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A Review on Rear Wheel Steering

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Abstract: The steering system being an essential part of the vehicle as it allows the driver to turn the vehicle which includes the steering wheel, steering gear box, pitman arm, drag link, tie rods, steering arms. Rear wheel steering is a well-known technology on which research is still going on but its implementation in real life applications are limited. Convenient front wheel steering does not provide tight turning which make rear wheel steering effective in the agricultural sector, Industrial vehicles are that it offers easy low speed maneuverability and assists in achieving tight turning radius.

Keywords: Rear Wheel steering, Steering geometry, Steering ratio, Ackerman

I. INTRODUCTION

Automobile is a rapidly growing industry in the world, with the rapid growth and technology advancement it produces a huge scope of opportunities for the improvement in the designs and safety aspects of the vehicles. Steering system being one of the essential systems in any automobile vehicle, thus gives lots of opportunities for engineers to develop and implement steering systems with more steering comfort and improve the stability of the vehicle by modifying the steering designs and parameters.

The most convenient arrangement of steering in any vehicle is front wheel steering system operated by a steering wheel through steering rod and universal joint acting as connection between both of them.

The Steering system consists of various types of gearbox which act as a mechanical advantage in the steering system. The gearbox which are normally used in vehicles are rack and pinion, worm and worm wheel, ball and screw etc.

II. LITERATURE REVIEW

Prof. V.I. Pasare, et al. (2017), "Design of Steering & Braking System for Self-Propelled Onion Harvester".

In this paper it has been discussed about designing the steering mechanism for agriculture machines. Agriculture machines have high strength and are robust, reliable, optimum and efficient. In order to get better turning radius and easy maneuverability during on field operation, a rack and pinion steering gearbox was used.

In this paper a front wheel steering system was designed for a self-propelled onion harvester for good field efficiency and easy maneuverability. The designing and fabrication was decided by taking the customer demands and vehicle dimensions into consideration and were properly studied. Ackerman steering geometry with a rack and pinion gearbox was selected as it fulfilled all the customer demands and provided best efficiency and life span to the system. An OEM steering gearbox of Maruti 800 was used which had a steering ratio of 18:1. The achieved results were that the turning radius was 2.859 m and had an Ackerman percentage of 70%. [1]

L. Strandberg, G. Tengstrand, H. Lanshammar (1982), "Danger, rear wheel steering". In this paper it has been discussed about Rear wheel steering which is most commonly used in forklifts and loaders. The paper specifies about the hazards of rear wheel steering which are illustrated with authentic accident case description and are explained through the analyses of vehicle dynamics. According to the paper the vehicle stability at every speed is required and the cornering stiffness coefficient of the rear wheels is larger than that of front wheels. The paper also states the risk of skidding of a vehicle is more in rear wheel steering. The paper states that if driver unknowingly oversteers the vehicle, insufficient tire pressure or improper loading are few of the causes which resulted in skidding. The experiments were conducted on Fork lifts and the forklifts were tested at different lateral forces, various road conditions and different reaction time of the driver. The paper concluded that using Rear wheel steering systems for high speed vehicle would promote accidents and have suggested using the front wheel steering system for normal cars which have high speed. [3]

Dr. V.K. Saini, et al. (2017), "Design Methodology of Steering System for All-Terrain Vehicles". In this paper it has been discussed that, the function of steering system is to steer the front wheels in response to driver's input. The paper states that the rack and pinion steering gearbox is widely used in passenger vehicles. In this paper a rack and pinion Ackerman steering mechanism was designed for an All-terrain Vehicle. Tata Nano steering column was used in the design and was connected to Rack and Pinion Gearbox by a Universal Joint. A proper market survey was done in order to find all the required components and accordingly

selected the appropriate component for the steering system. In the work the steering ratio and steering effort was 5.44:1 and 44.72N respectively. [2]

Lukas K., et al. (2019), “Design of Rear Wheel Steering System of an Experimental Electric Vehicle”. In this paper the Basics of steering system and also the four-wheel steering kinematics of vehicle was discussed. In the work, rear wheel steering angle was calculated and then the concept of rear wheel steering was applied on an electric vehicle. The paper concluded that for a non-autonomous vehicle rear wheel steering will improve driving performance in lower speed vehicles also vehicles with an autonomous steering system can use rear wheel steering system. [4]

Md. Danish Akhtar (2013), “Wheel Steering System”. In this paper, all basic information of the Steering system of vehicle and Design of 4-Wheel steering system has been discussed. In this paper different types of Steering system configuration and their advantages and limitation are stated. The paper concludes that the turning radius of a four-wheel steering system is less than that of two-wheel steering system by both analytical calculation and experimental method. It was also found that by analytical calculation there was 41.13% reduction in turning radius and by experimental method a reduction by 50.43% was observed. [5]

III. BASIC TERMINOLOGIES IN STEERING

A. Caster

- 1) Caster is the fore or aft inclination of the steering axis.
- 2) Positive caster is when the bottom of the steering axis is in front of the tire's contact patch.
- 3) Zero caster is when the steering axis is in line with vertical axis.
- 4) Generally for all vehicles are provided by a certain degree of positive caster. This ensures good stability, helps maintain straight-ahead direction and promotes steering wheel self-centering. [14]

