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Investigation on Power Battery To Be Used for Electric Go-Kart Development

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Abstract: Based on the research, all the information was be summarized to find out the suitable battery for the electric go kart development. The trending or demand of lithium battery was increased year by year compare to the lead acid. It all because of the performance of the lithium battery on density, weight and capacity give it the most demand on the market. The selection of the lithium and lead acid batteries was selected by refer to the research. The value of the internal resistance need to find out because it will give the impact of safety on the battery, which is the higher internal resistance with the higher current will heat up the battery that may causes of explode. So the lithium battery has the lower internal resistance with higher current, that means it was safe to be used. On the charging time, the calculation will be find out power of the batteries and the capacity of the battery charger to get the time taken to charge the batteries. The different output current on DC charger will give different charging time taken, which is the higher output current give lower time of charging. From this project, it will came out with the data to support the lithium battery as a suitable and safe to be used in development of electric go kart. Beside that, the DC charger with higher output current will cut off the time taken to charger the battery.

Keywords: Electric Go Kart, Battery, Battery Charger

1. Introduction

Go-kart is a simple four-wheeled, small engine, single sealed racing car, by definition it is a go-kart, no differential. Vehicles are usually run on scaled down tracks, but are powered by non-professionals often as entertainment or as a hobby. Karting is commonly perceived as the stepping shone towards higher and more expensive motor sports rank[1]. Kart racing is widely recognized as the most economical motor sport type available. It can be done as a free-time activity by nearly anyone and allows approved racing for anyone from age 8 onwards. Kart racing is typically used to introduce drivers to motor racing as a low-cost and fairly safe way. It is associated with many young drivers, but adults are also very involved. Karting is perceived as the first step in the career of any serious racer. It will prepare the driver for high-speed wheel-to-wheel racing by assisting in the creation of guide reflexes, car precision control, and decision taking abilities. Moreover, it gives knowledge of the different parameters that can be modified to try to boost the performance of the kart that also occurs in other

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motor racing types. Electric vehicles are becoming more and more common in our lives today. Especially on motorsport. They aren't as commonly used though. It's not enough to popularize Formula E, which was developed to improve electric motorsport. Any driver who wants to progress to F1 (highest-ranking racing series) will start from karting between 5 and 8 years of age. Yet go-karts today are powered only by internal combustion engines. To give young drivers the ability to race small electric cars called eKarts, internal combustion engines must be replaced with electric motors. In the case of combustion engine go-karts, eKarts will give similar efficiency. Growing knowledge of ecology and the quest for new areas of motorsport research has contributed to the introduction of hybrid technology, which was the first indication of a return to electricity [2]. The international policy agenda has been pushed towards greenhouse gas (GHG) reduction in response to the recognition of human-induced climate change in the last decades. The transport sector is the fastest growing source of all GHG emissions, especially land based passenger transport. It is recognized as an essential sectors [3].

1.1 Problem Statement

In this study, problem statement is emphasized so that the issue to be addressed or a condition to be improved upon are not neglected as it will be the main focus of doing this research. Yet go-karts today are powered only by internal combustion engines, so it will give a emission gas that causes to the pollution. The harmful gas-go-karts exhaust fumes are not only bad for the environment, but can also cause people to feel sick. Prolonged exposure can lead to more serious problems, such as respiratory damage, cardiovascular problems and more [4]. Throughout their lifetime, electric vehicles are far more affordable to keep up than their internal burning partners, since electric vehicles don't have a considerable lot of the segments that need support. For instance, oil or liquid changes, transmission work and so on. There are, in any case, a couple of segments that should be kept up in either vehicle, brakes and tires, for instance, which ought to be moderately cheap over the all out existence of the vehicle.

1.2 Objective Study

The objectives of this development are to study the selection of the batteries that will be used in electric go kart development. The second objective for this development is to study the charging time taken on batteries based on direct current (DC) charger current output.

