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Design and Implementation of Steering System for All Terrain Vehicle

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***Abstract*: The steering system is a vital component of the vehicle as well as the driver interface. The basic function of steering system has to provide maximum direction control and stability to the vehicle. Steering system of an ATV needs to be efficient as far as the parameters like weight, space considerations, rigidity are concerned. An ATV (All-Terrain Vehicle) is a vehicle which travels on all terrains. Because of this, the steering system of an ATV is designed according to the specifications for the worst possible terrain or geographical profile and should provide maximum directional stability, pure rolling motion to the wheel, minimum turning radius. This project explains about all the forces and torques encounter during the run are considered in order to design the mechanisms which will sustain these worst case scenarios and help to increases the ability of the ATV vehicle.**

***Keywords*: All-terrain vehicle, Ackerman geometry, Steering design, Rack and recirculating ball gearbox.**

1. Introduction

The steering system is a group of parts that transmit the movement of steering wheel to the front wheels. The objective of steering system is to provide directional control of the vehicle, to withstand high stress in off terrain conditions, to reduce steering effort and to provide good response from road to driver. When a vehicle is being driven straight ahead, the steering system must keep it from wandering without requiring the driver to make constant corrections. Ackerman steering system is based on the four bar linkage mechanism in which different links move relative to each other and finally direct vehicle in particular direction. This system is beneficial during sharp turning and reduces steering efforts. This helps in maneuverability.

2. Requirements of Steering System

1. The steering mechanism should be very accurate and easy to handle.
2. The effort required to steer should be minimum and must not be tiresome to the driver.
3. The steering mechanism should also provide the directional stability. This implies that the vehicle should have tendency to return to its straight ahead position after turning.
4. It should provide pure rolling motion to wheel.

3. Geometry Selection

Traction is an important aspect in off-road racing as compared to speed. Since Ackerman steering geometry high stability at lower speed. This type of geometry is appropriate for the vehicle.

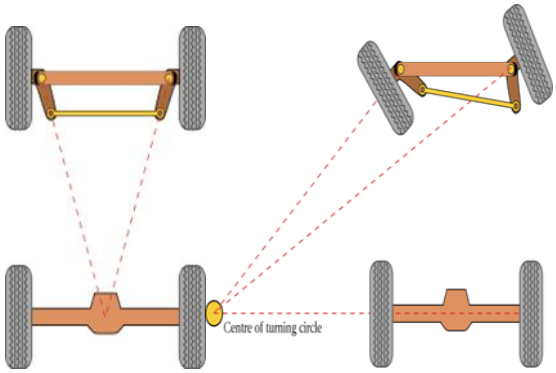

Fig. 1. Schematic diagram of Ackerman steering mechanism

Ackerman Principle state that the extended axes of steering arm should meet at the Centre of the rear axle. While taking turns, the condition of perfect rolling is achieved if the axes of the front wheels when produced meet the rear axis at one point. This is the instantaneous center of the vehicle. When vehicle is following a curved path the inner wheel deflects by a greater angle than the outer wheel to effectively complete the cornering without skidding.

4. Recirculating Ball Gearbox

The re-circulating ball gearbox consists of 8 steel balls and a nut arrangement, worm gear and sector gear. A worm and a nut are placed at the end of the steering shaft. The worm gear inside the block fixed and the outer of the block have gears and it engages with the sector gear portion to steer the vehicle. In this type of steering gear, the end of the worm shaft is machined with a continuous helical groove.

Precision finished helical grooves inside the ball nut match the helical grooves on the worm shaft which are filled with ball bearings. These ball bearings move the ball nut assembly up or down the worm shaft when the steering wheel is turned. There are two complete ball bearing circuits within the ball nut. To

keep the ball bearings from running out of the end of either circuit, the ball nut has two tubular ball guides which allow the ball bearings to constantly re-circulate, distributing wear evenly among them. The ball bearings circulate in one direction for a right hand turn and in the other direction for a left hand turn.

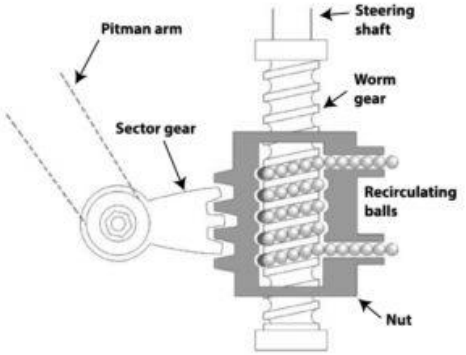

Fig. 2. Recirculating ball gearbox

5. Advantages of Recirculating Ball Gear Box

1. Achieves Angular motion of steering Wheels
2. Provide directional Stability of vehicle when going straight ahead
3. Minimize tire wear
4. Provide perfect steering condition
5. Maintain correct amount of effort needed to turn the wheels.
6. Transmit road feel to the driver's hand.
7. Allow for suspension action.

