

# A REVIEW PAPER ON HYDRAULICALLY ACTUATED FOUR WHEEL DRIVE SYSTEM

<sup>1</sup>Prof. Hardik A. Khunt

<sup>1</sup>Assistant Professor

Mechanical Engineering Department,

V.V.P.Engineering college.

**Abstract --** Steering system is considered as brain of any vehicle, without that the imagination of any vehicle is not possible. Generally in all the four wheeler there are two wheel drive system. But, according to today's scenario due to two wheel drive system is not preferable due to traffic problems, turning problems, parking problems etc. for that the four wheel drive is used. The four wheel drive are generally mechanically driven, which causes lots of effort so, we thought that if there is hydraulically actuated four wheel drive then it gives number of benefits. We cannot replace whole steering system so, we make a system which does the four motions. Such as zero turn, Crab steer, sharp turning and two wheels steer etc.

**Keywords :** Steering System, Four wheel drive, Automobile

## I. INTRODUCTION

Commonly in all four wheel steering mechanism two wheel steering mechanism is used i.e. Ackermann steering mechanism and Davis steering mechanism. By using this type of steering mechanism in the four wheel only front wheel steer whether front wheel or rear wheel mostly the front wheel.

We noticed following problems in today's used steering mechanism

- More space required for turning.
- More space required for parking.
- No movement in direct diagonally
- More effort required
- Less sensitive etc.

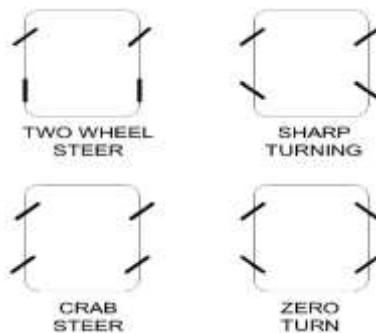


Fig.1 Different modes of steering

Thus to eliminate above mention problems in nowadays steering mechanism we thought we can able to steer all four wheel system hydraulically.

All four wheels can be steered with the help of Quadra mechanism and also to make zero radius turn control system uses mechanical system. To make that turn so hard work is required for the same so we thought mechanical system can be replaced with hydraulic system so less effort is required to make zero radius turn.

In Quadra mechanism it gives four types of steering to vehicle i.e. two wheel steering, four wheel steering, crab steering, Zero turn. So for zero turn, control system uses hydraulic system in order to reduce the effort carried out by driver. So driver input manoeuvre reduces.

In standard 2 Wheel Steering System, the rear wheels are always directed forward and do not participate in controlling the steering. While in four Wheel Steering System, the rear wheels participate for steering, which can be moved at high as well as low speeds.

## II.LITERATURE REVIEW

**Rex R. Bergsten, David H. Torborg, John B. Heckel**[1] Describes a mower having a cutting deck for cutting grass has four drive wheels that can be arranged in a square or rectangular configuration on the frame of the mower. Four wheel drive and four wheel steering are fixed with the drive wheels and the four wheel drive is provided with a hydraulic drive system which works as a pair of identical serial circuits which have their own pumps with each pump serially sending its output through a rear drive motor and a front drive motor that are catty-corner to one another on the frame, i.e. are on opposite sides of the motor. Various crossover paths or track and recirculation paths or track are provided in the serial circuits which satisfies the drive motors receive adequate in maximum turns of the mower. The recirculation paths around a pair of drive motors at one end of the frame are shut off during reverse and during braking so that all drive motors retain hydraulic braking in such conditions.

**Kaj Carlson**[2] Describes a hydrostatic four wheel drive system for an articulated vehicle, which system due to its special arrangement is also able to steer the vehicle. The hydraulic system includes two powered hydraulic pumps variable as to their output capacity and directions. The hydraulic motors powering the front right-side wheel and the rear left-side wheel, respectively are connected through a closed hydraulic circuit in parallel relation to the hydraulic pumps, and the motors powers the front left-side wheel and the rear right-side wheel, respectively they are connected through a second hydraulic circuit in parallel relation to the other of the hydraulic pumps. The vehicle can be able to steer by changing the rate and/or flow direction in one of the two hydraulic circuits according to the corresponding parameters of the other circuit...

