

Model of Four Wheel Steering Mechanism

Ananta Kumar Nath

Lecturer (SS), Mechanical (Automobile) Engineering, Bongaigaon Polytechnic, Bongaigaon, Assam, India.

Abstract:- The automobile industry in India is the fourth largest in the world. India facing its own challenges due to its huge and variety transport sector. These challenges may overwhelmed by using energy efficient advancements with the customer focused approach. In city driving conditions the vehicle with higher track width and wheelbase face problems of turning as the space is confirmed, the same problem is faced in low speed cornering. The turning radius is reduced in the four wheels steering of the vehicle which is effective in confirm space. In this project turning radius is effective in confirmed space, and tuning radius is reduced without changing the dimension of the vehicle. In situation like vehicle parking, low speed cornering and driving in city conditions with heavy traffic in tight spaces. Hence there is a requirement of a mechanism which result in less tuning radius and it can be achieved by implementing four wheel steering. In this report, the performance of four wheels steered vehicle model is considered which is optimally controlled during a lane change maneuver in two types of conditions. The main objectives of this project are to build a physical model of four wheel steering mechanism and to know the benefits of four wheel steering mechanism over two wheel steering mechanism. Now a day's all advanced modern vehicles are using this four wheel steering mechanism. Audi A6, Audi A8, Acura TLX, BMW 5 Series, BMW 7 Series, Cadillac CT6, etc. are the great example of four wheel steered vehicles.

Keywords: Steering system, rack and pinion, bevel gear, turning radius.

I. Introduction and Overview

The researchers have moved toward making vehicle more comfortable and secure focusing more on ergonomics and safety. [1] Steering system is use to give nonlinear movement and direction to the vehicle depending upon the drivers command. This will allow a vehicle to follow the desired direction. Four wheel steering (4WS), also called rear wheel steering or all wheel steering, provides a means to actively steer the rear wheels during maneuvers. [3] It should not be confused with four wheels drive in which all four wheels of vehicle are powered.

Four wheel steering is a method developed in automobile industry for the effective tuning of the vehicle, increase the maneuverability and reduce the drivers steering effort.[4] In city driving conditions, the vehicle with higher track width and wheelbase face problems of turning as the space is confined the same

problem is faced in low speed cornering.[4] The turning radius is reduced in the four wheels steering of the vehicle which is effective in confined space; in this project, turning radius is reduced without changing the dimension of the vehicles.

In situations like vehicle parking, low speed cornering and driving in city conditions with heavy traffic in tight spaces, driving is very difficult due to vehicle's larger track width and wheelbase. When both the front and rear wheels steer toward the same direction, they are said to be in-phase and this produces a kind of sideways movement of the car at low speeds. When the front and rear wheels are steered in opposite direction, this is called anti-phase, counter-phase or opposite-phase and it produces a sharper, tighter turn.

In four wheel steering system, the rear wheels are controlled by a gear arrangement. This allows the vehicle to turn in a significantly smaller radius sometimes critical for large trucks or tractors and vehicle with trailers and beneficial for high speed vehicles to change lanes faster than compared two wheel steered vehicles. In an active four wheel steering system, all four wheel turn at same time when the driver steers. The rear wheels generally cannot turn as far as the front wheels; they only assist the front wheels during high speed. Hence, there is a requirement of a mechanism which result in less turning radius and it can be achieved by implementing four wheel steering.

II. Objectives of the Present Study

1. To build a physical model of four wheel steering mechanism.
2. To know the benefits of four wheel steering mechanism over two wheel steering mechanism.
3. Comparison of four wheel steering system with two wheel steering conventional system.

III. Methodology and Tools/Techniques Used

The study has been carried out with the following steps:

(a) Background Theory:

The steering mechanism consists of rack and pinion arrangements which are used to turn the wheels in the front. And a bevel gear arrangement is made just after the steering and power is transmitted through the transfer shaft to the gear box assembly. Then power is

transmitted to the rear wheels. Layout/Operation of the system: Two subsystems: Rack and pinion for front and rear, identical geometry and components. Steering column is fitted with 3 bevel gears meshes and transmits power to front and rear rack and pinion. As steering wheel is turned the entire rotation is transmitted to front rack and pinion and only half of the rotation is transferred to rear rack and pinion.

i. Ackermann Steering Mechanism

Ackermann steering mechanism is a geometric arrangement of linkages in the steering of vehicle designed to solve the problem of wheels on the inside and outside of a turn needing of different radius. The intention of Ackermann geometry is to avoid the need for tires to slip sideways when following the path around a curve. The geometrical solution to this is for all wheels to have their axles arranged as radius of circles with a common centre point. As the rear wheels are fixed, this centre point must be on a line extended from a rear axle. Intersecting the axes of the front wheels on this line as well requires that the inside front wheel is turned, when steering, through a greater angle than the outside wheel.

