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Development of four wheel steering system

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1.INTRODUCTION TO STEERING SYSTEM

Steering is the term applied to the collection of components, linkages, etc. which will allow a vessel (ship, boat) or vehicle (car, motorcycle, and bicycle) to follow the desired course. An exception is the case of rail transport by which rail tracks combined together with railroad switches provide the steering function. The most conventional steering arrangement is to turn the front wheels using a hand–operated steering wheel which is positioned in front of the driver, via the steering column, which may contain universal joints, to allow it to deviate somewhat from a straight line. Other arrangements are sometimes found on different types of vehicles, for example, a tiller or rear–wheel steering. Tracked vehicles such as bulldozers and tanks usually employ differential steering that is, the tracks are made to move at different speeds or even in opposite directions, using clutches and brakes, to bring about a change of course or direction.

Four-wheel steering mechanism has been developing in automobile industry for the effective turning of the vehicle. In four-wheel steering system the rear wheel turn with the front wheel thus increasing efficiency of the vehicle. The direction of steering of rear wheels relative to the front wheels depends on the operating condition. At the low-speed wheel moment is pronounced, so that rear wheels are steered in the opposite direction to that of front wheels. At high speed, the front wheels and rear wheels are turn in the same direction. By changing the direction of 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 and overcome parking problems of the vehicle which is effective in confined space, In this project four wheel steering will be adopted for the existing vehicle and turning radius will reduced without changing the dimension of the vehicle.

1.1Functions of the steering system

The various functions of the steering wheel are:

1. To control the angular motion the wheels and thus the direction of motion of the vehicle.
2. To provide directional stability of the vehicle while going straight ahead
3. To facilitate 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 with the road feel for the driver so that he can feel the road condition without experiencing the effects of moving over it
5. To minimize tire wear and increase the life of the tires

1.2 Types of steering

Depending on the number and position of the wheels being steered, steering systems can be classified as follows:

1.2.1 Front wheel steering

The most commonly used type of steering, only the two front wheels of the vehicle are used to steer 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. A typical front wheel steering mechanism layout is given in Fig. 1.1

1.2.2 Rear wheel steering

Some types of industry battery trucks and 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

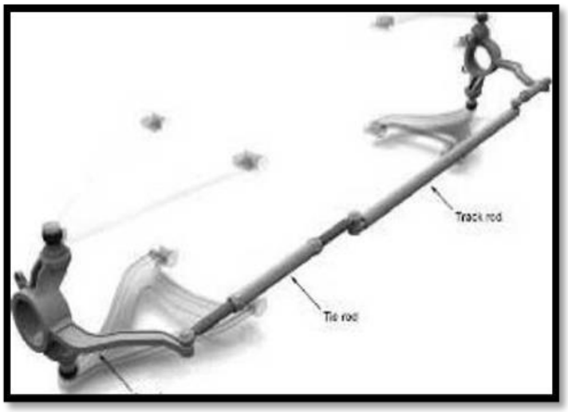

Fig 1.1 - Conventional Front Wheel Steering System

Rack and pinion, recirculating ball, worm and sector

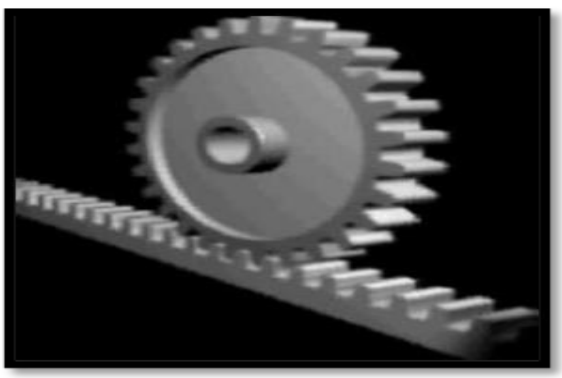

Fig 1.2 Rack and Pinion

Rack and pinion

Rack and pinion unit mounted in the cockpit of an Ariel Atom sports car chassis. For most high-volume production, this is usually mounted on the other side of this panel. Many modern cars use rack and pinion steering mechanisms, where the steering wheel turns the pinion gear; the pinion moves the rack, which is a linear gear that meshes with the pinion, converting circular motion into linear motion along the transverse axis of the car (side to side motion). This motion applies steering torque to the swivel pin ball joints that replaced previously used kingpins of the stub axle of the steered wheels via tie rods and a short lever arm called the steering arm.

