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Powertrain Of a Go-Kart Vs BAJA SAE For A Better Understanding

Sri Sai Sampath Kumar Saladi[1], Kolla Vyshnavi Mansi[2]

Student, Mechanical Department, GITAM Deemed to Be University, Visakhapatnam, A.P, India[1]

Student, Mechanical Department, GITAM Deemed to Be University, Visakhapatnam, A.P, India[2]

Abstract: Powertrain is an essential system in a vehicle as it involves every component responsible for the vehicle's movement. The powertrain of a Go-Kart and All-Terrain Vehicle (BAJA SAE) are unique but have some similarities, i.e., Power for both vehicles is produced using an Internal Combustion Engine (the motor is used for an Electric vehicle), and the end motive is to move the vehicle, but the difference between them lies in between the transfer of the power to the final position (Wheels). This paper is based on the experience from the competitions Indian Karting Race and BAJA SAE.

Keywords: Engine, Transmission, Chain Drive, Belt Drive, Shaft Drive, Go-Karts & ATVs

I. INTRODUCTION

Power Train is a set of all the components responsible for the vehicle's movement. The power train of an automobile starts at the engine, where power is produced, and ends at the wheels, which are the end receivers of this system. The main components of the powertrain system are the Engine and Transmission System. As shown in Fig.1

A. Knowing The Components

Engine: The engine is referred to as the heart of the vehicle as it produces power to drive it. An engine consists of pistons that move up and down inside cylinders and a crankshaft that transforms the Reciprocating motion into a rotating motion.

Transmission System: The transmission system consists of the Gearbox at the Engine, Chain Sprocket, CVT, Drive Shafts, Axle, and lastly, the wheels. Transmission is categorized based on the mode of the drives, i.e., **Chain Drive, Belt Drive and Shaft Drive.**

B. Purpose Of Powertrain

The three primary functions of Powertrain:

- Providing torque needed for the vehicle's movement upon a velocity of road and load conditions.
- To provide speed for faster mobility.
- Disengaging power for the stopping of the vehicle.

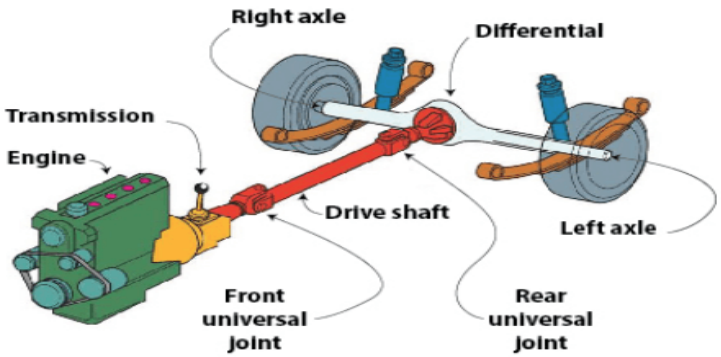

Fig.1 Powertrain of an Automobile

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II. TYPES OF POWER TRANSMISSION SYSTEMS

As discussed earlier, the powertrain is classified into chain drive, belt drive, and shaft drive. However, an intermediate system helps transmit power, which is known as transmission. Transmission and powertrain are the same; the only difference is that the powertrain involves the engine, whereas the transmission is the summation of all the parts except the engine.

Transmission is again two types:

- Manual Transmission
- Automatic Transmission

Now, we will discuss the Three types of drives and the types of transmission.

A. Chain Drive: It is the power transmission system where the mechanical energy generated by the Engine/Motor is transferred to the shafts/wheels with the linkage of a chain sprocket, as shown in Fig.2. The teeth of the sprockets decide the amount of power transmission. This transmission type is generally seen in two-wheelers like bicycles, Motorcycles, etc.

B. Belt Drive: This type of transmission uses pulleys placed at either end and a belt connected to it; this is similar to a chain drive; in a chain drive, sprockets are used where the gear ratio is fixed, whereas, in a belt drive, the pulleys can change the ratios continuously, so it's also called continuously variable transmission. As shown in Fig.3.

