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Development and Construction of Electric Propulsion System for Go-Kart

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***Abstract:** Go-kart ride is accessible to everybody, regardless the old age and driving expertness. Economic and environmental influences have raised the demand to change from conventional combustion engine to electric propulsion systems for go-kart. This project is focusing on design and development of propulsion and energy storage system. Electric propulsion system will improve energy efficiency and significantly reduce greenhouse gas emissions. This project is lead to practical experiment to analyze and explore the action of modifying combustion engine powered go-kart to an electric powered go-kart. Several aspects need to be considered to design a good performance of an electric go kart that involves hardware and electrical energy propulsion system. In this project the calculation of force and power was done base on both the weight of go-kart and driver. The power calculation with certain degree of slope was also done to determine the maximum power demand for motor selection. The project is expected to drive a total weight of 120kg including the weight of the go-kart and the driver. The design is also included the installation of the gear, propulsion, battery and controller in electric go kart. The electrical component that consist in go-kart are battery, brushless DC motor and controller, wiring harness with on, enable and forward/reverse switches and motor cable. These selections of components are based on calculation analysis for each selected device. Lastly, the performance of electric go kart will be analyzed in term of power, speed and energy work. As the results, the propulsion system could drive the go kart and speeds can be regulated, also the maximum speed of the go-kart reaches its desired speed.*

***Keywords:** Electrical Propulsion; Go-Kart; Brushless Dc Motor.*

I. INTRODUCTION

One of the popular motorsports that is affordable and safe is Go-Kart racing. It can be carried out as a leisure activity by anybody as well as competitive motorsport. A race car builder Art Ingles of America is generally considered as the father of modern go-karting. He built the first go kart in Southern California in 1956 and became instant popular. Go-karting rapidly spread across the globe and now has big following especially in Europe. The first commercial go-kart was produced by an American company called Go-Kart Manufacturing Co. in 1958. Whereas the first go-kart engine model McCulloch MC-10 was made in 1959 by McCulloch Company in United State of America. This engine was an adapted two-stroke engine of standard chainsaw. Starting from 1960s, motorcycle engines were also adapted for go-kart use. By now, they are many companies all over the world produce go-kart engines especially for the sport but mainly combustion type.

With the current trend of green technology in automotive industry for reducing its carbon footprint, it is now becoming more common in industry and has extended to motorsport that inclusive of go-karting. More and more researchers have embarked in research works to replace the existing combustion engine of go-kart with environmental friendly electrical motor.

Typical go-kart can be classified into many types such as speedway karting, indoor karting, road racing kart and sprint kart. Although they look similar in physical design but with wide range of technical specifications. Generally, go-karts are designed with load to 100 kilograms and maximum speed up to 160 kilometres per hours with small combustion engine and skeleton frame [1]. Fig. 1 shows the typical modern road racing go-kart.

Fig. 1 New version go-kart

The newly developed electrical go-karts involve various modifications with application of some latest technologies. The important parts involved in the advancement of the electric go-karts are the transmission system, energy source, power split controller and power electronic circuitry [2]. The crucial contribution of the energy sources in the traction system is to transmit the power for the load require. In order to storing the regenerative power from the electric vehicle is the ability of the storage devices.

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Power electronic converter circuitry are used as a function to stabilize the output response of the energy sources and deliver its constant output to the traction motor that drives the vehicle.

Both AC motor modelling and vehicle dynamics modelling are incorporating together for the development of the vehicle transmission system. Thus all the components intricate in the proposed model are developed individually and integrated to form a Fuel Cell Hybrid Electric Vehicle. Fig. 2 shows the integration of the key components with the complete model of the designed hybrid electric vehicle architecture [2].

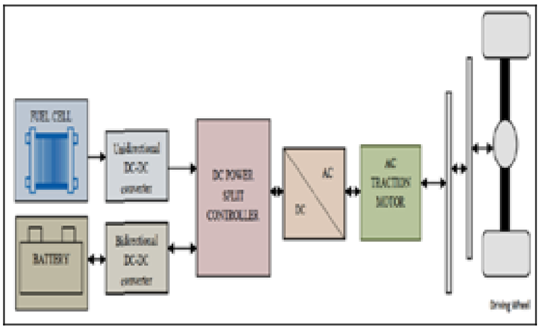

Fig. 2 System of fuel cell hybrid electric vehicle

A. Problem Statement

The concerns of economic and environmental aspects have resulted in increasing the demand for the electric drive system in motorsport such as go-karting. The electric go-karts have clear advantage due to electricity can be produced renewably, and can obtain from cleaner energy source. Electric go-karts can also generate more energy with efficiency better than the internal combustion mechanisms. This project has led to practical experiment to analyse and exploration in modifying a gasoline fuel powered go-kart to an electric powered go-kart.