**Danish Akhtar**[3] gives opinion behind four wheel steering is that a four wheeler requires less driver effort for any steering effort if all four wheels are steering the vehicle. As with two wheel steering vehicles, tyre grip clutch the four wheels on the road. However, when the driver turns the wheel slightly, all four wheels behave the same for the steering input, causing slip angles to form at all four wheels. The entire vehicle moves in one direction except the rear half tries to catch up to the front. The vehicle reacts more effectively to steering input because rear wheel lag is omitted. To get 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 normal to the vehicle's velocity vector 'v' at the mass centre 'C'

**Shirsath S.V. , Jadhav K.R., Patil R.V. , Mohite A.V., Prof. Patil .D.D.**[9] Describes Zero turn vehicle 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 Nano pixel, JCB, lawnmower. The Jeep Hurricane which has many steering modes using four-wheel independent steering. Each wheel can turn independently from the other. The vehicle has two modes of four wheel steering. In first mode front tires and rear tires turns in opposite direction and reduces the turning circle. In second mode, front and rear wheels turn in same direction for crab steering, which facilitates parking at narrow space without changing the direction .The jeep hurricane can actually rotate in place. The Jeep hurricane has some limitations like requirement of skilled driver, complex steering system wear of tire.

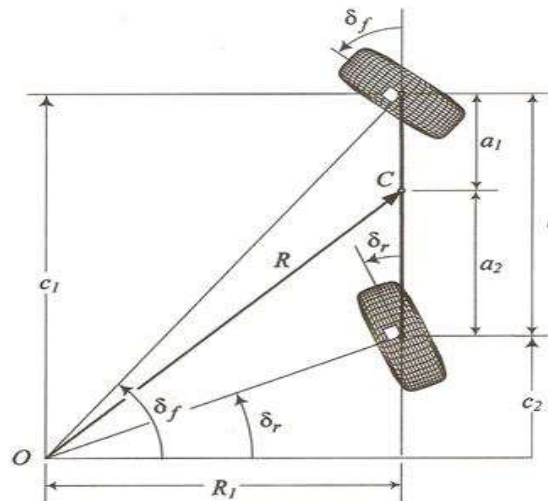


Fig. 2 Design of 4- wheel steering mechanism [3]

**Abhinav Tikley, Mayur Khangan**[4] Describes 4 wheel steer steering system works accordingly to different speed limits. In this system all 4 wheels are given power rather than 2 wheels it means all four wheel are involved in operation. Operation of this system shows below.

#### Working at low speed:

From 10km/hr to 40km/hr. During this speed, rear wheels moves in opposite direction to the front wheels and hence it is useful in turning at residential & parking areas. Thus turning is easier and as the front wheels move with less steering wheel motion.

#### Working at medium speed:

At 40km/hr to 80km/hr. During this speed, front wheels takes larger angle than the rear wheels and thus it is useful in driving in city areas and major roads and vehicle kept balance during it moves in desired direction with smooth turning. It provides good stability.

#### Working at high speed:

Above 80km/hr as the speed of vehicle boosts, the turning angle of front wheel reduces as well as the rear wheels in the same direction. In this speed, both front as well rear wheels moves in the co-equal direction which provides higher stability.

**Travis S. Mergener**[5] Describes Synchronizing system for hydraulic four wheel steering mechanism includes double acting front and rear steering mechanism cylinder. The front and rear steering cylinder are movable and are between retracted and extended position in response to the position in response to the position of a power steering valve. A synchronising valve assembly is connected with hydraulic lines between the front and the rear steering cylinders which includes a first directional relief valve that opens in response to hydraulic fluid pressure which is to synchronise both steering cylinder in a full left position and a second directional relief valve which is opens in response to hydraulic fluid pressure to synchronize both steering cylinders in a full right turn position.

**Saket Bhishikar, Vatsal Gudhka, Neel Dalal, Paarth Mehta, Sunil Bhil, A.C. Mehta**[6] Describes New generation of active steering systems distinguishes a need of steering of rear wheels for the reason of directional stability from a need of steering of rear wheels for the reason of cornering at slow speed.

