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Study of Four Wheel Steering Mechanism

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ABSTRACT: *Nowadays most of the vehicles use the two wheel steering mechanism as their main handling system. But the efficiency of the two wheel steering vehicle is proven to be low compared to the four wheel steering vehicles. Four wheel steering system can be employed in some vehicles to improve steering response, increase vehicle stability while moving at certain speed, or to decrease turning radius at low speed. Four-wheel steering is a technologically, tremendous effort on the part of automotive design engineers to provide near-neutral steering. In situations like low speed cornering, vehicle parking and driving in city conditions with heavy traffic in tight spaces, high speed lane changing would be very difficult due to vehicle's larger wheelbase and track width which brings high inertia and traction into consideration. Hence there is a requirement of a mechanism which result in less turning radius and it can be achieved by implementing four wheel steering mechanism instead of regular two wheel steering. 4-Wheel Steering System is not a new technology but it has not gained popularity over 2-Wheel Steering System even though experiments have proved that it has excellent maneuverability, high stability and it is a solution to oversteer/understeer.[1]*

Keywords: *Understeer/Oversteer, Turning radius, 2 Wheel steering system, 4 Wheel steering system , Wheel Configurations.*

I. INTRODUCTION

Four wheel steering is a method developed in automobile industry for the effective turning of the vehicle and to increase the maneuverability. In a typical front wheel steering system the rear wheels do not turn in the direction of the curve and thus curb on the efficiency of the steering. In four wheel steering the rear wheels turn with the front wheels thus increasing the efficiency of the vehicle. The direction of steering the rear wheels relative to the front wheels depends on the operating conditions [1]. At low speed wheel movement is pronounced, so that rear wheels are steered in the opposite direction to that of front wheels. At high speed, when steering adjustments are subtle, the front wheels and the rear wheels turn in the same direction. By changing the direction of the rear wheels there is reduction in turning radius of the vehicle which is efficient in parking, low speed cornering and high speed lane change. In city driving conditions the vehicle with higher wheelbase and track width face problems of turning as the space is confined, the same problem is faced in low speed cornering. Usually customers pick the vehicle with higher wheelbase and track width for their comfort and face these problems, so to overcome this problem a concept of four wheel steering can be adopted in the vehicle. Four wheel steering reduces the turning radius of the vehicle which is effective in confined space, in this project four wheel steering is adopted for the existing vehicle and turning radius is reduced without changing the dimension of the vehicle. [2]

II. BACKGROUND THEORY

The most effective type of steering, this type has all the four wheels of the vehicle used for steering purpose. In a typical front wheel steering system the rear wheels do not turn in the direction of the curve and thus curb on the efficiency of the steering. Normally this system is not been the preferred choice due to complexity of conventional mechanical four wheel steering systems. However, a few cars like the Honda Prelude, Nissan Skyline GT-R have been available with four wheel steering systems, where the rear wheels turn by an angle to aid the front wheels in steering.

However, these systems had the rear wheels steered by only 2 or 3 degrees, as their main aim was to assist the front wheels rather than steer by themselves. With advances in technology, modern four wheel steering systems boast of fully electronic steer-by-wire systems, equal steer angles for front and rear wheels, and sensors to monitor the vehicle dynamics and adjust the steer angles in real time. Although such a complex four wheel steering model has not been created for production purposes, a number of experimental concepts with some of these technologies have been built and tested successfully. The idea behind four-wheel steering is that a

vehicle requires less driver input for any steering maneuver if all four wheels are steering the vehicle. As with two wheel-steer vehicles, tire grip holds the four wheels on the road.

However, when the driver turns the wheel slightly, all four wheels react to the steering input, causing slip angles to form at all four wheels. The entire vehicle moves in one direction rather than the rear half attempting to catch up to the front. There is also less sway when the wheels are turned back to a straight-ahead position. The vehicle responds more quickly to steering input because rear wheel lag is eliminated. The direction of steering the rear wheels relative to the front wheels depends on the operating conditions. At low speed wheel movement is pronounced, so that rear wheels are steered in the opposite direction to that of front wheels. This also simplifies the positioning of the car in situations such as parking in a confined space. Since the rear wheels are made to follow the path on the road taken by the front wheels, the rear of a four wheel steering car does not turn in the normal way. Therefore the risk of hitting an obstacle is greatly reduced. At high speed, when steering adjustments are subtle, the front wheels and the rear wheels turn in the same direction. As a result the vehicle moves in a crab like manner rather than in a curved path. This action is advantageous to the vehicle while changing lanes on a high speed road. The elimination of the centrifugal effect and in consequence the reduction of body roll and cornering force on the tire, improves the stability of the car so that control becomes easier and safer.[2]

