

# Fabrication of Zero Degree Turn Four Wheel Steering System

D. A. Agrawal<sup>1</sup> Chetan D. Shende<sup>2</sup> Mohammed Ehtesham<sup>3</sup> Harshal M. Khobragade<sup>4</sup>

<sup>1</sup>Assistant Professor <sup>2,3,4</sup>UG Student

<sup>1,2,3,4</sup>Department of Mechanical Engineering

<sup>1,2,3,4</sup>J.D. College of Engineering and Management Nagpur

**Abstract**— Conventional steering mechanism involves either the use of Ackerman or Davis steering systems. The disadvantage associated with these systems is the minimum turning radius that is possible for the steering action. This difficulty that is associated with the conventional methods of steering is eliminated by employing a four wheel steering system. In this system, the wheels connected to the front axles are turned opposite to each other, and so are the wheels connected to the rear axle. The wheels on the on left half vehicle rotate in one direction and the ones on the right half of the vehicle rotate in the opposite direction. This arrangement of the wheels enables the vehicle to turn 360 degrees, without moving from the spot, i.e. the vehicle has zero turning radius. This helps in maneuvering the vehicle in tight spaces such as parking lots and within small compounds.

**Key words:** Conventional Steering Mechanism, Zero Degree Turn Four Wheel Steering System

## I. INTRODUCTION

Zero turn vehicle as the name itself indicates the meaning that a vehicle take the turn with zero turning radius and gives circular path without leaving its circular axis passing through the centre. Zero degree turning radius vehicle implies the vehicle rotating about an axis passing through the centre of gravity of vehicle. No extra space is required to turn the vehicle. So vehicle can be turned in the space equal to the length of the vehicle itself. Four wheel steering system can be employed in some vehicle to increase their steering response and as well as increase vehicle stability when moving at specific speed or to decrease turning radius at low speed. Nowadays most of the vehicles used two wheel steering system as their main steering system. But two wheel steering system has low efficiency as compared to the four wheel steering system. It gives high inertia therefore there is need of mechanism results in less turning radius. This can be achieve by four wheel steering system instead of conventional system.

### A. Type of Steering System

The most frequently used type of steering, are using the front two wheels of the vehicle. This type of steering suffers from the comparatively larger turning circle and the extra effort required by the driver to negotiate the turn. Some types of industry battery trucks and industry backhoe loaders use this type, where only the two rear wheels control the steering. It can produce smaller turning circles, but is unsuitable for high speed purposes and for ease of use. Many modern cars use rack and pinion steering mechanisms. The rack and pinion design has the advantages of a large degree of feedback and direct steering "feel". The recirculating ball mechanism is a variation on the older worm and sector design; the steering column turns a large screw (the "worm gear") which meshes with a sector of a gear, causing it to rotate about its axis as the worm gear is turned; an arm attached to the axis of the sector

moves the Pitman arm, which is connected to the steering linkage and thus steers the wheels. At either end of the apparatus the balls exit from between the two pieces into a channel internal to the box which connects them with the other end of the apparatus, thus they are "recirculated". Power steering assists the driver of an automobile in steering by directing a portion of the vehicle's power to traverse the axis of one or more of the road wheels. As vehicles have become heavier and switched to front wheel drive, particularly using negative offset geometry, along with increases in tyre width and diameter, the effort needed to turn the steering wheel manually has increased thus power steering systems have been developed. There are two types of power steering systems hydraulic and electric/electronic. A hydraulic electric hybrid system is also possible. An outgrowth of power steering is speed adjustable steering, where the steering is heavily assisted at low speed and lightly assisted at high speed. The most effective type of steering, this type has all the four wheels of the vehicle used for steering purpose. A detailed description of this type follows.

## II. FOUR WHEEL STEERING

Contemporary rear axles allows for coincidental steering through the influence of variation of elastokinematic steering; rear wheels rotate, due to an influence of variation of vertical load of wheels (tilting), in the same direction as front wheels. Nevertheless, such a turn of rear wheels is very small and driver's will-independent. A disadvantage of this so-called passive steering system is that it operates even when driving in straight direction when single wheel of an axle hits surface irregularity (deterioration of directional stability). Therefore, the active system means that rear wheels are possible to be turned either coincidentally or non-coincidentally. The increase of the maneuverability when parking the vehicle is achieved by means of dis-concordant steering, meanwhile the increase of the driving stability at higher speeds is achieved through concordant steering.