1.3 Scope of Study

For this project of research for electric go kart, the one thing to recollect about battery determination is that there is nothing of the sort as an ideal battery that works for each application. Choosing the correct battery for any application is tied in with recognizing the most significant battery measurements and exchanging these off against others. For example, if need a more power for the application, cell internal resistance should be limited, and this is regularly done by expanding terminal surface of electrode [5]. The limitation are what are going now , there is simply such a great amount of space to place a specific measure of vitality into a storage cell. The present innovation of batteries pack a great deal of vitality into such a little compartment, additionally it can turn out to be extremely unpredictable when something turns out badly. There are a few advancements that are being probed now that offer more vitality. It either have higher creation costs related with the materials utilized or still unfeasible and just excessively flighty and solid. The problem will get into when more vitality into a littler compartment that will have a more noteworthy possibility of disappointment, and when it failed it will be increasingly volatile [6]. All battery chargers make them thing in like manner, they work by taking care of an electric flow through batteries for a while with the expectation that the cells inside will clutch a portion of the vitality going through them. That is generally where the comparability between chargers starts and end. So, for this development, it should follow the guideline which to select the right batteries, to know the limitation of the batteries that will be used and the right type of charging process to make sure the flow of current that need to supply for motor will at the ideal condition and save.

2. Literature Review

It discovered this particularly significant given that electric engines are progressively supplanting gas motors in the present gasoline go kart since the electric go kart are all the more friendly environmentally and simpler to maintain. Develop an electric vehicle or electric go kart implies finding a relation between power, vitality utilization, weight, capacity, cost and cycling time used [7]. Electric go-karts have a low noise level and are progressively utilized on indoor tracks to be leased, so some organizations sell electric go-karts, for example, Speedomax, Sodikart, Swiss Hutles and since 2009, the greater part of these go-karts are contending with petroleum ones as far as execution [8]. For electric go karts, Lead acid is by far much cheaper, but it is much heavier. With a heavier battery you need a stronger frame, which weighs even more increase. With all of this weight, a go-kart need an even stronger motor to push it all. With lithium batteries can build a lighter, cheaper frame, and power it with a weaker and cheaper motor and still obtain the same speeds. Lead Acid batteries take up about 1/3 the weight of a go kart with rider which is 1/3 being the driver, and the other third being chassis and motor and other mechanical part. Reducing the weight by choosing the lithium ion batteries could have huge performance improvements. Lithium ion batteries got a more of evolution for its battery technology. Lithium ion batteries have more advantages and efficiency for standalone photovoltaic system to compare with lead acid battery [9]. Lithium ion batteries have high energy capacity, low maintenance and life cycle is higher than lead acid battery [10]. Lithium ion batteries are also environment-friendly [11].

2.1 Energy Density Of Lithium Battery And Lead Acid Battery

The small size of dimension is easier to consumer to use a small space and the important part of the light weight of batteries can increase the performance of application without carrying a heavy weight to move in distance. Beside that, the lead acid is the last or the low level of energy density which is the weight is very high to compare with the Lithium battery that has high density with light weight. The size of the lead acid battery also show the in the big size to compare with the lithium battery, that mean the lead acid need a big space of battery station in the vehicle or consumer user in daily life. Lead acid also has a high weight compare to other rechargeable batteries that need a strong chassis to support the batteries and the high weight also will effected the performance of motor to carried the load. From the Figure 1, it shows the different of comparison with different batteries in term of volumetric and gravimetric energy density which is the sale on worldwide for NiCd, NiMeH and Li-ion portable batteries is 23, 14 and 63.00 %, respectively. Moreover it proved the Lithium ion batteries is got the high density weight with the light weight and smaller size of dimension and weight that will attracted the consumer to use lithium ion batteries other than rechargeable batteries in market.

