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Active Four Wheel Steering

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Abstract: *Nowadays most of the vehicles use the two wheel steering mechanism as their main handling system. But the efficiency of the two wheel steering vehicle is proven to be low compared to the four wheel steering vehicles. Four wheel steering system can be employed in some vehicles to improve steering response, increase vehicle stability while moving at certain speed, or to decrease turning radius at low speed. It has two modes as 2 Wheel Steering and 4 Wheel Steering. All wheel steering is used for parking and low-speed maneuvers but in this type of steering system the vehicle can be steered on both, two wheels & four wheels. The "Active 4 wheel Steering" is the modified form of AWS (All Wheel Steering). In this, the engagement and disengagement of the four wheels steering can be done as per the driver ease. This provides the benefits of both two wheel and four wheel steer. Thus, can be used as front wheel steer in long straight runs and can be used as all wheel steer when sharp and close turns are needed.*

Keywords: *vehicle, efficiency, two wheel steering & four wheel steering.*

1. Introduction

1.1. Steering

Steering is the term applied to the collection of components, linkages, etc. which will allow the vehicle to follow the desired course. Steering system is the mechanism in a vehicle which makes it possible to steer it in different directions. The steering system consists of the following components:

a. Steering wheel handle the steering operation
b. Steering column joins the steering wheel and the steering gears.
c. Steering gears convert the steering torque and rotational deflection from the steering wheel.
d. Transmit them to the wheel through the steering linkage, and make the vehicle turn.
e. Steering linkage a steering linkage is a combination of the rods and arms that transmit the movement of the steering gear to the left and right front wheels.

1.1.1. Functions of steering system

a. To provide directional stability of vehicle
b. To facilitate straight ahead recovery
c. To minimize tire wear
d. To absorb major parts of the road shocks
e. To provide perfect rolling motions of the road wheels.

1.1.2. Working of steering

The basic aim of steering is to ensure that the wheels are pointing in the desired directions. This is typically achieved by a series of linkages, rods, pivots and gears. One of the fundamental concepts is that of caster angle. Each wheel is steered with a pivot point ahead of the wheel; this makes the steering tend to be self-centering towards the direction of travel.

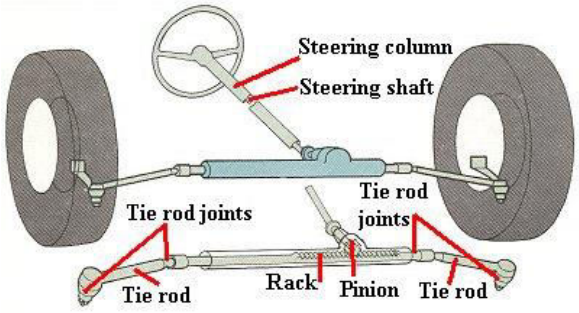

Figure 1. Rack and pinion steering

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.

1.1.3. Requirements of steering system

The steering system has the following requirements:

1. The steering system must be able to turn the front wheels sharply yet easily and smoothly.
2. The steering should be made lighter at low speeds and heavier at high speeds.
3. Smooth recovery while the vehicle is turning.
4. Minimum transmission of shock from road surface.

1.2. Steering principle

According to Ackerman steering system, is a geometric arrangement of linkages in the steering of a vehicle designed to solve the problem of wheels on the inside and outside of a turn needing to trace out circles of different radius**.** The intention of Ackermann geometry is to avoid the need for tires of slip sideways when following the path around a curve.

1.2.1. Ackermann Steering Mechanism

With perfect Ackermann, at any angle of steering, the center 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.