The rack and pinion design has the advantages of a large degree of feedback and direct steering "feel". A disadvantage is that it is not adjustable, so that when it does wear and develop lash, the only cure is replacement.

Older designs often use the recirculating ball mechanism, which is still found on trucks and utility vehicles. This 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. The recirculating ball version of this apparatus reduces the considerable friction by placing large ball bearings between the teeth of the worm and those of the screw; 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".

The recirculating ball mechanism has the advantage of a much greater mechanical advantage, so that it was found on larger, heavier vehicles while the rack and pinion was originally limited to smaller and lighter ones; due to the almost universal adoption of power steering, however, this is no longer an important advantage, leading to the increasing use of rack and pinion on newer cars. The recirculating ball design also has a perceptible lash, or "dead spot" on center, where a minute turn of the steering wheel in either direction does not move the steering apparatus; this is easily adjustable via a screw on the end of the steering box to account for wear, but it cannot be entirely eliminated because it will create excessive internal forces at other positions and the mechanism will wear very rapidly. This design is still in use in trucks and other large vehicles, where rapidity of steering and direct feel are less important than robustness, maintainability, and mechanical advantage. The much smaller degree of feedback with this design can also sometimes be an advantage; drivers of vehicles with rack and pinion steering can have their thumbs broken when a front wheel hits a bump, causing the steering wheel to kick to one side suddenly (leading to driving instructors telling students to keep their thumbs on the front of the steering wheel, rather than wrapping around the inside of the rim). This effect is even stronger with a heavy vehicle like a truck; recirculating ball steering prevents this degree of feedback, just as it prevents desirable feedback under normal circumstances.

The steering linkage connecting the steering box and the wheels usually conforms to a variation of Ackermann steering geometry, to account for the fact that in a turn, the inner wheel is actually travelling a path of smaller radius than the outer wheel, so that the degree of toe suitable for driving in a straight path is not suitable for turns.

The worm and sector were an older design, used for example in Willys and Chrysler vehicles, and the Ford Falcon. Other systems for steering exist but are uncommon on road vehicles. Children's toys and go karts often use a very direct linkage in the form of a bell crank (also commonly known as a Pitman arm) attached directly between the steering column and the steering arms, and the use of cable-operated steering linkages (e.g. the Capstan and Bowstring mechanism) is also found

1.2.3 POWER STEERING

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 tire width and diameter, the effort needed to turn the steering wheel manually has increased - often to the point where major physical exertion is required. To alleviate this, auto makers have developed power steering systems: or more correctly power assisted steering - on road going vehicles there has to be a mechanical linkage as a failsafe. There are two types of power steering systems—hydraulic and electric/electronic. A hydraulic-electric hybrid system is also possible.

A hydraulic power steering (HPS) uses hydraulic pressure supplied by an engine-driven pump to assist the motion of turning the steering wheel. Electric power steering (EPS) is more efficient than the hydraulic power steering, since the electric power steering motor only needs to provide assistance when the steering wheel is turned, whereas the hydraulic pump must run constantly. In EPS the assist level is easily tunable to the vehicle type, road speed, and even driver preference. An added benefit is the elimination of environmental hazard posed by leakage and disposal of hydraulic power steering fluid.

2.LITERATURE REVIEW

1.M. Kshristamto [1] has discussed in this paper that the four-wheel steering system, there is a condition when the front wheel turn left or right a condition in which the right and left wheel forming some angle or both wheels to form a different angle from the corner of wheel only. This condition called as parallel condition, Ackerman and reveres condition.

$$\cot\delta_o - \cot\delta_i = \frac{w}{l}$$

2. Mr.Swapnil A. [2] has discussed in this paper that the, A model for steering system is created to test all the possible cases available in this steering system. Four-wheel steering system is critical, and it is also popular in large farm vehicles and trucks. Some of the modern steering found it most widespread use in monster trucks, intercity buses also utilize four wheels steering to improve road stability.

3. Dr.Dinesh.N.Kamble [3] has discussed in this paper that the, 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.

4. Dr. N. K. Giri,[4] has discussed in this paper that the basic steering calculations like basic formula for true rolling condition, formula for finding out turning radius of each wheel, etc. Are done by referring this book.