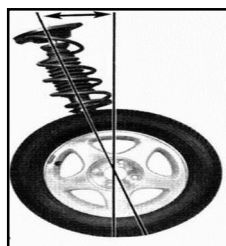


Figure 1 Caster Angle [15]

B. Camber

- 1) Camber is the inward or outward tilt of the front tires when viewed in front view.
- 2) Inward tilt is negative and outward tilt is positive.
- 3) Camber is used to distribute load uniformly across the entire tread.
- 4) Improper camber makes the tire wear on one edge, and causes the vehicle to pull to the one side. [14]

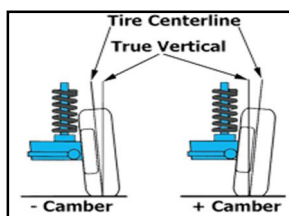


Figure 2 Positive and Negative Camber [14]

C. Toe

- 1) Toe is the difference in distance between the front and rear side of the tires.
- 2) If the distance is closer at the front, it is called as toe in. If the distance is closer at the rear, it is called toe out. [14]

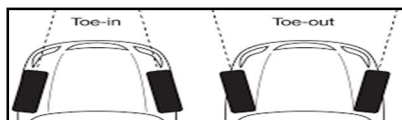


Figure 3 Toe Angle [13]

D. Understeer

When the slip angle of front tire is greater than slip angle of rear tire vehicle understeers. Thus the vehicle goes out of the circle of turning radius. Most vehicle manufacturers set the vehicle profile with some understeer. [11]

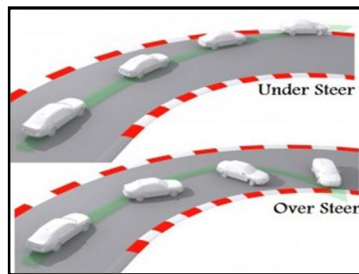


Figure 4 Understeer & Oversteer [11]

E. Oversteer

Over steer is defined when the slip angle of front tire is less than the slip angle of rear tire. This makes the vehicle to move inside the circle of turning radius. This is a far dangerous situation than understeer. [11]

F. Condition for Correct Steering

The condition for correct steering is that all the four wheels must rotate about the same instantaneous centre which lies on the axis of the back wheels. Let the axis of the inner wheels makes a larger angle θ than the angle ϕ subtended by the axis of outer wheel. [9]

$$\cot(\phi) - \cot(\theta) = \frac{W}{L} \quad [9]$$

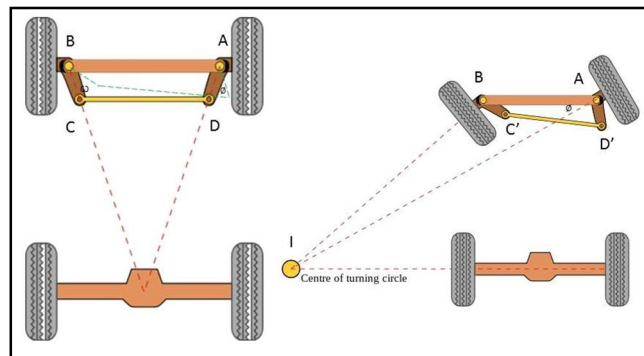


Figure 5 Ackerman Geometry [16]

G. Ackerman Percentage

- 1) Generally Ackerman percentage decide how much your inner tire turns compared to outer tire. 100 % Ackerman condition is when the turning circles of both inner and outer tire are concentric, while 0 % means both circles are the same.
- 2) In 100 % Ackerman condition the steering arms meet at the center of rear axle.
- 3) 100% Ackerman is ideal turning condition of vehicle. If reduce it cause understeer and if increased then oversteer is caused. Disadvantages come with the how much away you are from ideal conditions. [12]

$$\text{Ackerman} = \tan^{-1} \left(\frac{\text{Wheelbase}}{\frac{\text{Wheelbase}}{\tan(\theta_o)} - \text{Wheel track}} \right) \quad [12]$$

$$\text{Ackerman\%} = \frac{\theta_i}{\text{Ackerman}} \times 100 \quad [12]$$

IV. ADVANTAGES

- A. Smaller Turning Radius
- B. Better Stability
- C. Quicker Steering Response
- D. Better safety

V. DISADVANTAGES

- A. Higher risk of malfunction at High Speed.
- B. High Initial cost

VI. FUTURE SCOPE

- A. The Rear wheel steering can be implemented by using it with the assistance of power steering.
- B. Implementation of the rear wheel steering in conventional vehicles by assisting it with various electronic sensors and circuitries.
- C. Four-wheel steering is an emerging steering system and inspired by the rear wheel steering.

VII. CONCLUSION

- A. Rear wheel steering is a highly discussed topic in the development of the vehicles. It will improve the driving performance especially in Low Speed vehicles.
- B. Due to implementation of the rear wheel steering the maneuverability of the machine increases significantly along with achieving a very tight turning radius.
- C. It is also concluded that the turning radius of the vehicle can be further reduced near to its wheel base by implementation of turn-wheel locking.
- D. Four wheel steering is being used in luxury cars or heavy vehicles like trailers and buses etc.

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