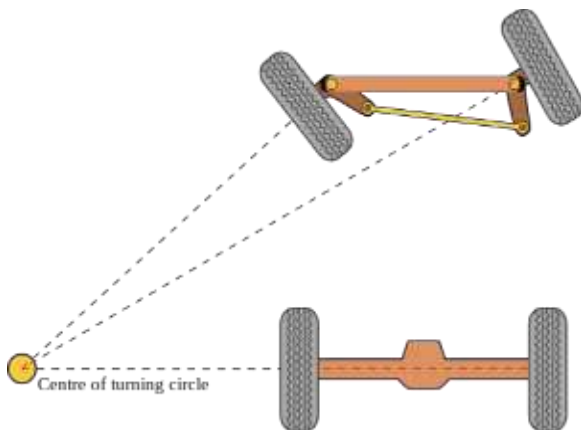


Fig1: Ackermann Steering Mechanism

ii. Gear Reduction

A reduction gear is an arrangement by which an input speed can be lowered for a requirement of slower output speed, with same or more output torque.

iii. Turning Radius

The turning radius of a vehicle is the radius of the smallest circular turn (i. e U-turn) that the vehicle is capable of making.

iv. Steering Geometry

Steering geometry is the geometric arrangement of the parts of a steering system and the value of the lengths and angles within it. Steering geometry changes due to bumps in the road may cause the front wheels to steer in a different direction together or independent of each other. Combined with the cars improved steering

geometry, a wide wheel and large footprint will notably improve handling and grip.

IV. Working Principle

The four wheel steering system consists of rack and pinion mechanism assisted by bevel gears of which is connected to the gear box, steering rod in which input is given by the driver and another will be connected to rear pinion. Rear wheel system consists of two racks with two pinions. One of the racks will be in front of the rear wheel axis and the other will be at the front axis. Also at any point in the system, one of the rack and pinion assemblies will be engaged with the other being disengaged. At lower speeds, the pinion will be in compound gear form, in contact with rear rack so as to keep the wheels motion OUT- PHASE while for higher speeds pinion will be in simple gear form giving IN-PHASE motion to the wheels.

V. Construction of Model

Project model consists of two rack & pinion (one for front and other for rear) and five bevel gears (two at the steering & set of three in the mid region) as shown in the figure 3. Initially, as steering movement is given, say in the right direction. This drives the pinion in right direction and it engages the rack (connected to the front wheels) towards the right thereby driving the front wheel to the right. First bevel gear is placed below the pinion to transfer the motion of the pinion driven right. The second bevel gear is engaged vertically to the previous one and transfer the motion to the shaft in the opposite direction, i.e. left. This shaft is further connected to the set of three bevel gears in which the first one attached to the shaft turns as same as the shaft (left), second one (engaged to the first) turns in the opposite direction (right) and finally the third one (engaged to the second) turns opposite to the second one (left again). This leftward motion of the final bevel gear transmits leftward motion on to the pinion on the rear side; this engages the rack in the rear side towards left, thereby moving the rear wheels in the opposite direction of the front wheels. This depicts the turning mechanism of a vehicle at low speeds as explained in the above.

VI. Operation of 4 Wheel Steering: Slow and High Speed Modes

At Slow Speeds rear wheels turn in direction opposite to that of front wheels. This mode is used for navigating through hilly areas and in congested city where better cornering is required for U turn and tight streets with low turning circle which can be reduced as shown in Fig 2

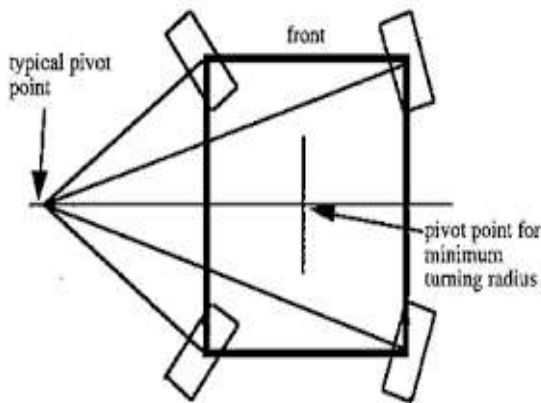


Fig.2: Less turning radius

At High Speeds, turning the rear wheels through an angle opposite to front wheels might lead to vehicle instability and is thus unsuitable. Hence the rear wheels are turned in the same direction of front wheels in four-wheel steering systems. This is shown in Fig 6.