3.FOUR WHEEL 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 this four-wheel steering model

3.1 SLOW SPEED - REAR STEER MODE

At slow speeds, the rear wheels turn in the direction opposite to the front wheels. This mode comes in particularly useful in case of pickup 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. It is described as following in Fig. 3.1

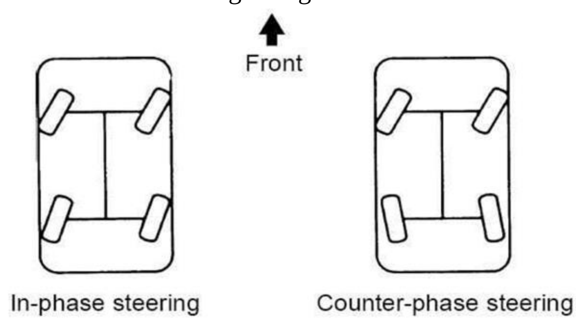

Fig 3.1 – Phase of steering

3.2 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 80 kmph, the rear wheels are turned in the same direction of front wheels in four-wheel steering systems. This is shown in Fig. 3.2.

Fig 3.2 - Crab Mode

For a typical vehicle, the vehicle speed determining the change of phase has been found to be 80 km/hr. The steering ratio, however, can be changed depending on the effectiveness of the rear steering mechanism, and can be as high as 1:1.

4 DESIGN OF FOUR WHEEL STEERING SYSTEM

4.1 Ackerman steering mechanism

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, Shown in

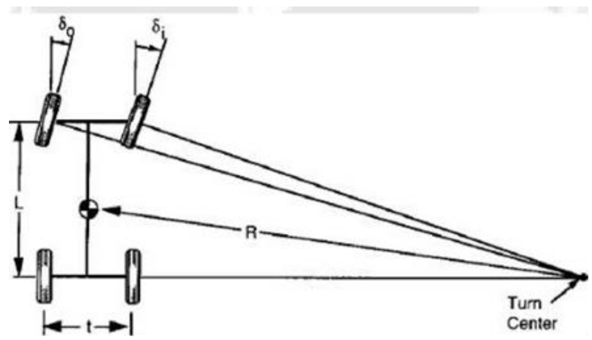

Fig 4.1 - Variation in steer angles for left and right wheels

4.1 Ackerman steering mechanism

Fig4.1 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. But this may be difficult to arrange in practice with simple linkages, and designers draw or analyze their steering systems over the full range of steering angles. 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 maneuvers, and the right and left wheels do not turn by the same angle, be it any cornering speed.

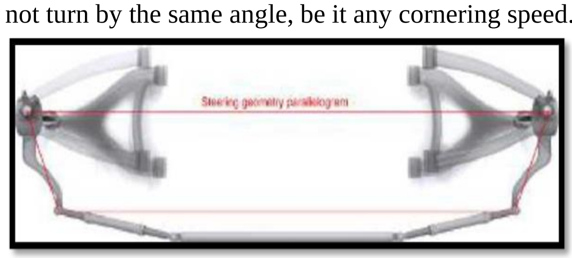

Fig 4.2 - Ackerman steering geometry

This presents a difficult problem for vehicles with independent steering, as the wheels cannot be easily given the correct Ackerman turning angles. This would directly affect the dynamic handling of the car, making it impossible to control properly. With all the four wheels steered, the problem gets compounded, since the appropriate steering angles for all four wheels need to be calculated. It is to be noted that the variation in steering angles as a result of Ackerman geometry is progressive and not fixed; hence they have to be pre-calculated and stored by the controller. This dictates that the control of four-wheel steering systems be very precise, and consequently, complex. This is another reason why manufacturers have not preferred the use of such systems in their vehicles, even with recent advances in technology. The cost of such systems can be high, and a good amount of research & development is required upfront. Nevertheless, the benefits that engineers can reap out of this technology are significant enough to work around these obstacles. 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.