B. Project Objectives

To carry out sizing of components use in the propulsion system.

- To assemble electrical wiring energy propulsion system of electric go-kart.
- To analyze performance of the whole energy propulsion system of the go-kart by using electrical instruments.

II. METHODOLOGY

The methodology used to develop and fabricate propulsion energy of electric go kart system consists of 8 steps including preliminary research on design propulsion and energy of electric go kart system. It follows by study done on selection for sizing and suitable devices for electric go kart. Calculation analysis performed on selected devices and all the standard devices were purchased followed by assembling of devices onto electric go kart frame. After all the devices and wiring were installed on the go-kart, fabrication on body and electric go kart frame can be done. Finally, the performance of electric go kart was tested and the results were analyzed. Calculations on results were shown as a proof as well for comparison purpose. Fig.3 shows the process flow for the development of electric go kart.

A. Design on Propulsion and Energy of Electric Go Kart System

Drive system such as electric motor, transmission, power electronics and energy storage which is battery are consist in a simple electric traction drive system. In Fig. 4 shows the typical electric drive system model [3]. Basically, energy source is stored in the battery. A power electronic converter converts the energy to drive an electric motor. The ratings of the electric motor are match by maintained the voltage and current output of the battery. The electric motor transforms the electrical power supplied by the battery into mechanical energy. Mechanical energy is converts into a linear motion by transmission. By using the gear box, speed and torque can be adjusted. The gear can transfer the rotational force at various torque, speeds and directions. The speed, energy management, optimization and energy conversion from battery to transmission will be controlled by a controller. The line power and regenerative braking operation can charged the battery power [3].

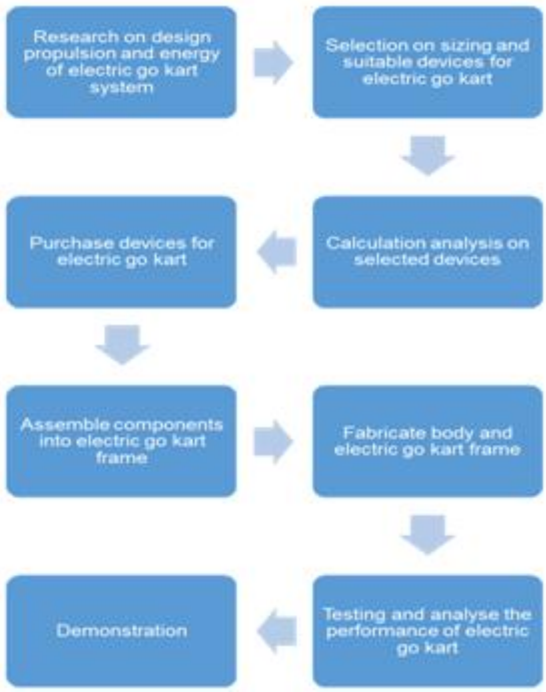

Fig. 3 Project Flow Chart

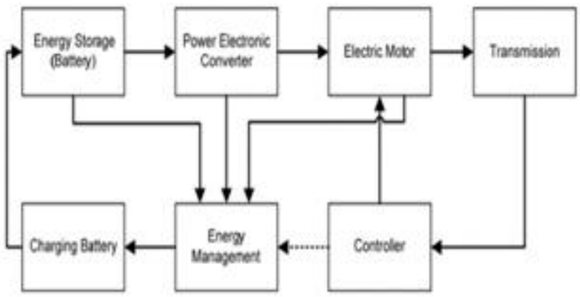

Fig. 4 Flow of electric traction drive system

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Table. I List of electrical devices

No	Item	Description	Qty	Images
1.	DC Motor	48Volt 3000W Brushless DC Motor (C80-8804)	1	
2.	Motor Controller	48Volt 360A 5000Watt Brushless DC Motor Controller (Z09-1718)	1	
3.	Battery	12Volt 15Ah YTX14AH-BS Replacement Lithium-Iron (LifePO4) Battery (X98-1424)	4	
4.	Battery Charger	12Volt 4.0Amp 12BC4000T-5 Battery Trickle Charger (C16-130)	1	
5.	Pedal	Hall Effect Foot Throttle (T53-6172)	1	

Table 1. above shows the list of electrical components that have been chosen based on calculated size and parameters.