#### Condition for True Rolling

While tackling a turn, the condition of perfect rolling motion will be satisfied if all the four wheel axes when projected at one point called the instantaneous center, and when the following equation is satisfied:

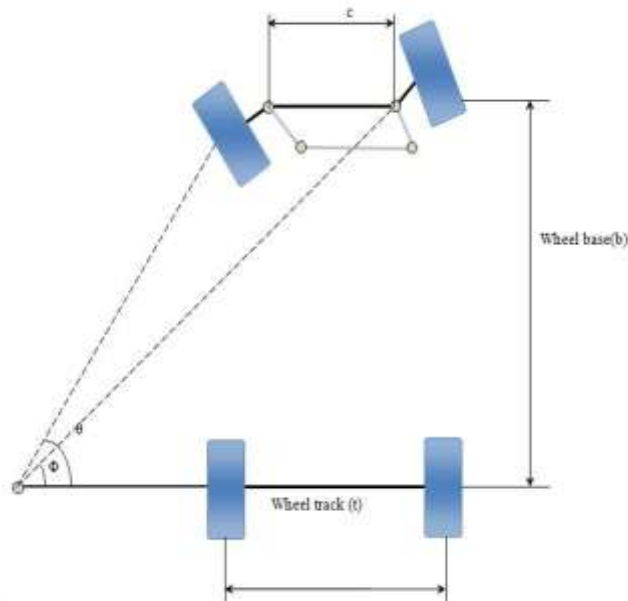


Fig 3. [6] True Rolling Condition

**Slow and High Speed modes**

At Slow Speeds rear wheels turn in direction contrary to that of front wheels. This mode is used for travelling through hilly areas and in occlude area where better turning is required for U turn and gum-up streets with low turning circle which can be decreases as shown in Fig 3.



Fig 4. [6] Slow Speed

At High Speeds, turning the rear wheels through an angle opposite to front wheels lead to vehicle imbalance and is thus not suitable. Hence the rear wheels are moves in the same direction of front wheels in 4WS. This is shown in Fig 4.



Fig 5.[6] High Speed

**In-Phase and Counter/Opposite-Phase Steering**

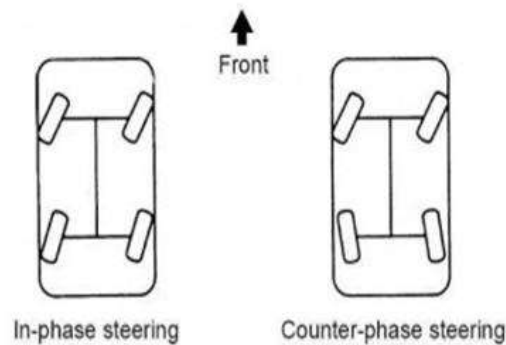


Fig 6. [6] In-Phase and Opposite-Phase Steering

The four wheel steering system performs two different operations: in- phase steering, where the rear wheels are moves in the same direction as the front wheels, and counter/opposite phase steering, where the rear wheels are moves in the opposite direction. The four wheel steering system is effective in the following scenes:

- Lane Changes
- Sharp Turn
- Crossings
- Narrow Roads
- U-Turns
- Parking

### U-Turns

By reducing the vehicle's turning radius, opposite-phase steering of the steering system enables U-turns to be performed easily on narrow roads, lane changing etc.

### Parallel Parking

Zero steer can significantly ease the parking situation, due to its extremely short turning footprint. This is seen in the parallel parking situation, which is common in foreign countries and is likely relevant to our cities. Here, a car has to park in between two cars parked on the service lane. This manipulation requires a three-way movement of the vehicle and consequently heavy steering effort. Moreover, for successfully park the vehicle without incurring any damage, at least 1.75 times the length of the car must be available for parking for a two-wheel steered car. The car requires just about the same length as itself to park in the spot. Also, since the zero turn mode does not require steering inputs, the driver can virtually park the vehicle without touching the steering wheel. All he/she has to do give throttle and brake inputs, and even they can be automated in modern cars. Hence, such a system can even lead to vehicles that can drive and park easily and automatically.

### High Speed Lane Changing

Another driving mode that frequently becomes awkward and even dangerous is changing lanes at fairly high speeds. Although this is less steering requires more effort, this does not require a lot attention from the driver since he has to judge the space and vehicles behind him.

**NISSAN MOTOR COMPANY** [7] Describes the 4WS (4 Wheel Steer) system helps drivers by automatically controlling the steering angle of a vehicle's four wheels according to speed. By actuating the steering angle of all four wheels, this 4WS helps improve stability and response at high speed and helps reduce driver's steering effort at low speed.

