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DESIGN AND MANUFACTURING OF RACK AND PINION STEERING SYSTEM

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Abstract: Steering is a basic function that ensures the wheels point in the right direction. This is usually achieved using a series linkages, rods pivots and pivots. One of the most basic concepts is the caster angle. Each wheel is steered with an initial pivot point before the wheel. This allows the steering to be self-centring in the direction of travel. A shaft connected to the steering column turns a wheel when the driving force turns it. The gear mechanism turns tie rods that connect to the front wheels. To turn the vehicle to one side, the tie rods move the front tires. The steering mechanism should provide control over vehicle direction, good maneuverability, and smooth recovery from turns. Because the driver releases the steering lever, the steering mechanism also must transmit minimal road shocks to the pavement. The steering mechanism controls the vehicle's direction, provides good maneuverability, smooth recovery after turns, and transmits minimal road shocks.

Index Terms **- steering mechanism, gear mechanism.**

I. INTRODUCTION

The most conventional steering arrangement is to show the front wheels employing a hand–operated wheel which is positioned ahead of the driving force, via the steering column, which can contain universal joints (which may additionally be a part of the collapsible steering column design), to permit it to deviate somewhat from a line. Other way to arrangements are sometimes found on differing kinds of vehicles, as an example, a tiller, etc. Tracked vehicles such as bulldozers and tanks usually use differential steering — that's, the tracks are made to maneuver tracks in opposite directions, by using clutches and brakes, to evoke a change in fact or direction. The direction of motion of a automobile is controlled by a mechanism. A basic steering mechanism has 3 main parts: A steering box connected to the wheel. The linkage connecting the steering box to the at the front wheels, front suspension parts to let the wheel assemblies pivot. When the driving force turns the handwheel, a shaft from the steering column turns a gear mechanism. The gear mechanism moves tie rods that hook up with the front wheels. The tie rods move the wheels to steer the vehicle right or left. Steering is that the collection of components, linkages, etc. which permit a vessel (ship, boat) or vehicle (car, motorcycle, bicycle) to follow the required course. An exception is that the case of rail transport by which rail tracks combined along with railroad switches (and also called 'points' in British English) provide the steering function. the first purpose of the steering mechanism is to permit the driving force to guide the vehicle.

There are 2 basic kinds of steering boxes - those with rack-and-pinion gearing, and those with worm gearing. In both cases, the gearing within the steering box makes it easier for the motive force to show the handwheel, and hence, the wheels. A rack-and-pinion steering mechanism includes a handwheel, a main-shaft, universal joints, and an intermediate shaft. When the steering is rotated, rotation is transferred by the shafts to the pinion. The pinion is meshed with the teeth of the rack, so pinion rotation moves the rack from left to right or right to left. this sort of steering is used on passenger vehicles because it's light, and direct. This steering mechanism has worm gearing. It provides a gear reduction, and a change in direction. it's more parts and joints than the rack type, but it is more robust, and will be used on heavier vehicles. To allow heavy transport vehicles to hold extra weight, two steering axles could also be used. They’re connected by a link to a standard steering box. These vehicles are called tandem, or twin-steered vehicles. Some modern passenger vehicles also steer the rear wheels slightly. this provides improved maneuverability. The system is thought as 4-wheel steering.

It may be controlled mechanically, through an instantaneous connection, between the front and rear steering boxes. Or it is computer-controlled. With heavier vehicles, increased use of front-wheel-drive, and wider, low-profile tires, more steering effort is required, so power-assisted steering is employed. An engine-driven pump provides pressure that helps the motive force steer the vehicle. the ability steering mechanism is intended so the vehicle can still be controlled, whether or not the engine or the facility steering mechanism, fails.

1.1 About Steering System

The conventional steering system uses a hand-operated steering mechanism to turn the front wheels. This steering column may also use universal joints, which can be used in collapsible steering columns to allow the column to move slightly from a straight line.