C. Shaft Drive: This type of drive system uses the shaft linkage to drive the vehicle. Shaft Drive is generally used in four-wheelers or heavy vehicles where the mechanical energy from the gearbox is transferred to the wheels using a shaft connecting the gearbox and differential and another set of shafts connecting the differential and wheels. As shown in Fig.4.

D. Manual Transmission: This is the type of transmission where the gear ratios are altered or set according to the driver's choice., i.e., the driver can change the gear (gear ratios) with the help of a lever or through pneumatic controls. As shown in Fig.5.

E. Automatic Transmission: Automatic transmission is the type of transmission where the gear ratios are set automatically according to the terrain conditions. The various automatic transmission systems include fully automatic and semi-automatic transmission systems. As shown in Fig.6.

F. Front Wheel Drive: It is a type of transmission system in which only the front wheels of a vehicle are connected to the transmission system.

G. Rear Wheel Drive: When the power from the engine is transmitted only to the rear wheels of an automobile, this type of drive is known as rear wheel drive.

H. All-Wheel Drive: An all-wheel-drive system is a drivetrain technology that sends power to all four wheels. However, there's no guarantee that the power shared between them is consistent or equally divided, which means an all-wheel drivetrain can deliver power between all four or just two wheels on a single axle.

I. 4-Wheel Drive: Four-wheel drive is also a drivetrain that can power all four wheels. But unlike AWD, 4WD can't constantly switch between 4WD and rear-wheel drive (RWD). Instead, it is set in RWD mode by default and then manually changed to 4WD.

Fig.2 Chain Drive

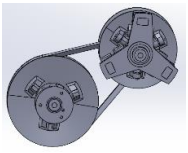

Fig.3 Belt Drive

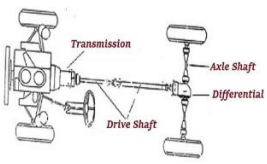

Fig.4 Shaft Drive

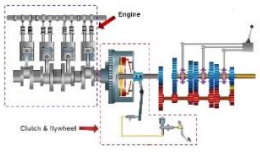

Fig.5 Manual

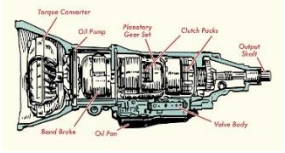

Fig.6 Automatic

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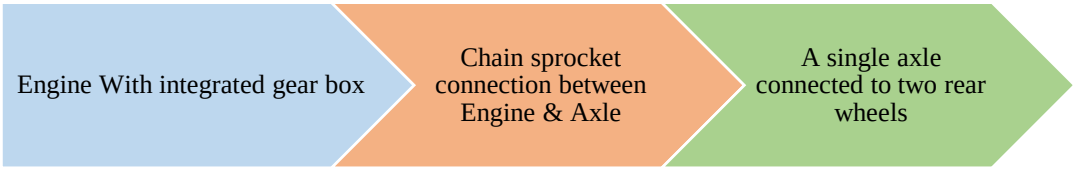
III. DESIGN OF A POWERTRAIN SYSTEM

A. Powertrain of a Go-Kart

1) Layout:



2) Engine Selection: The selection of an engine plays a crucial role in the efficiency or the outcome of the vehicle. Generally, the first step of the engine selection is based on the **cc** limit. According to the competition we attended, the limit is 160cc. Now, our main motive is to have more torque at less RPM, which can be easily identified by Table 1.

Company	Model	Cubic Capacity	Torque @ RPM (max)	Power @ RPM (max)	Cooling system
TVS	APACHE RTR 160	159.7cc	13.85Nm @ 7000rpm	16.04PS @ 8750rpm	Air Cooled
BAJAJ	PULSAR NS160	160cc	14.6Nm @ 7250rpm	17.20PS @ 9000rpm	Oil Cooled
YAMAHA	R15 V2	149cc	15Nm @ 7500rpm	17.24PS @ 8500rpm	Liquid Cooled

Table-1 Engine Comparison

We had chosen Yamaha R15 V2 because of its availability and specifications. Now the calculations for the engine are done in the following steps.