B. Motor Calculation Analysis

To choose the motor for an electric go kart, the following force calculations were done with conditions of 17o slope and flat level:

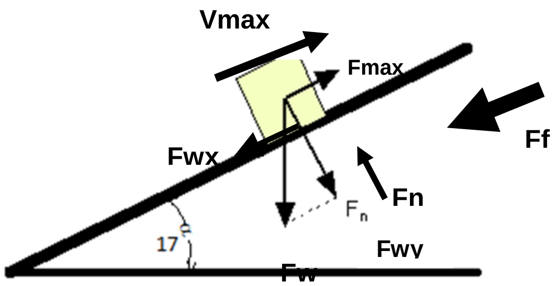


Table. II Force parameters with 17° slope

Slope = 17°	F_{wx} = mg sin θ
F_f = magnitude of friction	F_{wy} = mg cos θ
F_n = magnitude of normal force	Mass = 120 kg
F_w = mg	Coefficient of friction (μ) = 0.7

F_w = mg
= 120 x9.81
= 1177.2 N

$F_{wx} = F_w$ x sin 17°
= 1177.2 x sin 17°
= 344.20 N

$F_n = F_{wy}$
= F_w x cos 17°
= 1177.2 x cos 17°
= 1125.76 N

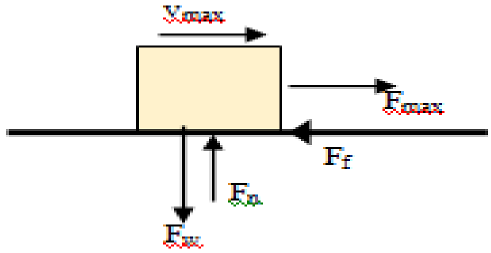
F_f = μ x F_n
= 0.7 x 1125.76 N
= 788.03 N

Go-kart maximum forward force;
$F_{max} = F_{wx} + F_f$
= 344.2 + 788.03
= 1132.23 N

Power = F_{max} x V_{max}
= 1132.23 x 4 m/s
= **4528.93 Watt** (at 100% efficiency)

Table. III Force parameters with flat level

Slope = Flat level (0°)	F_w = mg
F_f = magnitude of friction	Mass = 120 kg
F_n = magnitude of normal force	Coefficient of friction (μ) = 0.7



$F_n = F_w$ = mg
= 120 x9.81
= 1177.2 N

F_f = μ x F_n
= 0.7 x 1177.2 N
= 824.04 N

Go-kart maximum forward force;
$F_{max} = F_f$
= 824.04 N

Power = F_{max} x V_{max}
= 824.04 x 4 m/s
= **3296.16 Watt** (at 100% efficiency)

$\omega_{max} = V_{max} / r_{wheel}$
= 4/0.1397
= 28.63 rad s^{-1}

$N_{maxwheel} = \omega_{max}$ x 60/2π
= 28.63 x 60 / 6.284
= 2698.31 rpm (Wheel maximum rpm)

Motor sprocket diameter (d_1) = 61.47 mm

Wheel sprocket diameter (d_2) = 106.97 mm
$N_{maxmotor}$ = $N_{maxwheel}$ x (d_2 / d_1)
$N_{maxmotor}$ = 2698.31 x (106.97mm /61.47mm)
= 4695.59 rpm

Thus, standard brushless DC Motor type with range 3000-5000 rpm and the rated power is 3000 Watt to suit with the minimum 120 kg of go-kart weight. Therefore, it will only reach maximum speeds of 2.65 m/s (for 17o slope) and 3.64 m/s for flat level. Note that these speeds are estimated at 100% efficiency where the actual speeds will be obtained when the kart is tested. The actual efficiency will also be determined.

Fig. 5 The developed Go-Kart

III. RESULTS

Due to limited time and resources, the go kart was only tested on flat level road with total load of 120 kg. The best maximum speed achieved was 2.77 m/s.

Thus, the maximum actual output power is obtain as follows;

Powerout = Fmax x Vmax
= µ x mg x Vmax
= 0.7 x 120 x 9.81 x 2.77
= 2282.59 Watt

Therefore;

Efficiency, η = (Powerout / Powerin) x 100
= (2282.59 / 3000) x 100
= 76.09 %

IV. CONCLUSION

The go kart was successfully developed. The maximum speed of the go-kart reaches to its desired speed which approximately 10km/hr. The efficiency of the vehicle is about 76%. The lower efficiency is due to mechanical friction between the bearing, sprocket and also wheels. The charging time is relatively short, less than half an hour to charge the battery. For future improvement, the efficiency can still be improved by reducing the mechanical friction.

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