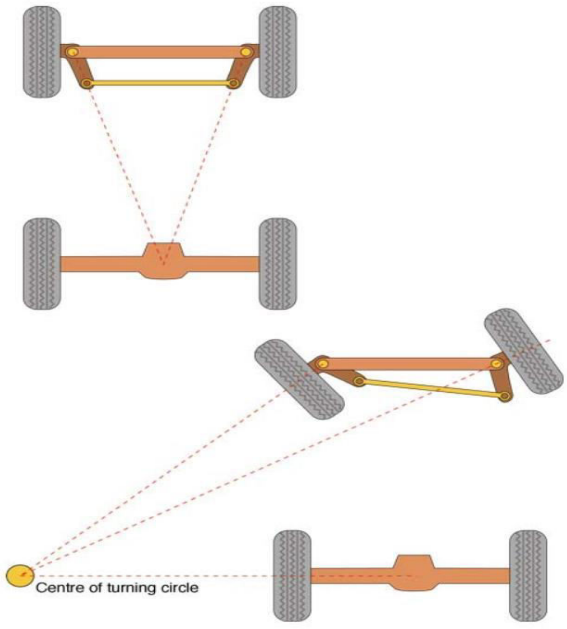

Figure 2. Ackerman steering mechanism

Ackermann steering geometry is a geometric arrangement of linkages in the steering of a car or other vehicle designed to solve the problem of wheels on the inside and outside of a turn needing to trace out circles of different radii. With perfect Ackermann, at any angle of steering, the center point of all of the circles traced by all wheels will lie at a common point.

1.3. Four wheel steering

Four-wheel steering, 4WS, also called rear-wheel steering or all-wheel steering, provides a means to actively steer the rear wheels during turning maneuvers. A system that uses all four wheels to steer the car. The steering angle is usually limited to 2° or 3°. Turning the rear wheels in the opposite direction to the front at slow speeds can allow faster maneuvering and a much tighter turning radius.
Turning the rear wheels in the same direction as those at the front at high speed allows sudden lane changes with much greater stability. Turning the rear wheels in the same direction as the front when parking makes parallel parking much easier.
Four wheel steering is a relatively new technology that improves maneuverability in cars, trucks and trailers.

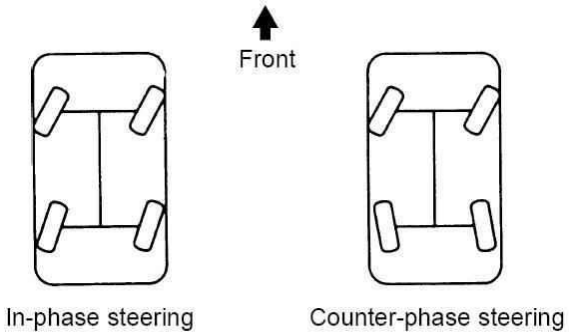

Figure 3. Four wheel steering

It should not be confused with four wheels drive in which all four wheels of a vehicle are powered. In four wheel steering systems, the rear wheels can turn left and right. To keep the driving controls as simple as possible, a computer is used to control the rear wheels.

1.3.1. Purpose of four wheel steering

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. Once the vehicle begins to respond to the steering input, cornering forces are generated. The vehicle sways as the rear wheels attempt to keep up with the cornering forces already generated by the front tires.

1.3.2. Types of four wheel steering

There are three types of production of four-wheel steering systems:

a. Mechanical 4WS

b. Hydraulic 4WS
c. Electro-hydraulic 4WS

1.3.3. Modes used in four wheel steering

Two modes are generally used in four wheel steering which are as follows:

1) Slow Speeds - Rear Steer Mode:
At slow speeds, the rear wheels turn in the direction opposite to the front wheels. 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.

2) High Speeds – Crab Mode:
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.

1.4. Turning radius

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

Turning circle radius= {track/2} + {wheelbase/sin (average steer angle)}

The turning radius of four wheel steering is approximately 30% to 40% less than two wheel steering.

2. Purpose of work

Nowadays all vehicles uses two wheel steering system, but the efficiency of the two wheel steering (2WS) vehicle is proven that it is still low compared to the four wheel steering (4WS) system car. So, is based on how to prove that the 4WS is better than radius will be decreased for the same vehicle of higher wheelbase. In this project a benchmark vehicle is considered and four wheel steering is implemented without change in dimension of the vehicle and reduction in turning radius 2WS in terms of turning radius.
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In two wheel steering vehicle it is quite difficult to negotiate a sharp turn and this drawback of two wheel steer is overcome by four wheel steering. But in four wheel-steering sometimes stability becomes a problem so to overcome this, convertible four wheel steering can be used so both stability and sharp turning problems can be solved.