i. Benefits of four wheel steering mechanism

- Ultimate cornering ability.
- Smallest turning radius possible.
- Better stability of the vehicle.
- The intensity of four wheel steering can be adjusted by the driver according to personal preference.

ii. Advantages

1. **Superior cornering stability:** The vehicle cornering behavior becomes more stable and controllable at high speed as well as on wet skipping road surfaces.
2. **Improved steering response and precision:** The vehicle response to steering input becomes quicker and more precise throughout the vehicle enter speed range.
3. **High speed straight line stability:** The vehicle's straight -line stability at high speed is improved. Negative effects of road irregularities and crosswinds on the vehicles stability are minimized.
4. **Improved rapid lane-changing maneuvers:** This is stability in lane changing at high speed is improved. In high speed type operation become easier. The vehicle is less likely to go into a spin even in situations in which the driver must make a sudden and relatively large change of direction.
5. **Smaller turning radius:** By steering the rear wheels in the duration opposite the front wheels at low speed, the vehicle's turning circle is greatly reduced. Therefore, vehicle maneuvering on narrow roads and during parking become easier.
6. **Controlling:** Computer-controlled Quadra steer can be switched on and off and has an effective trailer towing mode.

iii. Disadvantages

1. The 4WS, due to construction of many new components, the system becomes more expensive.
2. The system includes as many components (especially electronically) there is always a chance to get any of the part inactive, thus the system become in operative.
3. The system is not stable at high speed gets overpowered and topple in some cases.
4. Pump and sensors should be checked regularly to avoid its failure.

iv. Advantages of four wheel steering mechanism over two wheel steering:

- **Four wheel steering mechanism has greater turning radius than two wheel steering:** Four wheel steering system has the ability to make turns at a smaller radius because the rear wheels are able to turn in a different direction than the front wheels. This makes it easier to maneuver the vehicles around corners without having to widen turn too far out into the road.
- **Four wheel steering mechanism has better stability than two wheel steering:** A four wheel steering system makes it easier to control the vehicle and keep it stable, especially when the vehicle is turning around a corner or driving in the rain. If the vehicle is going down a straight road, the vehicle will continue to stay straight even if there are heavy winds or potholes to try and throw it off.
- **Four wheel steering mechanism has precise steering response than two wheel steering:** A four wheel steering system gives the vehicle steering wheel a much faster response than a standard two- wheel steering system. This will make our driving experience much more comfortable because it will be able to be more precise in the direction that we are traveling in.
- **Four wheel steering mechanism has rapid lane changing maneuvers than two wheel steering:** Who regularly drives on the interstate and you constantly find yourself changing lanes or passing people, then a four wheel steering system will help you do this fast and efficiently. With all the reliable and stable steering control, you'll be able to change lanes much faster than you would with a two-wheel steering system.

v. Applications

1. **Gentle Curve:** On gentle curves, in phase steering of the rear wheels improves the vehicle stability.
2. **Parking:** During a parking a vehicle driver typically turns the steering wheels through a large angle to achieve a small turning radius. By counter phase steering of the rear wheels, 4 WS system realizes a smaller radius then is possible with 2WS. As a result vehicle is turned in small radius at parking.

3. **Junctions:** On a cross roads or other junction where roads intersect at 90 degree or tighter angles, counter phase steering of the rear wheels causes the front and rear wheels to follow more-or-less path. As a result the vehicle can be turned easily at a function.

4. **Slippery Road Surfaces:** During steering operation on snow, icy, muddy and other low friction surfaces, steering of the rear wheels suppress sideways drift of the vehicles rear end. As a result the vehicles direction is easier to control.

5. **U-Turns:** By minimizing the vehicles turning radius, counter phase steering of the rear wheels enables U-turns to be performed easily on narrow roads.