3) Engine Location, Mounting, and Design: Generally, there are two types of engine positioning followed by the Go-Karts, i.e., Rear Engine and Side Engine, as shown in Fig.7&8, respectively. Previously, we used rear engine positioning. However, the current kart was made for the side engine position as the rear position is less favourable for the cooling system, especially for air-cooled engines. The engine mount was designed by taking the PCD of the actual engine positioning and mounting points; the engine mount made by using the PCD is shown in Fig.9

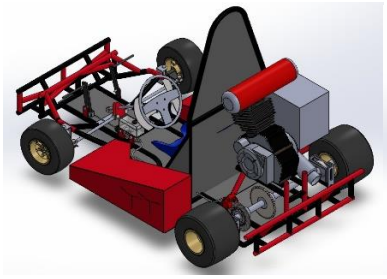


Fig.7 Rear Engine

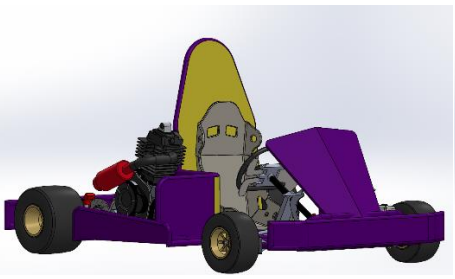


Fig.8 Side Engine

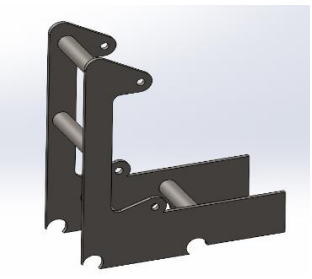


Fig.9 Engine Mount

4) Calculations:

Engine: Yamaha R15V2
Displacement: 149cc
Max Power: 17.24Ps@8500rpm
Max Torque: 15Nm@7500rpm
Primary Reduction Ratio: 3.042
Secondary Reduction Ratio: 3.133

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Wheel Radius:5.5in=0.1397m; Diameter: 0.2794m

Let, Speed(v)=70km/h=19.444ms/s

Angular Velocity(w)=v/r=19.444/0.1397 = 139.155rad/sec

Also, w=2πN/60; N=w×60/2π

N=139.155×60/2π = 1328.83

Gear Reduction (G.R) =Max rpm/N = 7500/1328.83 = 5.64

	Reduction Ratio = PRR×G.R×Req.Ratio(2.21)	**RPM = 7500/Reduction Ratio at each gear**	**Velocity = πDN/60×3.6km/h**
Gear-1	19.04	393.90rpm(N1)	20.75km/h
Gear-2	12.60	595.23rpm(N2)	31.35km/h
Gear-3	9.17	817.88rpm(N3)	43.07km/h
Gear-4	7.68	976.56rpm(N4)	51.43km/h
Gear-5	6.41	1170.04rpm(N5)	61.62km/h
Gear-6	5.64	1329.78rpm(N6)	70.03km/h

Table-2 Gear ratios calculations

Reduction ratio= 1:3=0.33

Drive torque=Max Torque×Reduction ratio×Efficiency = 15×40×0.33=198Nm

Drive Force=Drive Torque/Radius = 198/0.1397=1417.32N

5) Wheels & Tires: Generally, dry tires are used in the competition(as shown in Fig.10), but in case of any climatic changes, we are suggested to carry a set of wet tires too(as shown in Fig.11). The dimensions of the wheels declared by the competition are discussed in Table 3.

	Type	**Dimension (Inch)**
Dry (Slick) tires	Front	4.5×10.0-5
Dry (Slick) tires	Rear	7.1×11.0-5
Wet tires	Front	4.5×10.0-5
Wet tires	Rear	6.0×11.0-5

Table-3 Tire Data

Fig.10 Dry Tires

Fig.11 Wet Tire

B. Powertrain of ATV (BAJA SAE)

1) Layout:

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The Powertrain layout is shown in Fig.12.