3. Concept

The "Active 4 wheel Steering" is the modified form of AWS (All Wheel Steering). In this, the engagement and disengagement of the four wheels steering can be done as per the driver ease. This provides the benefits of both two wheel and four wheel steer. Thus, can be used as front wheel steer in long straight runs and can be used as all wheel steer when sharp and close turns are needed.
In "Active 4 wheel Steering" with two modes of operation can be changed as needed which assists by driver in parking at heavy traffic conditions, when Negotiating areas where short turning radius is needed and in off road Driving.
This project concentrates on the advancement in steering system of an automobile with objective to reduce the turning radius considerably up to 30% to 40%, thereby reducing the space required to turn a four wheeler vehicle, the driver's effort and time.
The basic idea was to develop a purely mechanical dual steering assembly that fulfills the objectives and acts as an add-on feature in today's automobiles. The need includes all classes of vehicles namely LMV's, HMV's with focus to improve their maneuverability as well.

3.1. Design of chassis

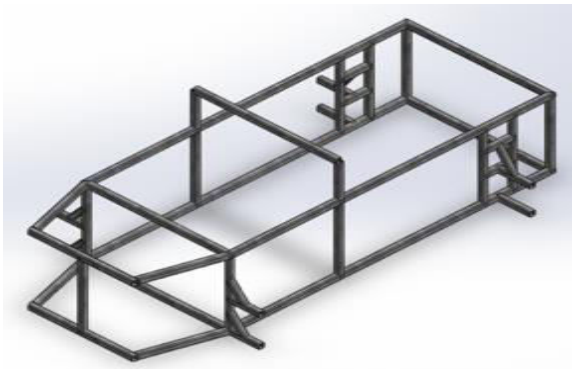

Figure 4. Chassis of project

3.1.1. Analysis of chassis

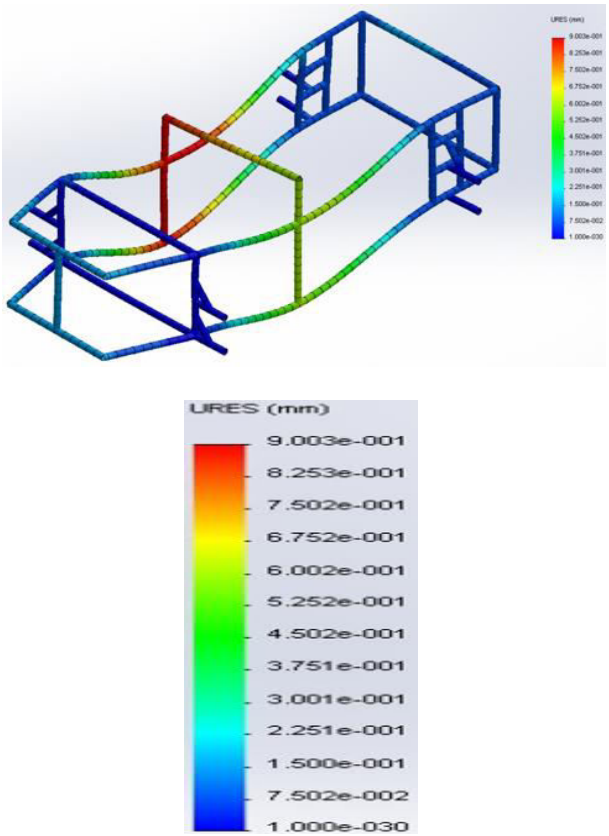

Figure 5. Deformation analysis

3.2. Components

a) 2 Rack and pinion assembly
b) 4 wheels and tires (135/70 R 12)
c) Drive Shaft/Drive Axle
d) Steering wheel column
e) Sleeve type coupling
f) Universal joints
g) Steering knuckle
h) Chain and sprocket