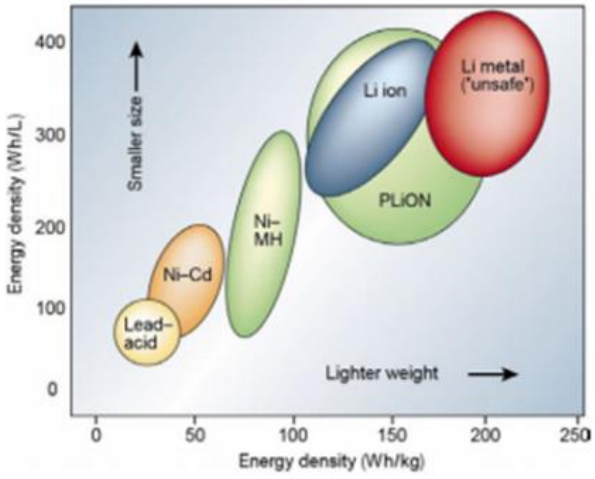

Figure 1: Comparison of energy densities and specific energy of different rechargeable batteries [12]

2.2 Cycle Life Of Lithium Battery And Lead Acid Battery

The life cycle of lithium ion is more high than the life cycle of the lead acid batteries. This limit decrease in maturing component is for the most part because of the accompanying component which is loss balance between cathodes, loss of anode area and loss of terminal material/conductivity [13][14]. Battery efficiency and performance will decrease with the rehashed use and age, that is limit is influenced which is the capacity to more than once store and discharge electric charge and decrease. This situation is regularly happened on battery maturing [15].

3. Methodology

Process of producing the study, the design of the study, as well as the research tools used during the research process or when obtaining research information. In this research methodology will tell more in detail about the product production process from the beginning of the idea to the product testing. Methodology is closely related to the methods and the use of flow charts to indicate the course of a project. In order to execute a project, it requires a specific method or procedure to implement the process of producing a project.