4.2 CONDITION FOR TRUE ROLLING MOTION

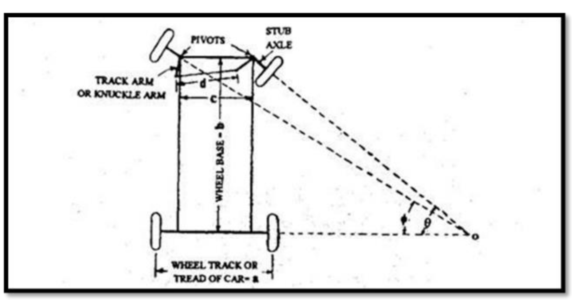

Fig 4.3 - Fundamental condition for true rolling motion

As observed from Fig.4.3, perfect steering of the wheels can be achieved only when all four wheels are rolling perfectly for all dynamic conditions. While taking 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 centre, and when the following equation is satisfied:

$$(Cot\emptyset) - (Cot\theta) = \frac{c}{d}$$

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.

4.3 Benefits of four-wheel steering

- 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.

4.4 High-speed straight-line operation

Even when travelling in a straight line at high speed, a vehicle's driver frequently needs to make small steering corrections to maintain his/her desired course. With the Honda 4WS/E-4WS system, in-phase steering of the rear wheels minimizes these corrective steering inputs.

4.5 Side wind sand other disturbance

When a vehicle is subjected to side winds, bumpy road surfaces, or other external disturbances, the driver needs to make steering corrections to maintain his/her desired course. The Honda 4WS/E-4WS system enables the driver to make these corrective steering inputs without causing significant changes in the vehicle's body attitude.

4.6 Gentle curves

On gentle curves; in-phase steering of the rear wheels improves the vehicle's stability.

4.7 Parking

During a parking maneuver, a vehicle's driver typically turns the steering wheel through a large angle to achieve a small turning radius. By performing counter-phase steering of the rear wheels, the Honda 4WS/E-4WS system realizes a smaller turning

Radius than is possible with a two-wheel steering (2WS) system. As a result, the vehicle is easier to maneuver into garages and other parking spaces.

4.8 Junctions

On a crossroads or other junction where roads intersect at 90 degrees or tighter angles, counter-phase steering of the rear wheels causes the front and rear wheels to follow more-or-less the same path. As a result, the vehicle can be turned more tightly as it negotiates the junction. With a 2WS system, the vehicle would need to follow a relatively curved path.

4.9 Narrow road

On narrow roads with tight bends, counter-phase steering of the rear wheels minimizes the vehicle's turning radius, thereby reducing side-to-side rotation of the steering wheel and making the vehicle easier to maneuver.

4.10U-Turns

By minimizing the vehicle's turning radius, counter-phase steering of the rear wheels enables U-turns to be performed easily on narrow roads.

5 CONTRUCTION AND WORKING

5.1 Construction

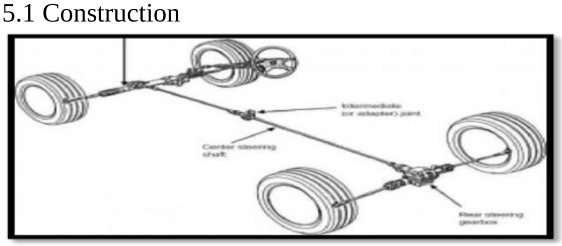

Fig.5.1 -Construction of four wheel steering

The main components of four-wheel steering system are the front steering gearbox, which turns the front wheels, the rear steering gearbox, which turns the rear wheels, and the center steering shaft, which links the two gearboxes. When the steering wheel is turned, the front wheels are steered in the same way as with a 2WS system. A rack-and-pinion mechanism in the front steering gearbox transmits this movement to the rear steering gearbox via the center shaft. (The rack-and-pinion mechanism is separate from the one to which the steering wheel is connected.) Via the rear tie rods, the rear steering gearbox steers the rear wheels by the appropriate angle and in the appropriate direction.

Steering of rear wheels

- When the steering wheel is turned from its straight-ahead position by an angle of 120 degree or smaller, the four-wheel steering system performs to increase in-phase steering of the rear wheels angle.
- When the steering wheel angle exceeds 120 degree, the rear wheels gradually straighten up then turn in the opposite direction.

5.2 Working principle

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 the preferred choice due to complexity of conventional mechanical four wheel steering system, 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, usually in vehicles during turning, the tires are subject to the forces of grip, momentum, and steering.