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 has not been the preferred choice due to the 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 a small 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 4WS model has not been created for production purposes, a number of

experimental concepts with some of these technologies have been built and tested successfully.

Two modes are generally used in these 4WS models:

#### A. Slow Speed Rear Steer Mode

At slow speeds, the rear wheels turn in the direction opposite to the front wheels. This mode becomes particularly useful in case of pick-up trucks and buses, more so when navigating hilly regions. It can reduce the turning circle radius by 25% and can be equally effective in congested city conditions, where U-turns and tight streets are made easier to navigate.

#### B. High speed

In high speeds, turning the rear wheels through an angle opposite to front wheels might lead to vehicle instability and is thus unsuitable. Hence, at speeds above 80kmph, the rear wheels are turned in the same direction of front wheels in four-wheel steering systems. For a typical vehicle, the vehicle speed determining the change of phase has been found to be 80kmph. The steering ratio, however can be changed depending on the effectiveness of the rear steering mechanism, and can be as high as 1:1. Zero Turning Radius – 360 Mode In addition to aforementioned steering types a new type of four wheel steering was introduced by the concept vehicle Jeep Hurricane, one that could significantly affect the way our vehicles are parked in the future. This vehicle has all three modes of steering described above, though it sports a truly complex drive train and steering layout, with two transfer cases, to drive the left and right wheels separately. The four wheels have a fully independent steering and need to run in an unconventional direction to ensure that the vehicle turns around on its own axis.

#### C. Zero Turning Radius – 360 Mode

In addition to aforementioned steering types, a new type of four wheel steering was introduced by the concept vehicle Jeep Hurricane, one that could significantly affect the way our vehicles are parked in the future. This vehicle has all three modes of steering described above, though it sports a truly complex drive train and steering layout, with two transfer cases, to drive the left and right wheels separately. The four wheels have a fully independent steering and need to run in an unconventional direction to ensure that the vehicle turns around on its own axis.

### III. PRINCIPLES OF FOUR WHEEL STEERING

It is to be remembered that both the steered wheels do not turn in the same direction, since the inner wheels travel by a longer distance than the outer wheels.

#### A. Ackermann Steering Mechanism

Ackermann steering geometry is a geometric arrangement of linkages in the steering of a car or other vehicle designed to solve the problem of wheels on the inside and outside of a turn needing to trace out circles of different radii. The steering pivot points are joined by a rigid bar called the tie rod which is also a part of the steering mechanism. With perfect Ackermann, at any angle of steering, the centre point of all of the circles traced by all wheels will lie at a common point.

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 maneuvers, and the right and left wheels do not turn by the same angle,

be it any cornering speed. We chose to use a simple control circuit to demonstrate the effectiveness of a four wheel steering system, and at the same time, simulated the suspension-steering assembly of a typical car to predict the Ackerman angles for corresponding steer angles. The design calculation for the model follows shortly.

#### B. Condition for True Rolling Motion

Perfect steering of wheels can be achieved only when all four wheels of rolling perfectly for all dynamic conditions. While tackling a turn, the condition of perfect rolling motion will be satisfied if all four wheel axes are projected at one point called the instantaneous center, and when the following equation satisfied:

$$\cot \delta - \cot \delta' = c/b \quad (1)$$

It is seen that the inside wheel is required to turn through a greater angle than the outer wheel. The larger the steering angle, the smaller the turning circle. It has been found that the steering angle can have a maximum value of about 44 degrees under dynamic conditions. The extreme positions on either side are called lock positions. The diameter of the smallest circle which the outer front wheel of the car can traverse and obtained when the wheels are at their extreme positions is known as the turning circle.

#### C. Benefits of Four Wheel Steering

With the 3600 mode, the vehicle can quickly turn around at the press of a button and a blip of the throttle. Complicated three-point steering maneuvers and huge space requirements to park the vehicle are entirely phased out with this. Crab mode helps simplify the lane changing procedure. In conjunction with rear steer mode, four-wheel steering can significantly improve the vehicle handling at both high and low speeds.