### Characteristics of the 4WS System

- (1) Vehicle can move firmly and are easy to drive both in the gum-up city and on awkward roads
- (2) Improved stability allows vehicles can be driven safely on highways and when changing lanes
- (3) Sudden and sensitive control system will allow gentle steering operation

### Parts of the 4 Wheel Steering System

**Front-wheel actuator**

An actuator is placed along the intermediate steering shaft, in order to controlling the result shaft in response to steering operations.

**Main controller**

Controlling rear-wheels  
Steering actuator to actuate

**Front controller**

Controlling front-wheel  
Steering actuator to actuate

**Rear-wheel steering actuator**

Attached to the suspension member in order to  
Steer the rear wheels.

**Steering angle Sensor**

**Bansode S. P., Gaikwad A. A., Salgude P. S., Tiwari T. D. , Prof. Avhad N.V. , Prof. Bhane A.B.**[8] Describes Zero turn vehicle means the vehicle rotating about axis passing through centre of gravity of vehicle. Vehicle do not require extra space to turn, so the vehicle turns in the space equal to longest length of vehicle itself. Longest length acts as a diameter for zero turn of vehicle. Turning radius of conventional steering is large in normal vehicle. But in zero turn vehicle the outer turning radius of vehicle is reduced.

**CONSTRUCTION**

Zero turn vehicle system consists of three double acting pneumatic cylinders which are actuated by 5/2 Direction Control Valve. Polyurethane tubing's are used to supply compressed air from 5/2 Direction Control Valve to pneumatic cylinders. Mechanical linkages are arranged between wheels and piston rod of pneumatic cylinders. Wheels are driven by side shaft D.C. Gear motor.

**Basic frame structure is as follows:**

- Wheel base (b)= 35mm
- Wheel track(a)= 72mm
- Pivot centre= 61mm

**WORKING**

Zero turn vehicle is based on the principle of pneumatic system in which compressed air is used to tilt the all wheels of four wheel drive vehicle to turn the vehicle in 360 degree. Zero turn vehicle is pneumatically operated in which three cylinders are used as an actuator.

Zero turn vehicle is the name itself giving the meaning that a vehicle take the sharp turn with zero turning radius and follow exact circular path without leaving its vertical axis passing through the centre. The air is pressurized in the compressor. The pressure and temperature of the air is increased and it is supplied to cylinder through 5/2 directional control valve. Manually operated 5/2 directional control valve is used to control the path of the pressurized air. Polyurethane hoses are used to carry the pressurized air and supply it to the 5/2 directional control valve, cylinders and further. The pressurized air which is supplied to the cylinder will move the piston in reciprocating motion. The piston cylinder is called as a actuator. The piston rod is connected to the wheel through the mechanical linkages. Due to actuation or motion of the piston, mechanical linkages are also actuated and give desire motion to the wheels of the vehicle. In mean while the dc motors which are connected to the each wheel give the four wheel drive to the vehicle. The dc motor can be rotate in clockwise direction as well as anticlockwise direction which are control by controller. The current is supplied to the dc motor through adapter which converts the ac supply into dc supply. Steering system of the vehicle is controlled by 12 volt dc motor. When supply of compress air is start, 5/2 directional control valve is manually operated to tilt the wheels to take zero turn. At that same time by means of controller dc motors are actuated and give the drive to the vehicle so that it can take zero turn. When there is no necessity of the zero turn the lever of 5/2 directional control valve is put into normal position and vehicle can move as per normal vehicle.

## RESULT

The result for prototype model are as follows:

	Zero Turn Vehicle	Conventional vehicle
Time required to turn in 360 degree (sec)	14	188
Turning radius (mm)	42	140

## Steering wheel configurations

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.

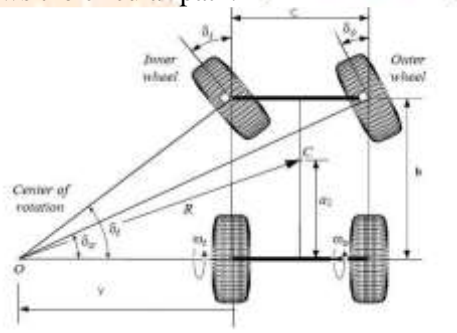


Fig.7. [9] Steering angles for inner and outer wheel

## ELEMENTS AND CONSTRUCTION

### 1. DC electric motor

Electric motor is device which converts the electric energy into mechanical energy. Its action is based on the principle that, when a conductor impregnated with current placed in magnetic field, it experiences a mechanical push whose direction is given by Fleming's Left Hand Rule

### 2. Pneumatic cylinder

In pneumatic cylinder power of compressed gas is used to produce reciprocating linear motion. Pneumatic cylinders having piston with piston rod and piston pin which move in a desire direction and piston rod transfers the force which is developed to the application. Because, the operating fluid is a gas, leakage from the pneumatic cylinder will not drip out and taint the surrounding. So it is desirable where cleanliness is required.