When making a movement other than straight ahead driving. These forces compete with each other during steering maneuvers. With a front-steered vehicle, the rear end is always trying to catch up to the directional changes of the front wheels. This causes the vehicle to sway. When turning, the driver is putting into motion a complex series of forces. Each of these must be balanced against the others. The tires are subjected to road grip and slip angle. Grip holds the car's wheels to the road, and momentum moves the car straight ahead. Steering input causes the front wheels to turn.

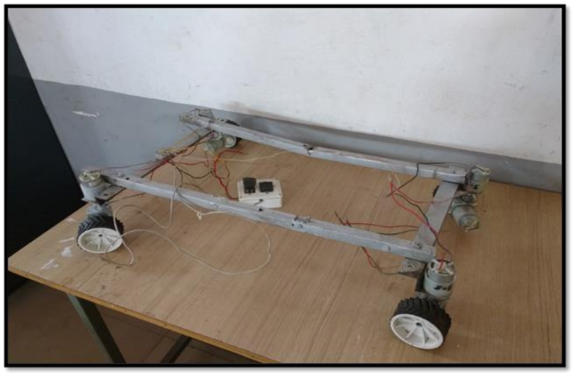

Fig.5.2 - Four-wheel steering

ADVANTAGES
1. It reduces the turning radius.
2. Such simple that an unskilled driver.
3. Very useful in heavy traffic of metro cities.
4. Parking of car in a less space is makes very simple.

DISADVANTAGES
1. Initial cost is high.
2. It increases the crabbing effect while driving.
3. It cannot be applied without power steering.

6.RECENT APPLICATION

In an active four-wheel steering system, all four wheels turn at the same time when the dsteers. Three controls to switch off the rear steer and options to steer only the rear wheel independent of the front wheels. At slow speeds (e.g. parking) the rear wheels turn opposite of the front wheels, reducing the turning radius by up to twenty-five percent, while at higher speeds both front and rear wheels turn alike (electronically controlled), so that the vehicle may change position with less yaw, enhancing straight-line stability. The "Snaking effect" experienced during motorway drives while towing a trailer is nullified. Four-wheel steering found its most widespread use in monster, where maneuverability in small arenas is critical, and it is also popular in large farm vehicles and trucks. Some of the modern European Intercity buses also utilize four-wheel steering to assist maneuverability in bus terminals, and also to improve road stability.

General Motors offers Delphi's Quadra steer in their consumer Silverado/Sierra and Suburban/Yukon. However, only 16,500 vehicles have been sold with this system since its introduction in 2002 through 2004. Due to this low demand, GM will not offer the technology on the 2007 update to these vehicles.

Previously, Honda had four-wheel steering as an option in their 1987-2000 Prelude, and Mazda also offered four-wheel steering on the 626 and MX6 in 1988.

A new "Active Drive" system is introduced on the 2008 version of the Renault Laguna line. It was designed as one of several measures to increase security and stability. The Active Drive should lower the effects of under steer and decrease the chances of spinning by diverting part of the G-forces generated in a turn from the front to the rear tires. At low speeds the turning circle can be tightened so parking and maneuvering is easier.

7.REQUIREMENT FOR REAL-TIME IMPLEMENTATION

Since our application was carried out on a scale model, there were bound to be a number of modifications as the project scales up to its true size. Following are some the requirements/modifications needed in a car to use four wheels steering with 360 mode:

- Replacing the rack and pinion steering mechanism up front with a fully electronic servo-motor controlled steering front and rear, since both the right and left wheels face in opposing directions. If it is possible to get opposing steer angles with a rack and pinion system, it may be used for the front wheels
- Increasing the suspension travel on all four struts. Since the wheels turn by close to 50 degrees for 360 modes, it is imperative that an extra load acts on the suspension. Hence, the suspension travel has to be increased by close to 25%
- In case of four-wheel drive vehicles, all four wheels must have constant velocity joints to handle both traction and steering purposes
- An advanced steering controller circuit with steering angle sensor must be installed to continuously monitor the vehicle's dynamic condition and adjust the steering angles

accordingly. The 360 mode can be activated/deactivated at the press of a button, and the ECU must handle the other two modes depending on vehicle speed

