Case Study on Different Go Kart Engine Transmission Systems

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Abstract. Go Kart, by definition is a simple 4-wheeler, single seater on track vehicle with no differential and suspension system. Fabrication of go-kart aid in learning about all the divisions involved in vehicle design like chassis, steering, transmission, brakes and so on. In any vehicle, engine determines the speed and power of a vehicle, as so in go karts. McCulloch MC-10 was the first go kart engine which is a manually transmitted two stroke engines adapted from chain saw, manufactured by McCulloch Company. At present they are many engines existing which are appropriate for go kart. This paper aims to study the velocity, acceleration, torque, sprocket ratio and slipping condition of three different types of engines (manual transmission engine, continuous variable transmission engine and industrial engine). Engines are opted as per standards issued by Society of Automobile Engineers (SAE), India and abroad. Analytical formulations are used to carry-out the performance comparison. This study helps design engineers or automobile enthusiasts in proper selection of engines based on their need and their application.

Keywords: Go-Kart, Transmission, CVT, Industrial Engine, Manual transmission

1. Introduction
In 1956, Art Ingels was the first person from southern California to build a kart and named it as KART 1. The structure of standard go-kart includes components viz.chassis, steering, engine (usually two-stroke gasoline, with a capacity of 5 to 15 HP). Transmission includes a power source and power transmission system, which provides total control over the power generated by the source. In Go-kart, power from the engine is transmitted to the axle using chain drive and then to wheels. Go-karts do not have a differential. Normally, Go-Kart vehicles are designed and built / fabricated by college / university undergraduates. According to instructions given by the Society of Automobile event organizers go-kart vehicle is designed and fabricated. Especially, selection of type of engine should be appropriate. In market, engines are available with various transmissions and different cubic capacities. It is difficult for the beginners to select the appropriate engine for their kart, as there are many engines which meet the requirement. Students may become uncertain in choosing the engine and transmission to fulfill their kart’s propelling requirement. This demands a proper case study to provide detailed information about different type of transmission and their performance parameters.
Vijay et al.[1] considered the top speed of a kart from a manual transmission system engine of go-kart, total gear ratio, rolling resistance, air resistance and further more are determined for only manual transmission. Gurunath et al.[2] calculated Gear ratio for maximum speed, under gearing and over gearing conditions in a manual transmission system. Raghav et al.[3] has given static behavior of chassis, wheel hub, brake disk hub, steering wheel hub, rear axle, stub axle, and c clap are acquired with ANSYS software. Now a days finite element analysis is becoming a popular tool for design and simulation [4–12] Manual transmission system and hydraulic braking system assembly and mathematical calculations were carried out. Ambe Prasad et al.[13] investigated for speed, steering system, breaking system, battery selection calculation and static behavior of chassis are obtained for an electrical go kart. Himam et al. [14] calculated speed, gear ratio and acceleration for an industrial engine. Chauhan et al. [15] calculated required parameters like maximum speed, selection of axle ratio and chain drive, acceleration and slipping condition. Prasad et al.[16] used only BAJAJ pulsar 135cc manual transmission system to derive maximum velocity and torque. Arjun et al. [17] presented his work on attainment of maximum speed with minimum load on a continuously variable transmission engine.

This paper investigated performance of three different types of engine transmissions. Velocities, accelerations, torque, gear ratios and slipping conditions are studied using analytical method for manual transmission, continuous variable transmission and centrifugal clutch transmission engine (industrial engine).

2. Methodology

Three commonly used engines based on their availability are selected for their performance comparison. Being different working principle (manual and automatic transmission) for all the selected engines, common parameters are identified.

![Figure 1. Block diagram representing the working Methodology](image)

Analytical formulation is presented used to calculate velocity, gear ratio, torque, slipping condition and acceleration. Overall vehicle weight is varied to see its effect on velocity and acceleration pattern for all the three engines. Flow chart shown in figure 1 describes clearly the procedure followed for the
present case study. In the section to follow types of engine transmission have been classified and presented with brief introduction.

**Engine – 1 - Honda GX160**
Honda GX160 is a single-cylinder 4-stroke internal combustion gasoline engine with a vertical shaft, manufactured by Honda Motor Company since 1997. These engines are used for general-purpose applications such as generators, construction, water pumps, and industrial equipment. As it is a low power engine, it is well suited and preferable to go-karts as a power house. It transfers power from engine shaft to rear shaft (Axle) with the help of a chain drive. Engine specifications are show in table 1. This engine utilizes centrifugal clutch type transmission, shown in figure 2. It is mainly specialized in performing shock less and smooth acceleration. Often used in ATV’s, go-karts, chainsaws, mini bikes, and many mechanical motors.

![Figure 2. CAD geometry of centrifugal clutch](image)

**Engine – 2 - Suzuki access 125**
Suzuki access 125 scooter engines are utilized as a power source in the go kart as they have better pickup, mileage and performance compared to other in the market. Specification of this engine is shown in the table 1. This engine works with Continuously Variable Transmission (CVT) that provides unending range of effective gear ratios. Two conical pulleys and a belt make up a basic CVT.