### 3. Direction Control Valve

Direction control valve are used for distribution of energy to various actuators by controlling the direction of flow of the pressurized oil or gas in the system. Generally DCV controls the fluid flow

### 4. Hoses

Hoses are made completely flexible to carry high pressure compressed air. It can be withstand to high temperature and pressure gasses. It is very flexible and easy to use.

### 5. Wheels

Wheels are the end link of the vehicle which give direct output of the system. They are move on a ground having rubber coating to outer side of the wheel for gripping. It carries whole weight of the vehicle. The system consists of three double acting pneumatic cylinders actuated by Direction Control Valve. Hoses are used to supply compressed air. In between wheels and piston rod of pneumatic cylinders mechanical linkages are arranged. Wheels are driven by side shaft D.C. Gear motor.

### Working Principle

It is based on the principle of pneumatic system in which compressed air is used to turn the all wheels of vehicle to turn the vehicle in circular path.

Zero turn vehicle means the vehicle which take the sharp turn with zero turning radius and follow exact circular path without leaving its vertical axis passing through the center.

The air is pressurized in the compressor. The compressor is used to pressurize the air due to which the temperature of the air increases. This pressurized air is supplied to the actuator through DCV. It controls the path of the air. The hoses carry the air between DCV and actuators. The rod of actuator is connected to the wheel through the mechanical linkages. Due to movement of the piston, linkages are also actuated which gives desire movement to the wheels of the vehicle. The dc motors gives the four wheel drive to each wheel. The dc motor can be rotate in both direction like clockwise and anticlockwise which are control by controller. An adapter is used which converts the ac current in dc current and gives to the dc motor. Normal steering system of the vehicle is regulated by dc motor. When supply of compress air is start, DCV is manually operated to tilt the wheels to take zero turn. At that same time the dc motors are actuated by means of controller and give the drive to the vehicle so that it can take zero turn. When there is no requirement of the zero turn the lever of DCV is put into normal position and vehicle can move as per normal vehicle.

### III.CONCLUSION

From our research I concluded that

- The four wheel hydraulic steering mechanism vehicle can turn  $360^\circ$  at its respective position i.e. zero turning radius smoothly.
- The vehicle can move diagonally i.e. crab steer.
- The vehicle will be able to take sharp turn either left or right direction with half the turning radius compared to normal steering vehicle.
- We can able to steer all the wheels.
- It requires less effort to steer the wheels by using hydraulic system compared to mechanical system.

### IV. REFERENCES

- [1]Mower with four wheel steering and hydraulic four wheel drive “Rex R. Bergsten, David H. Torborg, John B. Heckel” November-12, 2013 (patent no: - US 8,579,065 B2),
- [2] Hydrostatic drive and steering system for an articulated vehicle“Kaj Carlson”, Sep-11, 1984 patent no: - 4,470,475
- [3] Design and understanding of 4-wheel steering mechanism “Md. Danish Akhtar”,2013
- [4] Four wheel steering mechanism “AbhinavTikley, MayurKhanghan”, Volume-1.
- [5] Synchronizing system for hydraulic four wheel steering“Travis S. Mergener”,Feb-18, 2014patent no:-US 8,651,223 B2
- [6] Design and Simulation of four Wheel Steering System “SaketBhishikar, VatsalGudhka, Neel Dalal, Paarth Mehta, Sunil Bhil, A.C. Mehta”. Volume 3, Issue 12, June 2014
- [7] 4 Wheel Active Steer (4WAS) www.nissan-global.com/EN/2006-02
- [8] Zero Turn Vehicle“Bansode S. P., Gaikwad A. A., Salgude P. S., Tiwari T. D. , Prof. Avhad N.V. , Prof. Bhane A.B.” Volume 5, Issue 3, March 2015