- Manual override should be provided to use conventional two-wheel steering when demanded by the driver. This would be useful for experienced drivers who may not need the assistance of 4WS for most of their daily run
- The four-wheel steering system has to implemented in the vehicle right from the design stage, as it cannot be retrofitted in existing vehicles. Space constraints and lack of electronic processing capability and power supply might act as deterrents here
- A mechanism should be provided to reverse the drive on any one side (right/left) wheel, to achieve 360 mode
- To provide for the power requirement of high torque steering servos, the battery will have to be updated with a higher voltage and ampere-hour rating
- The current traffic scenario demands a revolution, rather than an evolution, and the zero turning circle four-wheel steering system can prove to be a panacea for the people. With its tight parking circles and improved high-speed handling, it is well worth the extra effort required in design and any extra cost that might have to be paid by the end consumer. A precise control strategy and dynamic handling solutions are the only roadblocks that prevent this system from reaching the people. But time and technology will soon help it get past these hurdles.

8. MANUFACTURING PRODUCT

Name of the Part : SQUARE RODS
Quantity : 4
Material : MILD STEEL
Overall Sizes : Length= 750 (mm.)
Side=1/2 * 1/2 (INCHES.)

NO.	Operation	Feed	Tool	Time in Min.
1.	Cutting the mild steel according to designed shape	Manual	Hack saw blade	30
2.	Drill 1 component having 3.5 mm. Dia.	Manual	Drill, Boring	30
3.	Applying the coating on the rod	Manual	....	15
4.	File of length of 60 mm. Rod. Mark of the centre.	Manual	File, Punch	20

Table 8.1 Manufacturing product

9. CALCULATION

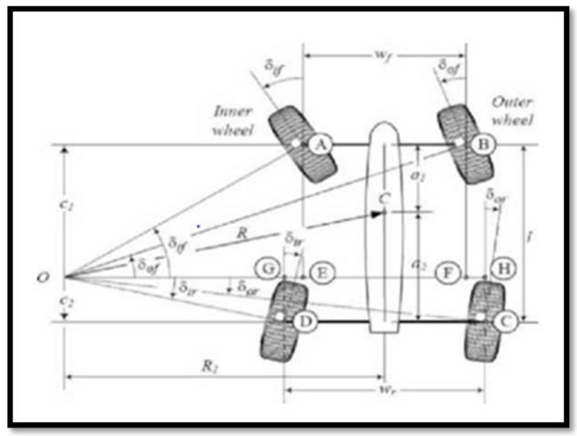

Fig.9.1 -Steering geometry

Calculations:

ALTO 800

The data of vehicle considered are,

Wheelbase: - (L) =2360 mm

Wheel track: - (Wf) =1300 mm(approx.)

Turning radius: -4.6 m= 4600 mm

Four-wheel steering system

Calculation for steering angles for the turning radius of 4.6 m.

We know that

$R^2 = a_2^2 + R_1^2$ ---------------- (1)

To find a_2,

$W = (W * a_2)/L$------------ (2)

$a_2 = 1416mm$

∴From equation (1),

$R_1 = 4376.6361mm$

To find steering angles,

From experiment we found the angle of tyre,

∂_{if} = 25.6°

$\tan\partial_{if}$=C1/(R1-(Wf/2)) ------(3)

∴tan 25.6 = C1/(4376.6361- (1300/2))

$C_1 = 1785.50\ mm$And

$C_1 + C_2 = L$------(4)

$C_2 = L - C_1$

$C_2 = 574.5mm$

To find ∂_{of}

$tan\partial_{of} = C_1/(R_1 + (Wf))$------(5)

∂_{of}= 19.6°

To find ∂_{ir}

$tan\partial_{ir} = C_2/(R_1 - (\frac{Wr}{2}))$------(6)

∂_{ir}=8.7637°

To find ∂or

$\tan\partial_{or}$=$C_2/(R_1 + \left(\frac{Wf}{2}\right))$ ------(7)

∂_{or} = 6.5201°

Now, considering the same steering angle for front and rear wheel, we reduce in turning radius of the vehicle but keeping the wheelbase and track width same as reference vehicle.