3.1 Methodology Flow Chart

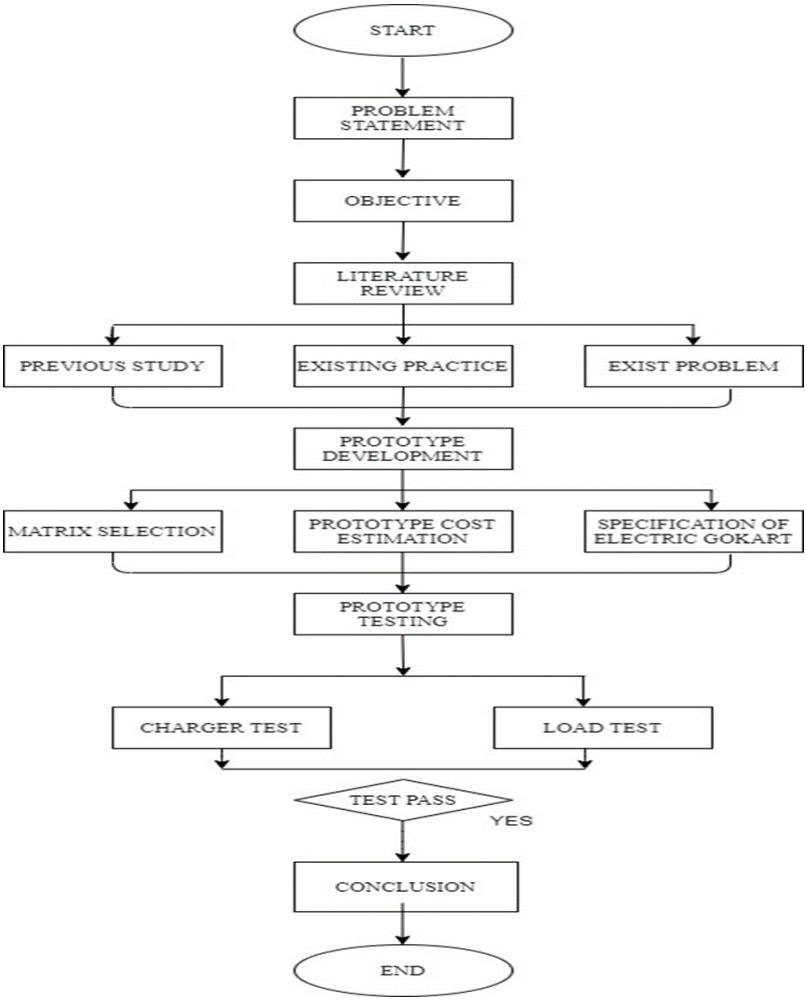

Figure 2: Methodology Flow Chart

3.2 Batteries Selection By Using Matrix Method

Table 1: Matrix Selection For Batteries

Batteries Type	Lithium Battery 48 volt		Lead Acid Battery 48 volt	
Criteria	Rating	Description	Rating	Description
Batteries Capacity	3	Flexible suggestion	3	Flexible suggestion
Life Cycle	3	Range 1000-1200	2	Range 500-800
Weight	3	4 kilogram	1	6kg and above
Cost	2	Expensive	2	Expensive
Safety	1	Can explode if over heat	2	Can expand
Size	3	Small size with high capacity	1	Big size with high capacity
Total	15		11	

- 3 = Matches an ideal system
- 2 = Almost meet the spec of ideal system
- 1 = Does not match the ideal system

Based on the matrix selection method above, it prove the Lithium battery is the high rating which is the best recommendation by data and researched. Based on the density of the lithium battery, got the high density weight with the light weight and smaller size of dimension and weight that will attracted the consumer to use lithium ion batteries other than rechargeable batteries in market. The small size of dimension is easier to consumer to use a small space and the important part of the light weight of batteries can increase the performance of application without carrying a heavy weight to move in distance [12]. For the batteries capacity for the both batteries show the same rating which is the capacity of the battery can be requested and choose by the user. The life cycle of the Lithium battery show that it more long lasting can be used which is the usage of the battery no need to be replace in the short period. The light weight of the Lithium battery make a more advantage between the lead acid battery, the light weight of the lithium battery will help to decrease the load that will be carry by the motor on the electric go kart. For the safety criteria on Lithium battery is very low, so it need a safety precaution when handling and using the batteries. Thermal runaway is a state that occurs when the temperature of the lithium battery reaches a critical value such that the reaction rate of an exothermic reaction increases the temperature, which in turn leads to further acceleration of the reaction rate[16]. On this problem, it need a safety housing station of the lithium battery and it should identify the limit of the battery before it become hot.

3.3 The Electric Go Kart Specification

Table 2: Electric Go Kart Specification

Part and Equipment	Description

Batteries	• Lithium Battery • 48 Volt • Weight is 4kg • 12000 AH capacity • 1000-1200 life cycle
Chassis	• Weight 11kg
Motor	• DC Motor • 48 Volt • 6000 Watt
Motor Control Board	• Battery Connector • Motor Connector • 48v/6000 watt
Battery Charger	• DC charger • Input Volt = 180-240 Volt • Input Current = 0.5A • Output Volt = 48 Volt • Output Current = 1.2 A/ 2A

3.4 Direct Current (DC) Load Test On Lithium Battery

DC load test will measure to check the large stationary batteries and the ohm reading of batteries was very accurate and repeatable. A voltmeter will measure the open circuit voltage with no load, the it will followed by measure the volt with the load. Then the Ohm Laws can be calculate the resistance value. So the formula is represent as:

$$Voltage\ No\ Load - Voltage\ \ With\ Load \div Current = Internal\ Resistance \qquad Eq.1$$

The Lithium battery with low internal resistance will give a high current on requirement which is when the resistance high it may heat up the lithium battery and make the voltage drop.

3.5 Experiment of Charging Process

For this experiment, it will be tested the charging system by using the theoretical data from calculation. It will calculate the power of the batteries and the capacity of the battery charger to get the time taken to charge the batteries. The calculation will be used two different output DC charger to compare which charger will give the best time to fully charged the lithium battery of 48 volt. The

formula below will show how to calculate the power by battery, battery charger and time taken to charge the batteries.

- Battery Charger = Charger Volt × Output Current
- The Batteries Power = Battery Volt × Capacity Battery (Ah)
- Time Taken To Charge Battery = Power By Battery ÷ Battery Charger

4. Result

This section will review the detail of result and data installation for the lithium battery that was selected by the matrix method. Therefore, the cost estimation for development of electric go kart also was review in this section. So, the data was come from the battery DC load test and calculation of the charger time taken.