![Figure 3. CAD geometry of CVT Transmission System](image)

The gap between the cones determines the effective diameter of the pulley. Initially, output speed will be less than input speed as the vehicle accelerates diameter of input pulley increases and diameter of output pulley decreases, speed of the belt increases. Consequently, Overdrive is achieved. However, maximum torque may not be achieved compare to manual transmissions but it is a step ahead in providing smoother experience with ease. Because of their performance, CVT remained as one of the major choices for the go-karts.

**Engine - 3 - Bajaj pulsar 135**
Bajaj pulsar 135 is having a 4-stroke, single-cylinder, gasoline engine. Engine specifications are show in table 1. This engine works with manual transmission system. the driver has to manually change the
gear ratio setting by using the gear stick according to the required speed and load on the vehicle. Multiple gear ratios vary the speed under different conditions like taking the turn, applying the brakes and many more. There can be different gears on the main shaft of different diameters similarly on the counter shaft, shown in figure 4. The transmission shaft linkage is designed in such a way that driver has to un-mesh one gear before meshing to another. Pulsar 135 engines are most commonly used in the go-kart which are designed by the students of engineering to explore their skills practically and take part in national events organized by the Society of Automotive Engineers.

Figure 4. CAD geometry of centrifugal clutch

Table 1. The technical specifications of the different engines are depicted

|                      | HONDA GX 160                | SUZUKI access 125              | BAJAJ pulsar 135              |
|----------------------|----------------------------|--------------------------------|-------------------------------|
| Engine type:         | 4-stroke, single cylinder  | 4-stroke, 1-cylinder, air       | Bajaj Pulsar, 4-stroke         |
|                      | inclined by 25°             | cooled                         | single cylinder               |
| Displacement         | 160 cc                      | 125cc                          | 135cc                         |
| Transmission Type    | Centrifugal clutch          | CVT                            | Manual                        |
| Net power            | 4.8 HP / 3600 rpm           | 8.4 bhp                        | 13.3 bhp at 9000rpm           |
| Max. net torque      | 10.3 Nm at 2500 rpm         | 10.2Nm at 5000rpm              | 11.4Nm at 7500rpm             |
| Ignition System      | Transistorized magneto      | Capacitor Discharge Ignition   | Digital Twin Spark Ignition   |
|                      | ignition                    | Electric                        | Electrical and kick           |
| Starter              | kick                        |                                |                               |
| Engine-oil capacity  | 0.6 L                       | 1L                             | (0.54 -- 0.59 L)              |
| Dimensions (L x W x H)| 312 x 362 x 346 mm          | 1870 x 655mm x 60mm            | 257 x 347 x 320mm             |
| Dry weight           | 15.1 kg                     | 24kg                           | 15kg                          |

3. Mathematical Formulation

3.1 Velocity (v)

To determine the top velocity of a kart, we are using force = drag force + frictional force + inclination force. By assuming a grade of 1° on normal condition. Achieved equation is substituted in power formula with multiplying efficiency of chain and belt (or) gear.

\[
F = \left(0.5 \times \rho \times A \times v^3 \times C_d\right) + \left(GVW \times g \times C_n\right) + \left(GVW \times g \times \sin \theta\right)
\]

(1)

\[
P \times \eta_p \times \eta_b = F \times v.
\]

(2)

In above, \( \rho \) is density of air = 1.226 kg/m³, \( A \) represents frontal area = 1 m², \( C_d \) is the Co-efficient of drag = 0.35, \( GVW \) is Gross Vehicle Weight 180 kg, \( g \) is acceleration due to gravity = 9.81, \( \theta \) is the inclination = 1°, \( P \) is engine power, Efficiency of CVT (\( \eta_c \)) = 88%, Efficiency of Chain drive (\( \eta_c \)) = 98%, \( F \) is Force and \( v \) is Velocity.
3.2 Gear Ratio
In select a gear ratio according to the achieved kart velocity we used angular velocity formula
\[ v = r \times \frac{2\pi N_{\text{max}}}{60} \times r_o \times r_{\text{drive}}. \]  
(3)
where, \( r \) is radius of drive wheel = 0.1397 m, \( N_{\text{max}} \) is Maximum Engine RPM, \( r_o \) is overdrive ratio = 0.9, \( r_{\text{drive}} \) is rear sprocket gear ratio.

3.3 Slipping Condition
In determining the slipping condition of Kart we need to compare Maximum Tractive Torque and Maximum Wheel Torque. Maximum Tractive Torque can be found using Total normal reaction acting on rear drive wheels
\[ N_i = 0.6 \times GVW \times g \]  
(4)
\[ \text{tt}_{\text{max}} = \mu \times N_i \times r. \]  
(5)
\[ t_{\text{max}} = T \times r_i \times r_{\text{drive}} \]  
(6)
\[ t_{\text{max}} > t_{\text{max}}. \]  
(7)
In above, \( N_i \) is Total normal reaction acting on rear drive wheels, \( \text{tt}_{\text{max}} \) is maximum tractive torque, \( \mu \) is co-efficient of friction for slicks = 0.9, \( t_{\text{max}} \) is maximum Wheel Torque, \( T \) is engine output torque and \( r_i \) = Under drive Ratio.