VII. Conclusions:

This paper focused on a steering mechanism which offers feasible solutions to a number of current manoeuvring limitations. Different mechanisms were

adopted by trial and error method in order to facilitate the engagement of the wheels in the required direction, and the most convenient method was adopted. Thus the four-wheel steering system is a relatively new technology that imposes cornering capability, steering response, straight-line stability, lane changing and low-speed manoeuvrability in cars, trucks and trailers. The aim of 4WS system is a better stability during overtaking manoeuvres, reduction of vehicle oscillation around its vertical axis, reduced sensibility to lateral wind, neutral behaviour during cornering, improvement of active safety. Even though it is advantageous over the conventional two-wheel steering system, 4WS is complex and expensive. Currently the cost of a vehicle with four wheel steering is more than that for a vehicle with the conventional two wheel steering. Four wheel steering is growing in popularity and it is likely to have with all vehicles. As the systems takes over market the cost of four wheel steering will fall down.

At slow speed, In COUNTER PHASE

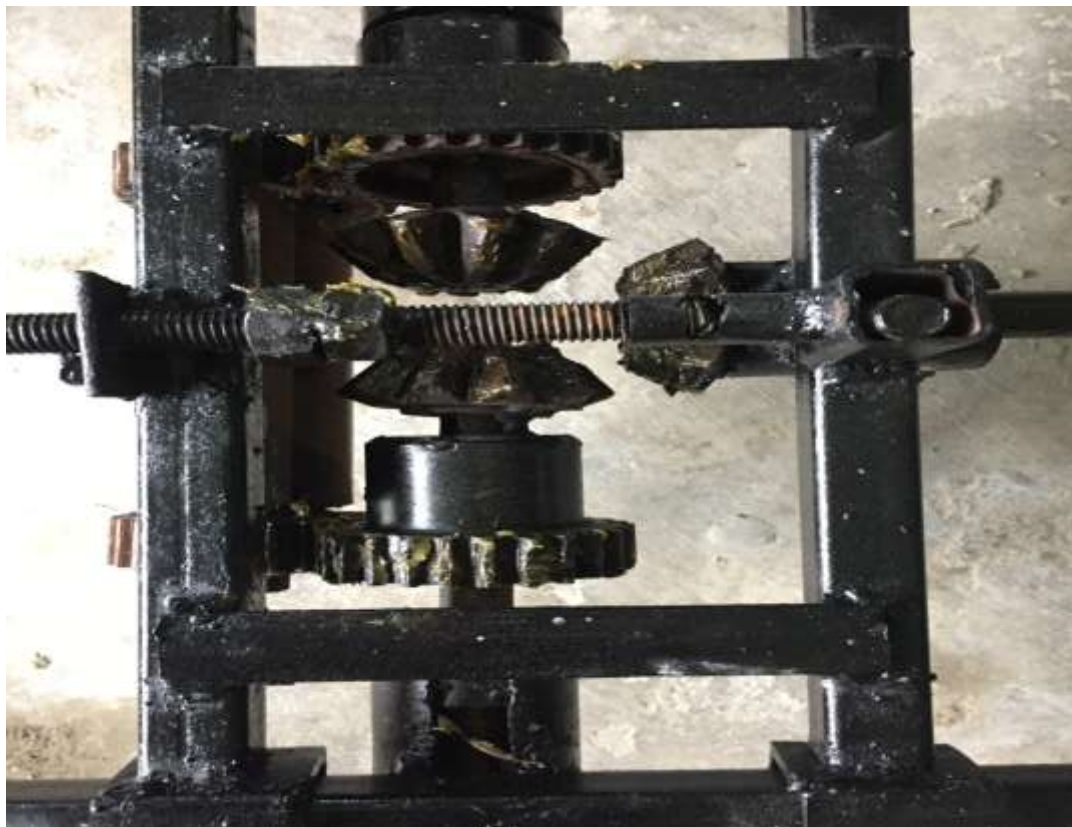


Fig 3: Top view of the COUNTER-PHASE gear mechanism



Fig 4: Top view of the COUNTER-PHASE steering mechanism

At high speed, IN-PHASE

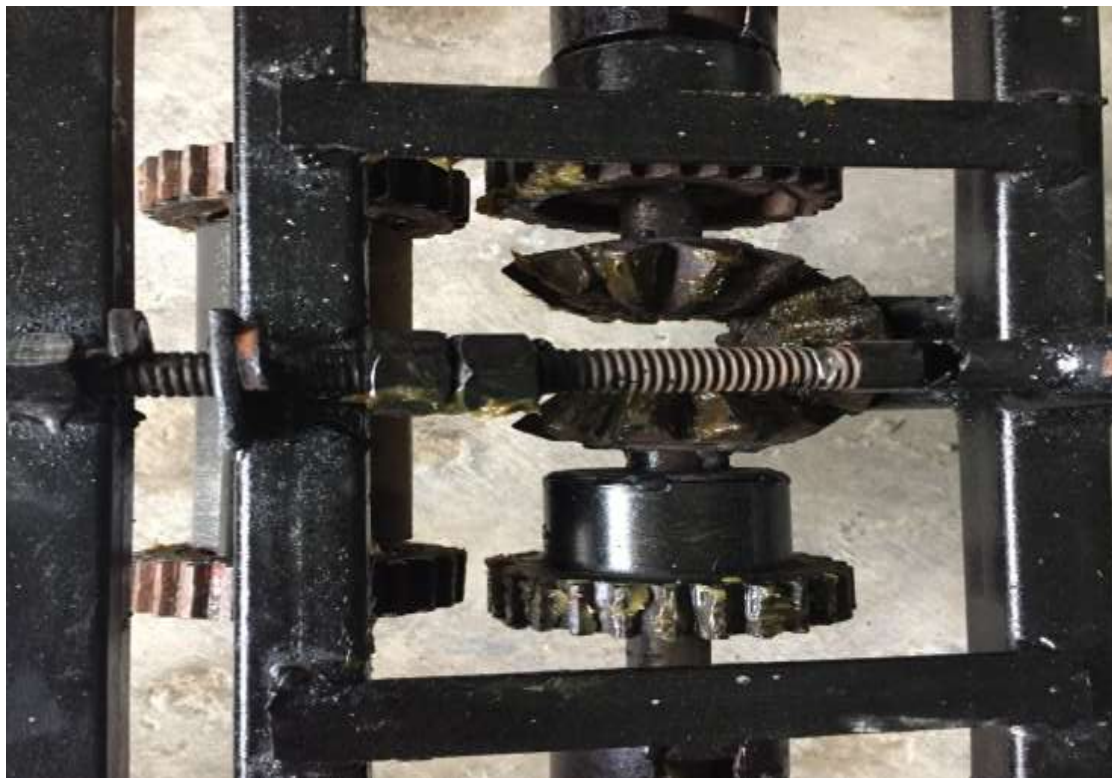


Fig. 5: Top view of the IN-PHASE gear mechanism



Fig 6: Top view of the IN-PHASE steering mechanism

References:

[1] Kumar P. Suresh, Joshi Swapnil, Kumari N. Prasanthi, "Design and Fabrication of Four-Wheel Steering System for Efficient Transportation Systems" International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-8 Issue-10, August 2019.