III. STEERING SYSTEM

Steering mechanism is used to give the required path and achieve a perfect steering condition. The main function of the steering system is to achieve angular motion of the front wheels to negotiate a turn. For steering linkages and steering gear used which convert the rotary motion of steering wheel into angular motion of the front road wheels.[2]

3.1 Function of the steering system :-

1. To control direction of motion of the vehicle
2. To give directional stability for vehicle while going straight ahead.
3. To enables straight ahead condition of the vehicle after completing a turn.
4. The road irregularities must be damped to the maximum possible extent. This should co-exist the road feel for the driver so that he can feel the road condition without experiencing the effects of moving over it.
5. To reduce tire wear and increase the life of the tire.

3.2 Steering requirement:-

1. The steering should be very accurate and easy to handle.
2. The effort should be minimal and must not be tiresome to the driver.
3. Should provide directional stability. This implies that the vehicle should have a tendency to return to its straight ahead position after turning.

3.3 Zero turn radius vehicles:-

Zero turn vehicles takes the sharp turn about a vertical axis passing through its center of gravity .For zero turn vehicle there is no need of additional space .The vehicle rotate in the circle having diameter equal to its length .The requirement of additional space is neglected. This system is used in jeep hurricane, Tata nanopixel, JCB, lawn mower. [3]

IV. STEERING WHEEL CONFIGURATION

The various types of steering wheel configuration are as follows:-

- Two Wheel Steer:- In this mode only one axle is driven.
- Four wheel steer:- In this both axle are driven but in direction opposite to each other.
- Crab steer:- When all the wheels turn in same direction it is known as crab steer.
- Zero turn steer-: In this mode vehicle follows the circular path.[4]

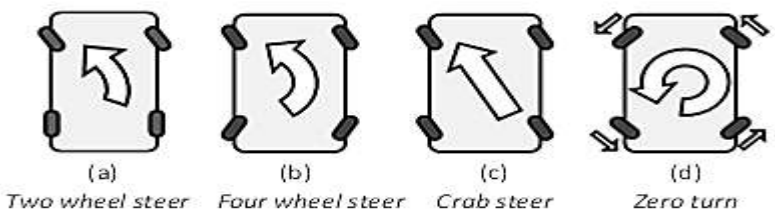

Fig.1. Steering wheel configurations

V. STEERING PRINCIPLE AND COMPONENTS

5.1 Ackerman Steering Mechanism

With perfect Ackermann, at any angle of steering, the perpendicular line through the centre point of all the wheels will meet at a common point. But this may be difficult to arrange in practice with simple linkages. Hence, modern cars do not use pure Ackermann steering, partly because it ignores important dynamic and compliant effects, but the principle is sound for low speed manoeuvres.[5]

5.2 Turning Radius

The turning radius or turning circle of a vehicle is the diameter of the smallest circular turn (i.e. U-turn) that the vehicle is capable of making. Turning circle radius = (track/2) + (wheelbase/ sin (average steer angle)).[3]

5.3 Understeer

When the slip angle of front wheels is greater than slip angle of rear wheels vehicle understeers. Thus the vehicle goes out of the circle of steering. Most vehicle manufacturers set the vehicle profile with some understeer.[3]

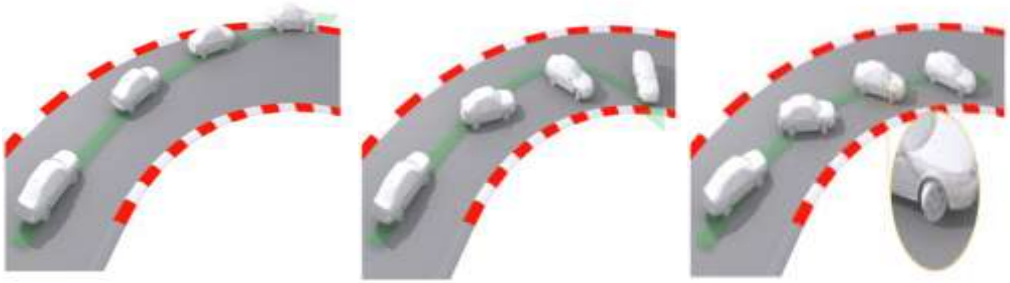

Fig.2. Understeer, Oversteer and Countersteer.