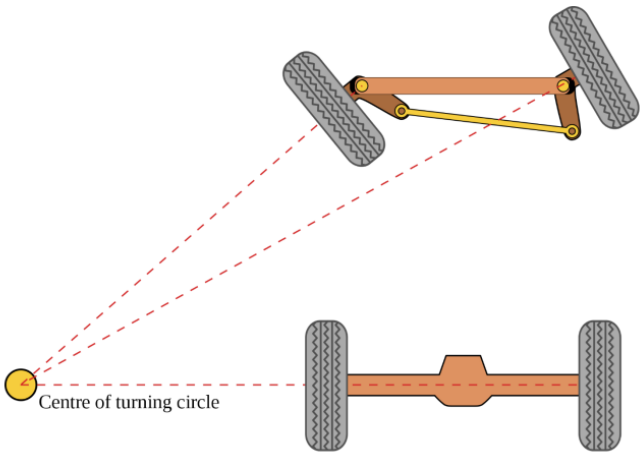
There are 2 basic types of steering boxes

People with rack-and pinion gearing and those with worm gearing. The gearing in the steering box allows the motive force to see the handwheel and thus the wheels more easily. A rack-and pinion steering mechanism has a handwheel and a main-shaft with universal joints. It also includes an intermediate shaft. The shafts transfer rotation to the pinion when the steering wheel is turned. Because the pinion gear is meshed to the teeth of rack gear, pinion rotation causes rack to move from left to right or left to right.

This type of steering is used on passenger cars because it's direct and light. This provides a reduction in gear and a degree of direction change. It has more parts and joints that the rack type but is more durable and should be used with heavier vehicles.

1.2 Basic Wheeled Steering System

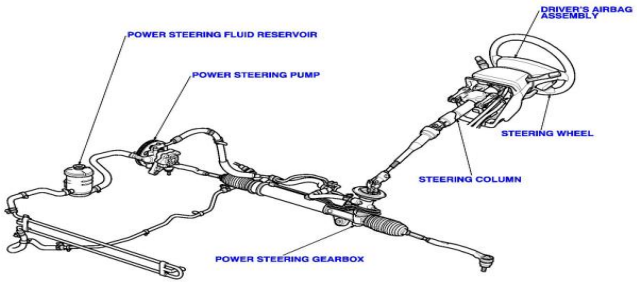
Steering is a process that ensures the wheels point in the right direction. A series of links, rods, pivots, and gears are used to achieve this. The caster angle is one of the most fundamental concepts. Each wheel is steered with an outside pivot point. This allows the steering to be self-centring in the direction of travel. A variation of Ackermann steering geometry is used to connect the steering box to the wheels. This is to account for the fact the inner wheel travels a smaller path than the outer one in turn. The angle of the steering linkages to the steering box and the wheel usually conforms to Ackermann steering geometry. Camber angle, which is also a factor in steering dynamics, affects the angle of the wheels with the vertical plane. Modern cars have rack-and-pinion steering mechanisms. The steering wheel rotates the pinion gear, and the pinion moves rack. This is a linear gear that meshes to the pinion. It converts circular motion into linear motion along its transverse axis (side to side) of the car. This motion applies steering torque the swivel ball joints, which have replaced the previously used kingpins on the stub axle of steered wheels via tierods and a short lever arm known as the steering arm.



Ackermann Steering Mechanism

1.3 Power Steering

The power steering assists the driver by using some of the vehicle's power to help them steer. It enables the wheels to be wowed around their axes by the steering wheel. With heavier vehicles, especially those with negative offset geometry, and increasing tire diameters, the effort required to move the wheels around their steering axis has increased. This is often to the point that power assistance would not be necessary. Power steering systems or power-assisted driving have been developed by automakers to alleviate this problem. Road-going vehicles must have a failsafe mechanical linkage. There are two types: electric/electronic and hydraulic power steering systems. It is also possible to have a hydraulic-electric hybrid system. Hydraulic power steering (HPS), which uses hydraulic pressure from an engine-driven pump to help the motion of turning a steering wheel, is also possible. Electric power steering (EPS), which is less efficient than hydraulic power steering is, is easier to use because the electric power steering motor is only required to turn the wheel, while the hydraulic pump must be running continuously. EPS can be adjusted to suit the vehicle type, speed and driver preference. The environmental hazards of hydraulic power steering fluid leakage and disposal are eliminated. Additionally, electrical assistance does not stop working when the engine fails, or stalls. Hydraulic assistance stops working if it stops. This makes the steering double-heavy as the driver must turn the heavy steering wheel, without any assistance, and the power-assistance system.