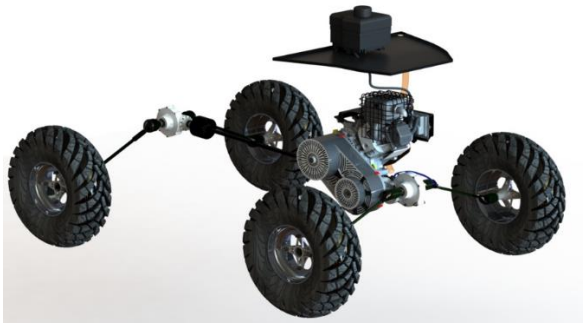

Fig.12 Powertrain Layout of BAJA SAE

2) Engine Specifications: Unlike go-kart competitions, BAJA SAE vehicles have a fixed engine model with the CC limit mentioned in the rule book. Engine specifications are mentioned in Table-4

Engine	Briggs & Stratton m19 10Hp OHV
Displacement	305cc
Max Power	7.5kw @ 3800rpm
Max Torque	19.6NM@2600rpm

Table-4 Engine Specifications

3) Mounting, Location, & Design: Powertrain mounting for buggy consists of an engine mount followed by a gearbox mount, so the design of the mount should be in such a way that it should act as an engine mount along with the gearbox mount maintaining the eye to eye distance of the CVT, the integrated powertrain mounting is shown in fig.13.The engine location is already defined by the competition, which is the rear engine, as shown in Fig.14.

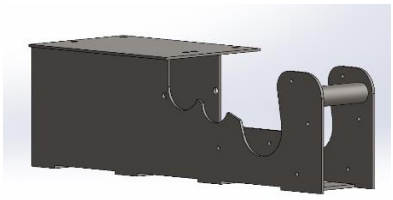

Fig.13 Integrated Powertrain mount

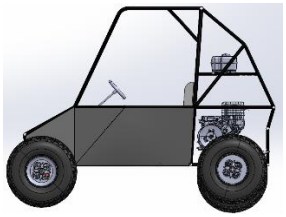

Fig.14 Engine location

4) Calculations:

Gearbox reduction: 8.81
Gradeability:89.7
Rear differential type: Single spool drive
Front differential type: Open
Power split ratio front & rear 1:1
CVT speed ratio:
Let max speed be 60km/h=16.66m/s
Tire diameter=0.5842m
Tire rpm at max speed=v×60/πd=16.66×60/3.14×0.5842=543rpm
Max speed of the engine is 3600rpm
Speed reduction required=n/N×GR=3600/543×8.81=0.75
Min gear reduction to have a speed of 60km/h is 0.75 at CVT
M=180kg, μ=0.05
Torque=M×g×(sinØ+μ)×r=180×9.81×(sin89.7+0.05) ×0.5842=1031.57Nm
But the engine can produce only 19.6Nm at 2600rpm.
Therefore, Speed reduction=1031.570/19.6×2×8.81=1031.57/345.352=2.9
Acceleration: F=Ma=a=F/M

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Fw=Tw/r=644.30/0.28956=2225.1
F=2225.1-644.30=1580.8
M=1800
a=1580.8×9.81/1800=8.615m/s^2

5) Wheels & Tires: The tires used for the Baja SAE are gripped tires of either trail thread or knob thread. The rear tire used is trail thread with the dimensions 23×7-10 and the Front tire of knob thread with 23×7-10 dimensions, as shown in Fig.15.

Fig.15 Tires of ATV

IV. CONCLUSION

The main objective of this paper is to provide detailed knowledge on the powertrain and the type of power transmission systems used by the student-developed vehicles based on the type of vehicle. When speed is the essential factor, like in a Go-Kart, a two-wheeler engine is used by using a chain sprocket connection; if torque is the main factor, like in an All-Terrain Vehicle, CVT and Gearbox are used to ensure smooth movement of the vehicle in any road conditions.

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