4.1 Management of the Charging System

For this experiment, be tested the charging system by using the theoretical data from calculation. To calculate the power of the batteries and the capacity of the battery charger to get the time taken to charge the batteries. The calculation be used two different output DC charger to compare which charger will give the best time to fully charged the lithium battery of 48 volt.

By Using 48 v/2 Ah DC charger

- Battery charger = 48 V x 2 Ah

  = 96 Ah
- Power By Batteries = 48 V x 12 Ah

  = 576 Wh
- Time Taken To Charge The Batteries

  = Power By Batteries ÷ Battery Charger

  = 576Wh ÷ 96Ah

  = 6 Hours

By Using 48V/1.2Ah DC Charger

- Battery Charger = 48V x 1.2Ah

  = 57.6 Ah
- Power By Batteries = 48V x 12Ah

  = 576Wh
- Time Taken To Charge The Batteries

  = Power By Batteries ÷ Battery Charger

  = 576Wh ÷ 57.6Ah

  = 10 Hours

Based on the theoretical calculation by using different output of DC charger of 48 volts, it shows the different of the time taken to charge the lithium batteries of the 48 volts/12 Ah. By using the DC charger that has output of current 2 A, the charging time to fully charged the lithium batteries is 6hours and by using the charger of that the output is 1.2 A it needed 10 hours to charge the batteries capacity of 12 Ah. It was 4 hours different time between using different output of current 2 A and 1.2 A, so

technically the output current 2 A of DC charger is the best charger to charge the lithium batteries because it give a good time to charge the lithium batteries.

4.2 Time Taken For DC Charging Based On Current Ampere

Here is the calculation of the different type of DC charger with different current ampere which is to compare the time taken needed to charging the lithium batteries. The DC charger that was calculated is the standard type in the market, it will provide the different of output current ampere that based on user requirement. So, the usually output current ampere that was calculated by using the theoretical formula is 2Ah, 4 Ah, 6 Ah and 8 Ah. Table 3 shows the calculation of the different current ampere with same the power of lithium batteries 48 V/12 Ah.

Table 3: Calculation Of Time Taken Charge Batteries With Different Current Ampere

Output Current Ampere Of The DC Charger	Power Of The Lithium Batteries (48V/12Ah)	Battery Charger Capacity	Time Taken To Charge The Batteries
2 A	576 Wh	96 Ah	6 Hours
4 A	576 Wh	192 Ah	3Hours
6 A	576 Wh	288Ah	2 Hours
8 A	576 Wh	384 Ah	1.5 Hours

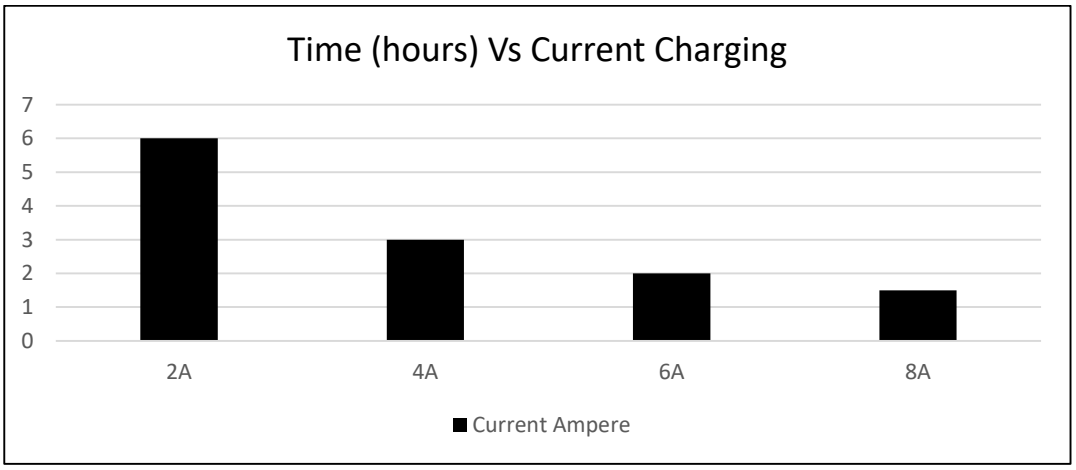

Figure 3: Time Vs Current Charging Graph

Based on the Figure 3, it showed the time taken that need by the charger to charge the lithium batteries with the different output current ampere. That how the output of current ampere will effected the time taken to charging which is when the output of the current from the charger has high value it will give a short time to charge the lithium batteries.