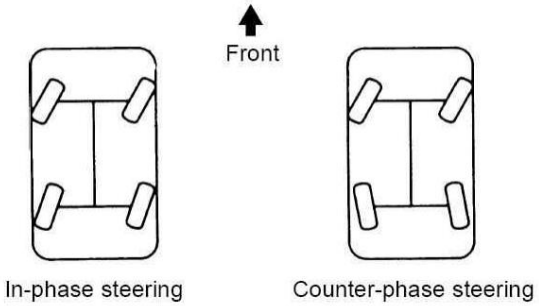


Power steering

Speed sensitive steering is a result of power steering. It is where the steering is heavily assisted at low speeds and lightly assisted at higher speeds. Automakers recognize that drivers might need to make large steering inputs when parking or maneuvering for parking. However, this is not necessary while driving at high speeds. Citroen SM was the first vehicle to have this feature. However, rather than changing the amount of assistance like modern power steering systems do, it changed the pressure on a centring camera which caused the steering wheel to try to "spring back" to its straight-ahead position. Modern speed-sensitive power steering systems allow for a more direct feeling by reducing the amount of mechanical or electrical assistance when the vehicle speeds increase. This feature is becoming more popular.

1.4 Four Wheel Steering

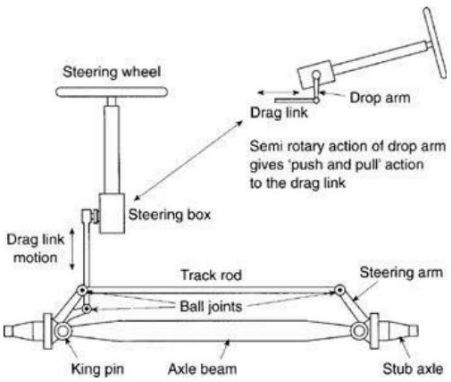
Active four-wheel steering systems have all four wheels turning simultaneously when the driver steers. The rear wheels of most active four-wheel steering system are controlled by actuators and a computer. The rear wheels are generally not able to turn as far as those of the front. You can switch off the rear steer or steer the rear wheels separately from the front wheels using controls. Low speeds (e.g. Low speed (e.g., parking) causes the rear wheels to turn oppositely to the front wheels. This reduces the turning radius by as much as twenty-five percent. At higher speeds, both the front and rear wheels rotate simultaneously (electronically controlled), so the vehicle can change its position with less yaw and improves straight-line stability. This eliminates the "snaking effect" that can be experienced while towing a trailer on motorways.



Four Wheel Steering

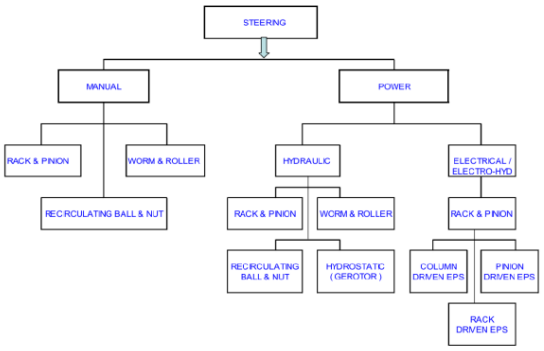
1.5 Principle of Steering System

The steering system should provide vehicle control, good maneuverability and smooth recovery after turning. The steering system controls the vehicle's direction, provides smooth manoeuvrability and recovery after turns. It also transmits minimal road shocks. The steering box converts the rotary motion from the steering wheel to the linear motion required to steer the vehicle. The steering box also provides the driver with a mechanical advantage. The linear motion of the steering wheel is transferred to the steering arms by tie-rods. The ball joints on the tie rods allow for steering movement and suspension movement. The ball joints of the steering-arm arm are designed so that suspension movement does not affect steering operation.



Principle of Steering System

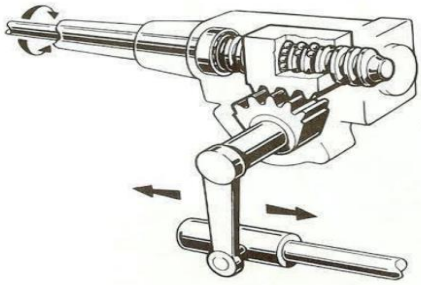
1.6 Types of Steering System



Types of steering system

1.7 Worm and Roller Steering System

The worm-roller steering gear looks very similar to the sector and worm, but a roller is supported within the sector by ball bearings or rotter bearings that are mounted on the pitman shaft. These bearings reduce the friction between the sector and worm. The worm is turned by the steering wheel, and the roller follows it. This causes the sector to turn, and the pitman arm shafts to rotate. The hourglass shape and tapering at the ends of the worm allows for better contact between the roller and worm in all positions. This design allows for a variable steering ratio, which makes it possible to steer more efficiently and faster.