3.4 Acceleration (a)
Acceleration of kart is determined using force applied on a rear wheel = drag force + frictional force + inclination force + acceleration force
\[ F = \frac{t_{\text{max}}}{r} \]  
(8)
\[ F = (GVW \times g \times C_{rrr}) + \left( \frac{1}{2} \times A \times V^2 \times C_d \right) + (m \times a) \]  
(9)
m is mass of the vehicle taken as 180 kg and a is acceleration in m/s².

4. Result and discussion
Based on above mathematical formulation, transmission parameters are calculated. For all the three engines, values are obtained and presented in Table 2 for vehicle weight 180 kg. The effect of go-kart weight on velocity and acceleration is represented graphically in figure 5 and 6. Slight change in velocity reduction with respect to increase in the weight. According to graph, manual transmission is maintaining the same level without any huge difference when compare to other transmissions. CVT and Centrifugal seems to be identical with equal drop as the weight increases.

| Parameters          | Engine -1            | Engine -2            | Engine -3            |
|---------------------|----------------------|----------------------|----------------------|
| Velocity (v)        | 75.69Kmph            | 94.608Kmph           | 119.808Kmph          |
| Gear Ratio (r_{drive}) | 2.78                | 3.714                | 5.57                 |
| Normal reaction (N_i) | 1059.48 N            | 1059.48 N            | 1059.48 N            |
| Tractive Torque (tt_{max}) | 133.208 N-m        | 133.208 N-m          | 133.208 N-m          |
| Torque at drive axle (t_{max}) | 77.3 N-m       | 110.2 N-m            | 203.6 N-m            |
| Slipping conditions | No slipping          | No slipping          | Slipping at 1 & 2 gears |
| Acceleration (a)    | 2.43 m/s²            | 3.58 m/s²            | 6.676 m/s²           |
Figure 5. Graph showing effect of weight of a kart on velocity for the selected three engines

Figure 6. Graph showing effect of weight of a kart on acceleration for the selected three engines

Acceleration of manual transmission has massive decrease as the weight increases. In addition, highest acceleration can be seen in manual transmission compared to other transmissions. Moreover, gradual decrease in both the remaining transmissions with respect to weight.

To manufacture an economical and low weight kart, Honda GX160 (Industrial Engine) is the best option. As it has centrifugal clutch transmission, no gear change required to increase the speed. It occupies less space compared to other transmission engines. Less circuit problem. Most of the karts build for fun tracks prefer industrial engines, as they can be controlled easily by non-professional drivers too. Dynamic range, maximum velocity of 21.025 m/s (75.69Kmph), sprocket ratio is 2.78, maximum wheel torque as 77.311 N-m and Acceleration of 2.43 m/s² is achieved. On the other hand, Industrial engines cannot give higher pickup and speed than other traditional automotive transmission counterparts. Yet, recoil starter remains as a major drawback for this engine.

Majority of upcoming automobiles are CVT based as they give more comfort and easy drive experience. Fabricating a high-speed kart with better pickup, CVT’s are considered to be a better option. Suzuki access 125, instant pickup, speed and other parameters compared to Honda GX160 are absolutely phenomenal. Results obtained for Suzuki access 125 scooter are maximum velocity as 26.25 mps (94.6 kmph), Sprocket ratio is 3.71, Maximum wheel torque to be 110.2 N-m and Acceleration as 3.58 m/s. On the other hand, space requirement, cost, mounting, maintenance is higher compared to other transmission engines.

Manual transmission engines provide agility and feasibility to the kart. As they deliver maximum torque at initial gears, students prefer manual transmission. Complete 5 speed gear box will be under the control of driver, he/she can shift the gear to previous position and accelerate more to achieve maximum torque after taking the turn. Bajaj pulsar 135 is a manual transmission engine with maximum power and torque. Results obtained for Bajaj pulsar 135 are Maximum velocity as 33.38 m/s (119.8 kmph), Sprocket ratio as 5.57, Maximum wheel torque is 203.6 N-m and Acceleration 6.67m/s has been obtained. On the flip side, driver should be skilled enough in order to control the stability of vehicle. Driver handled clutch used to engage and disengage the power remained as a major drawback.

5. Conclusion
In conclusion, any of these three transmissions can be opted by students and industries in building their karts. No matter if it is a Centrifugal Clutch Type (HONDA GX 160cc industrial engine) or Continuous Variable Transmission (Suzuki access 125 scooter engine) or Manual Transmission (pulsar 135cc engine), calculations and comparisons make the viewer to select the required engine without any misconception. In closing, we have designed and fabricated the kart which can be driven by all non-professional and professional drivers with maximum acceleration and experience of speed. We induced Suzuki access 125cc continuous variable transmission (CVT) to our kart, as it can full fill our kart requirement.

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