[2] Choudhary Dilip S., "Four Wheel Steering System". International Journal of Mechanical Engineering and Robotic Research". Volume: 3 Issue: 4, ISSN 2278-0149 October 2014.

[3] Singh Arun, Kumar Abhishek, Chaudhary Rajiv, Singh R.C. "Study of Four Wheel Steering System to Reduce Turning Radius and Increase Stability". International Conference of Advance Research and Innovation. ISBN 978-93-5156-328-0, 2014.

[4] Lohith, K. Dr. Shankapal S.R., Gowda M.H. Monish, "Development of Four Wheel Steering system for a Car" vol. 12, pg. 90-97, Issue 1, April 2013.

[5] Tikley Abhinav, Khangan Mayur, "Four Wheel Steering- A Review". International Journal of Research in Science and Engineering. Volume: 1 Issue: 3 e-ISSN: 2394-8299, p-ISSN: 2394-8280.

[6] Bhandari V. B. "Design of Machine Elements" McGraw Hill Education India Pvt. Ltd., vol. 3, 11th Edition, 2013.

[7] Bhishikar Saket, Gudhka Vatsal, Dalal Neel, Mehta Paarth. "Design and Simulation of 4 Wheel Steering system". International Journal of Engineering and Innovative Technology (IJEIT) Volume 3, Issue12, ISSN: 2277-3754, June 2014.

AUTHOR



Mr. Ananta Kumar Nath received his B.E. degree in Mechanical Engineering from Jorhat Engineering College, Jorhat, under Dibrugarh University, Assam in India in 2002 and did his M. E. degree in Mechanical Engineering (Specialization of Production and Industrial Engineering) from Jorhat Engineering College, Jorhat, under

Dibrugarh University, Assam in India in the year of 2015. He is a member of Institution of Engineers. He has also 27 years teaching experience in different Institutes. He is a Lecturer (SS) in Mechanical (Automobile) Engineering Department at Bongaigaon Polytechnic, Bongaigaon, Assam, India under Dept. of Higher Education (Technical), and Govt. of Assam in India. He published three different papers in International journals. His research interests include Alternative fuels, Automobile Engineering and Tea Industry.