6. Steering Specifications

Table 1
Steering Specifications

Wheel Base (l)	2.40m
Track Width (d)	1.30m
Inner Steering Angle	35.3º
Outer Steering Angle	27.15º
Ackerman Percentage	93.9%
Lock to Lock Turns	570º (1 2/3 revolution)
Turning Radius	5.26m
Steering Ratio	16:1

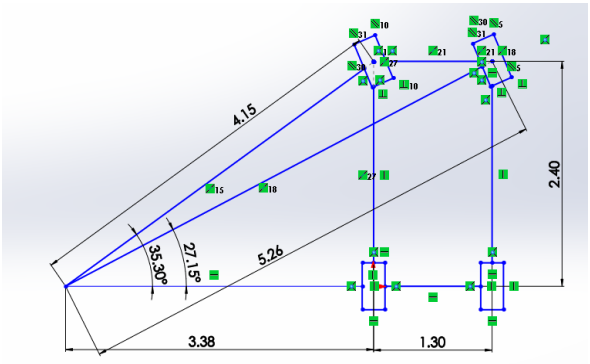

Fig. 3. Steering calculation diagram

7. Steering Geometry Calculations

1. Wheel base (l) – 2.40 m
2. Track Width (d) – 1.30 m
3. Lock to Lock Turns - 570º ($1\frac{2}{3}$ revolution)
4. Turning Circle Radius
Turning Radius of front inner wheel – 4.14 m
Turning Radius of front outer wheel – 5.30 m
Steering Angles
Inner Steering Angle (θ_i)

$$\tan\ \theta_i = \frac{2.40}{3.38} = 0.7100$$

$$\theta_i = \tan^{-1}(0.7100)$$

$$\theta_i = 35.3º$$

Outer Steering Angle (θ_0)

$$\tan\theta_0 = \frac{2.40}{4.68}$$

$$\tan\theta_0 = 0.5128$$

$$\theta_0 = \tan^{-1}(0.5128)$$

$$\theta_0 = 27.15º$$

6. Ackerman = $tan^{-1}[\frac{l}{\left(\frac{l}{tan\,\theta}\right) - d}]$

= $tan^{-1}[\frac{2.40}{\left(\frac{2.40}{tan\ 27.15°}\right) - 1.30}]$

= $tan^{-1}(0.7700)$

= 37.59

7. Ackerman Percentage = (Inner Steering Angle) × 100 / Ackerman

= (35.3×100)/37.5

= %

8. Steering Effort Calculations

1. Steering ratio	=	570º: 35.3º
	=	16.1: 1
2. Considering weight distribution	=	60:40
Weight on front wheel	=	weight of car × weight distribution
	=	1166×.60
	=	699.6kg
3. Normal force acting on the front wheel	=	699.6×9.81
	=	6863.07N
4. Friction force on tire	=	normal force on tire × coefficient friction of tire
	=	6863.07×0.8
	=	5490.4N
5. Torque on steering arm	=	friction force on tire × length of steering arm
	=	5490.4×0.15
	=	823.56N-m
6. Force required to move pitman arm	=	Torque on steering arm / Pitman length
	=	823.56 / 0.15
	=	5490.4N
7.Force on steering column	=	(Force required to move pitman arm) / (steering ratio)
	=	5490.4/16.3
	=	339.99N
8.Torque on steering	=	(force on steering column)/ (radius of steering)
	=	339.99×0.19
	=	64.59N-m

9. Model Representations

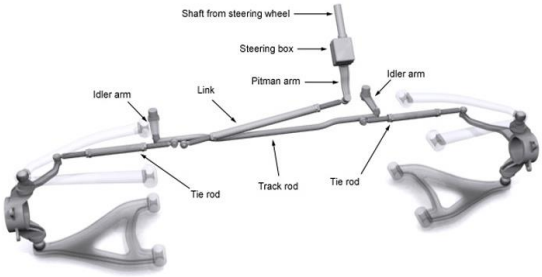

Fig. 4. Steering linkage system

Fig. 5. Steering assembly view

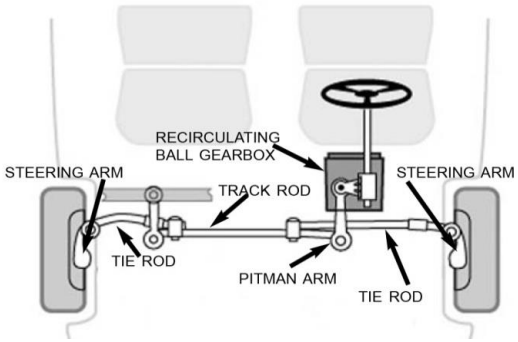

Fig. 6. Steering arrangement view

10. Conclusion

The basic aim of steering is to ensure that the wheels are pointing in the desired directions and to allow the driver to guide the vehicle. The most conventional steering arrangement is to turn the front wheels using a hand–operated steering wheel which is positioned in front of the driver. As the driver turns the steering wheel, the movement is carried to the steering gear or; it changes rotary motion of the steering wheel into linear motion. As per the aim of our project, we have designed and implemented the steering system for the ATVs using Ackerman principle and Recirculating Ball type steering.

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