm)
Low	573	1610.4	26.8
Medium	1500	1666.5	10.6
Hard	2000	1735.8	8.29

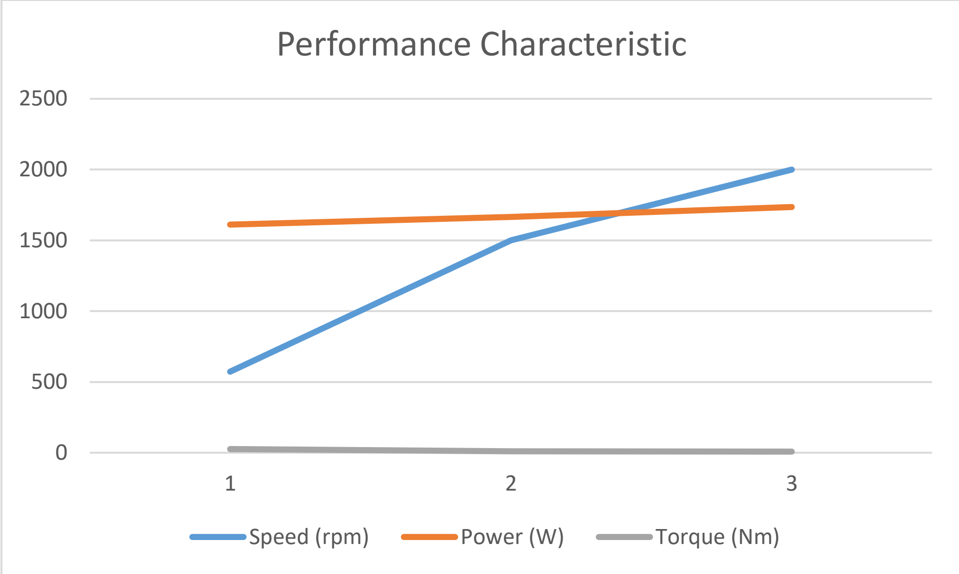

Fig. 4 - Graph performance of BLDC motor 2kW 48V

The graph depicts the performance of the electric motor in terms of speed, power, and torque. The rpm of the motor is obtained by measuring it using a digital tachometer. When the throttle speed is pressed hard, tachometer measurements are obtained every 5 minutes to guarantee consistent numbers and no inaccuracies. The highest speed is 2000rpm when there is no weight on the go kart and it is just running on the table. To create a graph, the speed is measured three times: once with high, once with medium, and once with low pressure on the throttle. Medium pressure receives 1500rpm, whereas low pressure receives 573rpm. Using reverse speed, the value of low pressure is obtained. That means the average operating speed of the reverse motor is less than 573rpm, and the braking system is safe at this speed without a clear view at the rear. When the speed increases, so does the value of the power. The power value is obtained from the power consumption tables in table 5. The power may be calculated by taking the voltage and multiplying it by the related current. Lastly, torque at the motor can be define when the value of speed and power was identified. Each pressure applied to the speed throttle result in a different value for the torque, with the higher the speed value resulting in a lower torque value. In the Figure 4 graph show that the motor need 26.8Nm torque to rotate the motor at speed 573rpm and the motor just need 8.29Nm to rotate the maximum speed. The reason for this is because the back EMF opposes the supply that is attempting to force current into the stator, that will generate EM-Torque. As a result, the performance characteristic of an electric motor is almost same with the internal combustion engine with the same power output. When direct convert the output power of 2000W to the mechanical horsepower, the value is 2.682hp. Based on the dynamic characteristic comparison of the electric vehicle and the conventional vehicles it can be said that the vehicles propelled by an electric motor are mostly equal with their corresponding conventional vehicles. Under certain conditions of the exploitation, electric vehicles have significant advantages (driving in city traffic and mastering certain upward grades of a road). Disadvantages of electric vehicles are mainly manifested in achieving higher driving speed than those which are common to city traffic conditions. Advantages of electric vehicles could be significantly improved by reducing the weight of the vehicle battery which would greatly alleviate their disadvantages or completely eliminate them.

4. Conclusion

The research is concluded in this section with all data obtained and findings of the experiments that have been performed. The objective of this research to select a prototype of Electric Motor drive mechanism and their performance was verified. The power requirements of an Electric Go Kart base on motion capabilities and performance specifications parameters range had been accomplished successfully.

The researcher was selected the best electric motor to power the Electric Go Kart. It can fulfil the speed requirement due to a 48V DC motor with 2000W of power. The Go Kart is powered by a 51.2V 25Ah NimH battery pack that can operate for around 28 minutes on a single charge. With a gear ratio of 2.54 and a maximum torque of 70Nm at the wheel, the BLDC motor is ideal for a single driver weighing less than 60kg to ride on a level surface up to a 20° inclination plane. Other than that, hopes the simplified version of the Go Kart is more user friendly and that users can easily maintain it. Below is the finished prototype managed to be developed.

Fig. 5 - Completed electric go kart prototype

In order to enhance the design as well as its performance, the researcher recommends that the project's successor undertake the following experiment with different types of electric motors while using this prototype to assess its performance so that the best electric motor may be found as a result of the experiment. It is recommended that the test be performed on the road rather than in a lab. All data generated and gained from each testing or experiment should be fully used so that future researchers and designers may benefit.

Acknowledgement

The authors would like to express their gratitude to the staff of Faculty of Engineering Technology at Universiti Tun Hussein Onn Malaysia for their assistance and contribution.

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