4.3 Internal Resistance Measurement On Lithium Battery

The power losses in the battery can be calculated by using the internal resistance of the battery. An ohmmeter is not possible to be used in order to measure the internal resistance due to the current generated by the battery itself will interfere with the measurement. DC load test is one of the techniques that can be used to measure the internal resistance of the battery. Here the calculation of the internal resistance after get the data from the load test. Table 4 show the parameter of the induction mode that was set up in B&K Precision's 8500 DC load.

Table 4 : Parameter of Induction Motor

Stator Resistance	0.0064 ohm
Rotor Resistance	0.0071 ohm
Core Resistance	6.5336 ohm
Stator Leakage Inductance	22.371 uH
Rotor Leakage Inductance	22.371 uH
Magnetizing Inductance	0.43871 mH

After the parameter of induction motor was key in the B&K Precision's 8500 DC load, the result show the load voltage with different value. Table 5 will show the value of the load voltage which is the using different current and same parameter of induction motor.

Table 5 : The DC Load Test Measurement Result

Voltage	Current (A)
48.9	0
48.3	5.1
47.9	9.7
47.4	14.3

From the DC load test measurement result, it can help to find the value of the internal resistance by using the Ohm's Law formula. Here is the calculation of the internal resistance by using Ohm's Law:

$$\mathbf{R_i} = \frac{\mathbf{V_l - V_0}}{\mathbf{i}} \qquad \textit{Eq. 2}$$

- Load Voltage = 48.3V, Current = 5.1 A, Open Circuit Voltage = 48.9V

  (48.9V – 48.3V) ÷ 5.1A = 0.118Ω
- Load Voltage = 47.9V, Current = 5.1A, Open Circuit Voltage = 48.9V

  (48.9V – 47.9V) ÷ 9.7A = 0.103Ω
- Load Voltage = 47.4V, Current = 14.3A, Open Circuit Voltage = 48.9V

  (48.9V – 47.4V) ÷ 14.3A = 0.104Ω

Table 6: The Internal Resistance After Load Test

VOLTAGE	CURRENT (A)	Rin (Ω)
48.9	0	-
48.3	5.1	0.118
47.9	9.7	0.103
47.4	14.3	0.104

Based on the Table 6, it shows the value of the internal resistance, current and load voltage. From the result, it shows when the current was level up the load voltage was going down which follow with the internal resistance also going down. So its mean, when the resistance was added to the circuit, it will reduce the value of the voltage and that make reduce the lithium battery from heat up. Low resistance, delivers high current on demand which is battery stays cool but high resistance, current is restricted, voltage drops on load and battery heats up.

5. Conclusion

Based on the objectives of this study, the result will be to produce a correct outline of electric go-kart which is has a correct and suitable battery that can be a powered the go kart. So the battery will supply consistantly power to the motor based on motor requirement the motor, this to make sure the go kart chassis and the driver of the go kart can be carried. Beside that, the battery meet the requirements and characteristics set in order to complete and simplify the process of movement on the go-kart with the optimum point. The battery charging also is the important part to make sure the battery can reached the fully capacity voltage when the battery in the low condition of power. When the battery on that situation, the charger will supply the power from the electricity power sources depend on the capacity of the battery with the safety way that will not over charged the battery more than the capacity that can dangerous situation will occur. Moreover, the charger will charge the battery faster by using the fast charging to make sure the efficiency of the go-kart performance still at the top condition which means the electric go-kart always ready to be used. For the selection of the battery, several test required to make sure the lithium battery can be used safety and at the optimum performance. From the literature review, it was mentioned about the flammable hazard that usually occurred when used the lithium battery, so the load test was carried out the data with came out with internal resistance. The internal resistance equation was used to calculate resistance came from the load that make a lithium battery heat up and maybe can be explode. So the load test is the best way to determine the limit of the resistance of the lithium battery.

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