

A Review Paper on Hydraulically Actuated Four Wheel Steering System

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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 wheel steer etc.

Keywords: Four wheel steering, all wheel steer, hydraulically, different modes, zero turn, crab steer, sharp turn

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.

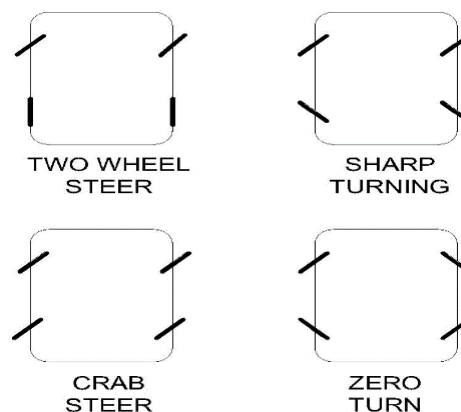


Figure1. Different modes of steering

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 steer 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 steer to vehicle i.e. two wheeler steer, four wheel steer, crab steer, Zero turn. So for zero turn, control system uses hydraulic system in order to reduce the effort carried out by driver. So driver input maneuver 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 participates 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-comer 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 steer 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-WheelSteeringvehicles. The radius of turn 'R' is normal to the vehicle's velocity vector 'v' at the mass centre 'C'

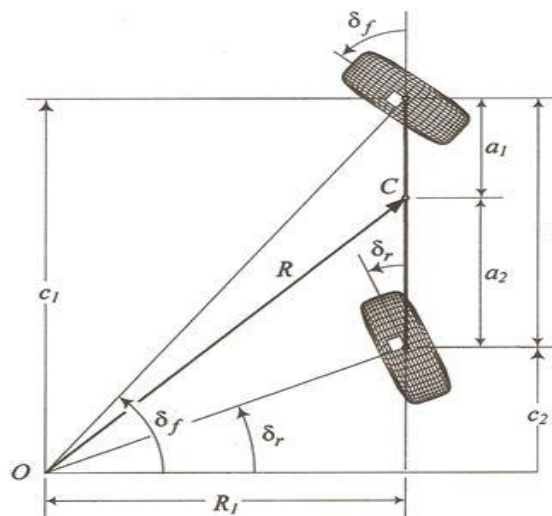


Figure 2. Design of 4-wheel steering mechanism^[3]

AbhinavTikley, MayurKhangana^[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 road 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.

SaketBhishikar, VatsalGudhka, Neel Dalal, Parth 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:

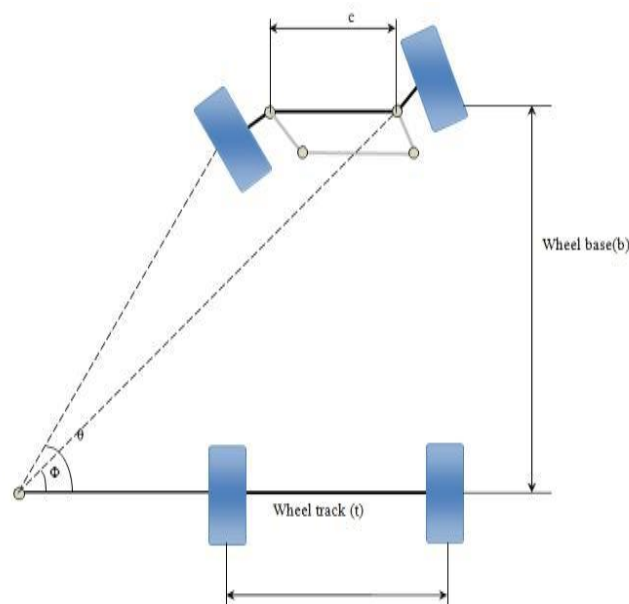


Figure 3. True Rolling Condition^[6]

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.



Figure 4. Slow Speed^[6]

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.



Figure 5. High Speed ^[6]

In-Phase and Counter/Opposite-Phase Steering

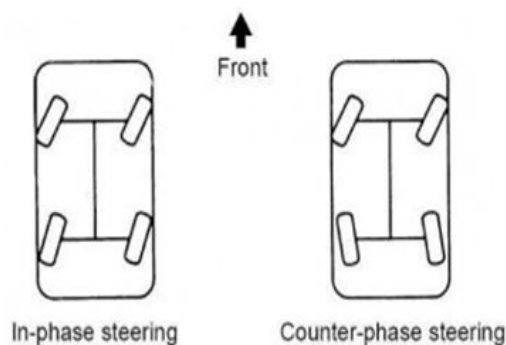


Figure 6. In-Phase and Opposite-Phase Steering ^[6]

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

Steering angle sensor measures the angle of the wheel

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.

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 we concluded that

- The four wheel hydraulic steering mechanism vehicle can turn 360° 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.

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