Now, $\partial_{if} = \partial_{ir}$=25.6° and

$\partial_{of} = \partial_{or}$ =19.56°

∴$\partial_i = \partial_{if} + \partial_{ir}$ = 25.6°+25.6° =51.2°

$\partial_o = \partial_{of} + \partial_{or}$ = 19.56°+19.56° = 39.12°

∴To find cot ∂,

cot ∂ = $(\frac{cot\partial_i + cot\partial_o}{2})$ ------(8)

cot ∂ = $\frac{cot51.2 + cot39.12}{2}$

∴cot ∂ = 1.01682

To find turning radius R,

$R_2 = a_2^2 + L^2 cot^2\partial$------ (9)

R = 2786.32 mm

R= 2.78m

Now same step is to find the C1 and C2,

∴From equation (1),

$R^2 = a^2 + R_1^2$

∴$R_1^2 = R^2 - a^2$

$R_1 = 2.4m$

∴From equation (3),

tan ∂if = $\{\frac{C_1}{2.4} - \left(\frac{1.3}{2}\right)\}$

∴$C_1 = 0.8385m$

$C_1 = 838.5mm$

and, $C_1 + C_2 = L$

∴$C_2 = L - C_1$

∴C_2 = 2360-838.5

$C_2 = 1521.5mm$

10

9.COST ANALYSIS

Sr.No.	Description	QTY.	Amount
1	Square Bar	2m	380
2	Battery	1 Nos	1250
3	Electronic motors	6 Nos	2520
4	Nut & Bolt	16 Nos	45
5	Circuit panel	1 Nos	25
6	Wire	4m	480
7	Clips	6 Nos	190
8	Arm	4 Nos	45
9	Wheel	4Nos	580

Table 10.1 Cost analysis

COST ESTIMATION

Total cost of project = Std. Material Cost + Raw Material Cost + Machining Cost + Assembly Cost + Other Cost.

Std. Material Cost:

Std. Material Cost = Electric motor + Battery + wire +wheel.

= 2520 + 1250 + 480 + 580

= 4830 /-

Raw Material Cost:

Raw Material Cost = L Angle +Square bar + Arm

= 110 + 270 + 45

= 425 /-

Machining Cost:

Machining Cost =Cutting + Welding + Grading + Drilling

= (90 X 8) + (110 X 4) + (80 X 4) + (110 X0.3)

= 720 + 440 + 320 + 33

= 1513 /-

Other Cost:

Other Cost = 1400/-

Total cost:

Total cost = Std. Material Cost + Raw Material Cost + Machining Cost +Other Cost.

= 4830 + 425+ 1513 + 1400

= 8168 /-

11 FUTURE SCOPE

Thus, the four-wheel steering system has got cornering capability, steering response, straight-line stability. Even though it is advantageous over the conventional two-wheel steering system, 3MI 4WS is complex and expensive. Currently the cost of a vehicle with 3MI

4WS is more than that for a vehicle with the conventional two-wheel steering. On large scale industrial production, we can reduce the cost of this system.

The rapid increasing in number of vehicles on road day by day, demands an exploration of such mechanism to reduce driver's effort and get rid of from the huge traffic. If an electronic and hydraulic assistance is given to 3MI 4WS system, it will reduce the complexity and helps in better handling.

Introduction of sensors and hydraulic actuators instead of the pure mechanical system used in the project will make the vehicle more stable and efficient. Also, the introduction of 900 turn to the front and rear wheels helps the vehicle to move in a horizontal direction will make the marking easier, by this method vehicle can be moved easily from the parking easily. All the modes i.e. reducing radius mode, sliding mode, normal mode and the 90 0 turning of the vehicle can be more accurate and efficient with the help of hydraulic/pneumatic actuators and sensors. The above-mentioned modes will help to control the vehicle more easily in every situation.

12. RESULT

Our 4 Wheel Steering System gives 39.56% reduction in turning circle radius of a hatchback which is reduced from 4.6 m to 2.78 m, considering Maruti Suzuki ALTO 800 as a standard car for our calculations which gives much better maneuverability and control on the car even while driving at high speeds.

Turning Radius	Four Wheel Steering	Two Wheel Steering
By Calculation	2.78m	4.6m

Table 3: Comparison between 4WS and 2WS

13 CONCLUSION

Four-wheel steering is a complex and expensive. Currently, the cost of a vehicle with four-wheel steering is more than that of the conventional two wheels 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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