5.4 Oversteer

Over steer is defined when the slip angle of front wheel is less than the slip angle of rear wheel. This makes the vehicle move inside the circle of steer. This is a far dangerous situation than understeer.

5.5 Neutral Steer OR Countersteer

Counter-steering can defined as when the slip angle of front wheels is equal to slip angle of rear wheel. The vehicle follows the line with utmost stability.[5]

VI. DESIGN AND UNDERSTANDING OF FOUR WHEEL STEERING

The idea behind four wheel steering is that a vehicle requires less driver input for any steering manoeuvre if all four wheels are steering the vehicle. As with two wheel steer vehicles, tyre grip holds the four wheels on the road. However, when the driver turns the wheel slightly, all four wheels react to the steering input, causing slip angles to form at all four wheels. The entire vehicle moves in one direction rather than the rear half attempting to catch up to the front. The vehicle responds more quickly to steering input because rear wheel lag is eliminated. To find the vehicle's turning radius 'R', we may define equivalent bicycle models as shown in Figure below for positive 4-Wheel Steering vehicles. The radius of turn 'R' is perpendicular to the vehicle's velocity vector 'v' at the mass centre 'C'.[7]

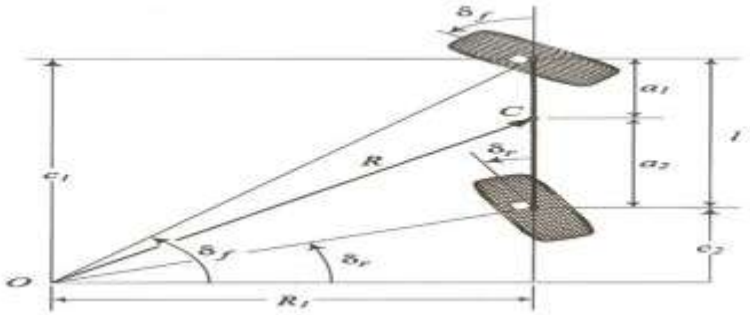

Fig. 3. Geometry of Four Wheel Steering

VII. COMPARED OF 4 WHEEL SYSTEM WITH 2 WHEEL CONVENTIONAL SYSTEM

1. Car more efficient and stable on cornering.
2. Improved steering responsiveness and precision.
3. High speed straight line stability.
4. Notable improvement in rapid, easier, safer lane changing maneuvers.
5. Smaller turning radius and tight space manoeuvrability at low speed.
6. Relative Wheel Angles and their Control.
7. Risk of hitting an obstacle is greatly reduced.[6]

VIII. ADVANTAGES

1. Improved steering responsiveness and precision.
2. High speed straight line stability.
3. Relative wheel angles and their control.
4. Superior cornering stability.
5. Notable improvement in rapid lane changing manoeuvres.
6. Smaller turning radius and tight space manoeuvrability at low speed.[8]

IX. APPLICATION

1. Parallel parking: Due to smaller turning radius the parking and un parking of vehicle is easily performed towards the right or left side.
2. High speed lane changing: In this is less steering sensitive this does require a lot of concentration from driver since he has to judge the space and vehicles behind them.[2]
3. Slippery road surfaces: Due to the rear wheel steering operation on low friction surfaces occurs hence vehicle direction easier to control.
4. Narrow Roads: Due to rear wheel steering on narrow roads with tight bends, counter phase steering reduces the turning radius.[6]
5. U-Turns: By minimizing the vehicle's turning radius and counter phase steering of rear wheels enables U-Turns to be performed on narrow roads.[9]

X. CONCLUSION

Thus, the four wheel steering system has got cornering capability, steering response, straight-line stability, lane changing and low speed maneuverability. Even though it is advantageous over the convectional two wheel steering system, four wheel steering is a complex and expensive. Currently the cost of a vehicle with four wheel steering is more than that of the convectional two wheel steering of vehicle. Four wheel steering is growing in popularity and it is likely to come in more and more new vehicles. As the system become more common place, the cost of four wheel Steering system will drop down.

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