Due to the better handling and easier steering capability, driver fatigue can be reduced even over long drives. The only major restriction for a vehicle to sport four-wheel steering is that it should have four or more wheels. Hence, every kind of private and public transport vehicle, be it cars, vans, buses, can benefit from this technology. Military reconnaissance and combat vehicles can benefit to a great extent from 360 mode, since the steering system can be purpose built for their application and are of immense help in navigating difficult terrain.

### IV. COMPONENTS OF SYSTEM

The main parts used for fabrication of vehicle are sprocket, steering system, wheels, etc, mounted on rectangular chassis shown in fig.

#### A. Sprocket Gear

Sprocket are used in bicycles, motorcycles, cars, tracked vehicles, and other machinery either to transmit rotary motion between two shafts where gears are unsuitable or to impart linear motion to a track, tape etc



Fig. 1: Sprocket gear

## B. Steering Column

The automotive steering column is a device intended primarily for connecting the steering wheel to the steering mechanism or transferring the driver's input torque from the steering wheel.

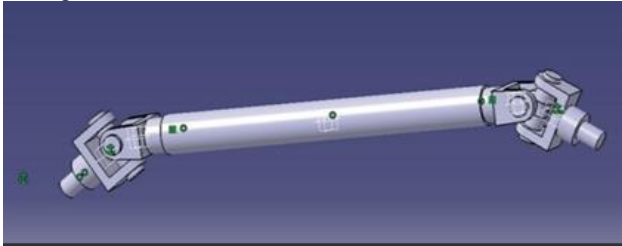


Fig. 2: Steering column

## C. Universal Joint

A universal joint (universal coupling, U-joint, Cardan joint, Spicer or Hardy Spicer joint, or Hooke's joint) is a joint or coupling in a rigid rod that allows the rod to "bend" in any direction, and is commonly used in shafts that transmit rotary motion. It consists of a pair of hinges located close together, oriented at  $90^\circ$  to each other, connected by a cross shaft. The universal joint is not a constant-velocity joint.

## D. Pedestal Bearing

A pillow block, also known as a Plummer block or housed bearing unit, is a pedestal used to provide support for a rotating shaft with the help of compatible bearings & various accessories. Housing material for a pillow block is typically made of cast iron or cast steel.

## E. Wheel Hub

A hub is the central part of a wheel that connects the axle to the wheel itself. Many expressions use the term for a literal or figurative central structure connecting to a periphery

## F. Rack & Pinion

A rack and pinion is a type of linear actuator that comprises a pair of gears which convert rotational motion into linear motion. A circular gear called "the pinion" engages teeth on a linear "gear" bar called "the rack"; rotational motion applied to the pinion causes the rack to move relative to the pinion, thereby translating the rotational motion of the pinion into linear motion.

## V. PROCESSES USED IN FABRICATION

Various types of manufacturing processes are used during fabrication, the processes are welding, cutting, drilling, turning, etc.

### A. Arc Welding

Arc welding is a process that is used to join metal to metal by using electricity to create enough heat to melt metal, and the melted metals when cool result in a binding of the metals. It is a type of welding that uses a welding power supply to create an electric arc between an electrode and the base material to melt the metals at the welding point. They can use either direct (DC) or alternating (AC) current, and consumable or non-consumable electrodes. The welding region is usually protected by some type of shielding gas, vapor, or slag. Arc welding processes may be manual, semi-automatic, or fully automated. First developed in the late part of the 19th century, arc welding became commercially important in shipbuilding

during the Second World War. Today it remains an important process for the fabrication of steel structures and vehicles.

### B. Cutting

Cutting has been at the core of manufacturing throughout history. For metals many methods are used and can be grouped by the physical phenomenon used.