3.3. Construction

A simple design has been made to show the desire mechanism. There was no use of any kind of engine or motor. To give direction to wheels, steering wheel is used which is connected with the front wheels.
A small bevel gear is fixed at the end of pinion shaft of front rack and pinion assembly. Another bigger bevel gear is mounted in such a way that, both the axis of gears would intersect each other in 90 degree. This bigger bevel gear mounted on a hollow shaft which is extended up to rear rack and pinion assembly connected by means of universal coupling. Hence, rotary motion is transferred from front to rear pinion shaft.
On this shaft a Mechanism is fitted at mid which will help to make and break the rotary motion between front and rear to achieve two modes of steering i.e. 2WS and 4WS.
To achieve out phase mode or rear steer mode, we mounted a rear rack and pinion assembly exactly opposite to front rack and pinion assembly. So that, rear wheels can turn in opposite direction to the front wheels.

3.4. Working

Our main objective was to achieve the engagement and disengagement of the four wheels steering as per the driver ease. Our project consists of two modes of operation:
a) Front steer mode
b) Rear steer mode

a) Front steer mode:
In First mode of operation, the steering operation will be carried out in normal condition that is only front wheels steer. At this stage the coupling will be in disengaged condition i.e. sleeve will rotate only with input dog shaft rather than both dog shafts. So no power will transfer to steer rear wheels.

b) Rear Steer Mode:
In second mode of operation, Sleeve of the coupling get engaged with output dog shaft so power will be transfer from input dog shaft to output dog shaft through a sleeve. Because of this steering of rear wheel is ensured and is in opposite direction to that of the front wheels.

4. Advantages and disadvantages

4.1. Advantages

- The vehicle's cornering behavior becomes more stable and controllable at high speeds as well as on wet or slippery road surfaces.
- The vehicle's response to steering input becomes quicker and more precise throughout the vehicle's entire speed range.
- The vehicle's straight-line stability at high speeds is improved.
- Smaller turning radius and tight space manoeuvrability at low speed.
- Stability in lane changing at high speeds is improved.
- Vehicle maneuvering on narrow roads and during parking becomes easier.
- Improved steering responsiveness and precision.
- Controllable on wet or slippery road surfaces.
- Relative wheel angles and their control.

4.2. Disadvantages

- The 4ws, due to construction of many new components, the system becomes more expensive.
- Due to the presence of more number of parts, it becomes more complex in construction.
- It requires high maintenance.

5. Applications

5.1. Two wheel steering

- **Driving at high speed:** While driving at very high speed, we need two wheel steering system. For example in sports car, we use two wheel steering system which helps to reduce toppling of car while taking turn at very high speed.
- **Normal driving:** It means casual driving like driving in city, village etc. At these times, we do not have need of four wheel steering.

5.2. Four wheel steering

- **Parking:** 4ws system realizes a smaller turning radius then is possible with 2ws system. As a result vehicle is turned in small radius at parking.
- **Junctions:** On a cross roads or other junction where roads intersect at 90 degrees or tighter angle with the help of 4ws, we can
- **Slippery road surfaces:** In slippery road surface, we can easily get out as we can steer all four wheels.
- **Narrow roads:** On narrow roads, reducing rotation of the steering wheels make the easier turn of vehicle.
- In Ghaat sections, where we have to steer the vehicle in very less space.
- In U-turns.

6. Conclusion

The implementation of four wheel steering improved the overall performance of vehicle especially in steering and stability. Four wheel steering is a relatively new technology. The rear set of wheels are always directed forward therefore and do not play an active role in controlling the steering in four wheel steering system the rear wheel can turn left and right. The aim of 4WS system is a better stability during overtaking maneuvers, reduction of vehicle oscillation around its vertical axis, reduced sensibility to lateral wind, neutral behavior during cornering.

Even though it is advantageous over the conventional two wheel steering system, 4-Wheel Steering is complex and expensive. It is not economically viable to replace two wheel steering with 4-Wheel Steering in cars where the consumer expects more from the technology for the extra cost, but in heavy truck and towing vehicles it gives more driving advantage over cost. Both 2WS and 4WS have their own advantages and disadvantages. Hence, by use of convertible steering system, we can use any of them according to the situation.

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