### C. Drilling

Drilling is a cutting process that uses a drill bit to cut a hole of circular cross-section in solid materials. The drill bit is usually a rotary cutting tool, often multipoint. The bit is pressed against the workpiece and rotated at rates from hundreds to thousands of revolutions per minute. This forces the cutting edge against the workpiece, cutting off chips from the hole as it is drilled. In rock drilling, the hole is usually not made through a circular cutting motion, though the bit is usually rotated. Instead, the hole is usually made by hammering a drill bit into the hole with quickly repeated short movements. The hammering action can be performed from outside of the hole or within the hole. Drills used for horizontal drilling are called drifter drills. In rare cases, specially-shaped bits are used to cut holes of non-circular cross-section; a square cross-section is possible

### D. Grinding

Grinding is an abrasive machining process that uses a grinding wheel as the cutting tool. A wide variety of machines are used for grinding. Hand cranked knife-sharpening stones (grindstones) Handheld power tools such as angle grinders and die grinders Various kinds of expensive industrial machine tools called grinding machines Bench grinders often found in residential garages and basements.

## VI. APPLICATIONS

- In industries for automation of raw material like automated guided vehicle.
- In automobiles application.
- In big industries for transportation of raw material.
- To park the vehicle in congested space
- Take easily 360 -turn.

## VII. ADVANTAGES

- Less costly
- Less maintenance
- More efficient
- Car can easily parked.
- Saving the time

## VIII. DISADVANTAGES

- Wear and tear of wheel occurs in short period of time.
- Sudden uneven increase in work load in front wheel can be dangerous.

## IX. CONCLUSION

By the experimental we conclude the result. The working of four wheel steering system is a new concept that can improve the working parameters in a car. We worked with different mechanisms to make the working simpler. The

manufacturing of the components is done in much simpler manner in our own workshop.

#### X. FUTURE SCOPE

With the increasing number of future vehicle registrations, traffic and parking space problems become intensified. Hence there is a need of a suitable steering mechanism on a vehicle, which gives comfort and abide parallel parking, parking issues in a well-organized manner, is necessary. This project focuses and aims on designing an all wheel steer platform, which is capable of achieving zero turn radius. It forms a solution for above discussed problem. Zero turn radius steering mechanism drive wheels in a unique manner such that four wheels of the vehicle follow an exact circular path, so that the chassis/platform will be capable of rotating about a fixed point. Hence, this would reduce the requirement of moving the vehicle in a defined path with large turn radius, as employed in traditional steering systems

#### REFERENCES

- [1] K. Lohith, Dr. S. R. Shankapal, M. H. Monish Gowda, "Development of four wheel steering system for a car", Volume 12, Issue 1, April 13.
- [2] International Journal of mechanical engineering & robotics research, National conference on "Recent advances in Mechanical Engineering" RAME -2013, Vol. 1, No.1, January 2014.
- [3] Xiaodong Wu, Member, IACSIT, Min Xu, and Lei Wang, "Differential Speed Steering Control for Four-Wheel Independent Driving Electric Vehicle" International Journal of Materials, Mechanics and Manufacturing, Vol. 1, No. 4, November 2013.
- [4] Allan Y. Lee, "Performance of Four-Wheel-Steering Vehicle in Lane Change Maneuvers", California Institute of Technology.
- [5] D. Stajanko, P. Berk, B. Mursec, P. Vindis, "The influence of different steering system on a wheel slips", Volume 55 Issue 2 December 2012.
- [6] Unknown, four wheel steering report, [http://www.scribd.com/doc/34677964/Four-Wheel\\_Steering\\_report](http://www.scribd.com/doc/34677964/Four-Wheel_Steering_report), Retrieved on 13th sep 2012.
- [7] Unknown, four wheel steering report, <http://www.wisegeek.com/what-is-four-wheel-steering.html>, Retrieved on 13 sep 2012.
- [8] Dr. Kirpal Singh "Automobile Engineering" Standard Publisher Distributers, vol. 1, 12th Edition 2012.
- [9] Tom Murphy andnBrian Corbelt (2005), Quadra Steer off Course.
- [10] ISSN 2277-3754 International Journal of Engineering and Innovative Technology Volume 1. Developing a system to reducing the turning Radius of a car B.L. Salvi, J.K Maherchandani, Dr. B.P.Nandwana.
- [11] ISSN 2394-3696 International Journal of Innovation In Engineering Research And Technology Volume 2. Four Wheel Steering System For Automobile, Krishna Bevinkatti, Atul Mali, Rahulsingh Bayas, Abhijit Ghadge