Worm and roller steering system

II. METHODOLOGY

2.1 Study of Steering System

2.2 Study Steering Geometry and Construction

2.3 Study of various Gear Boxes in Steering System

2.4 Steering Parameter Study

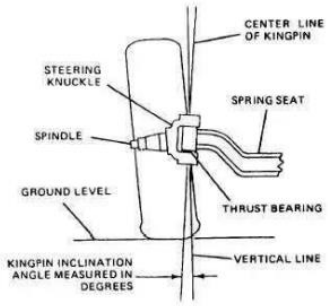
2.5 Design

2.6 Analysis

2.7 Manufacturing

III. STEERING PARAMETERS

The following parameters govern how the automobile steering system works: 1) Kingpin axis. The steering angle is created by rotating the wheel around a steer rotational axis. Figure shows the kingpin axis. 2) Kingpin angle: Angle at the front elevation between the vertical and the steering axis. Caster angle is the angle between the vertical and the steering axis. 4) Camber angle is the inclination of the wheel plan to the vertical. 5) Steering Ratio: This refers to the relationship between the turn (in degrees) of the steering wheel or handlebars and that of the wheels. The steering ratio is the ratio between the number and the turn of the steering wheels.



Steering parameters.

IV. DESIGN OF STEERING SYSTEM

4.1 Design Calculations of Steering System

According to rules of competition wheelbase, trackwidth and Kingpin distance selected.
Wheelbase (b)=1700mm
Trackwidth (a)=1200mm
Distance between kingpin (c)=1100mm
Inner wheel angle (Θ)=300
Outer Wheel angle(ω)=22.360
Ackerman angle(α)=tan-1
(c/b)=32.900
Turing Radius
Inner turning radius Outer turing radius

$$R_{in} = b/\sin(\Theta)-(a-c/2) \quad R_{out}=b/\sin(\omega)+(a-c/2) \qquad (4.1)$$

=3.35m =4.01
Steering Ratio
Maximum turn=250 …….(Assume)
Steering wheel movement=1800
Therefore,
Steering Ratio(S.R.)=180/25=7.2

4.2 Design of Pinion

Material for rack and pinion =Mild Steel ..(I.S. specifications)
Minimum No. of teeth for pinion:- Zpmin=2/sin2 (outer wheel angle) =17.09 =18 Module=2. (Assume)
For 200 full Depth involute system (outer wheel angle=200)
Addendum (ha) = 1*m = 2mm.
Deddendum (hf) =1.25*module = 2.5mm.
Pitch circle diameter (d)=module*Z = 36mm.
Addendum circle diameter (da) = M*(Z+2) =40mm.
Deddendum circle diameter (d f) = M*(Z-2.5) =31mm. 9. Clearance (c) = 0.25*M = 0.5mm.
Whole depth = 2.25*M = 4.5mm.
Tooth thickness = 1.5708*M = 3.14mm.
Circuler pitch = (3.14*d)/Z =(3.14*36)/18 =6.28mm. 13. Diametral pitch =Z/d =0.5

4.3 Design of Rack

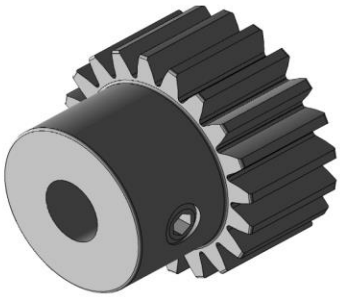
Dimensions Of Rack
Rack shaft length = 15 inch = 381 mm.
No. of teeth on rack = 50.
Steering lock = 300.
Rack eye to eye length = 14 inch = 355.6 mm.
Rack center lock = 3.5 inch = 88.9 mm.
Rack tooth thickness = 3.25 mm
Rack pitch = 6.5 mm.
Addendum and deddendum = 2 mm.
Clearance = 0.5 mm.
Travel lock to lock = 4.48 inch = 113.79 mm
Pinion Radius = 0.78 inch = 20 mm.
(Note :- As per standard rack size.)
Length of tie rod = 8 inch = 203.2 mm.
Arm length = 4.3 inch = 109.22 mm.
Steering shaft length = 750 mm.
Steering shaft diameter = 12 mm. (pinion to column joint) Steering Wheel
According to standard dimensions steering wheel diameter ranges from 141/2 to 171/2 inch and grip circumference ranges from 23/4 to 41/4 inches.
Generally from 2009, 141/2 inch wheel diameter is used with grip circumference of 23/4.
Steering wheel travel for one complete revolution=2*3.14*r =19.72mm

4.4 Cad Modeling

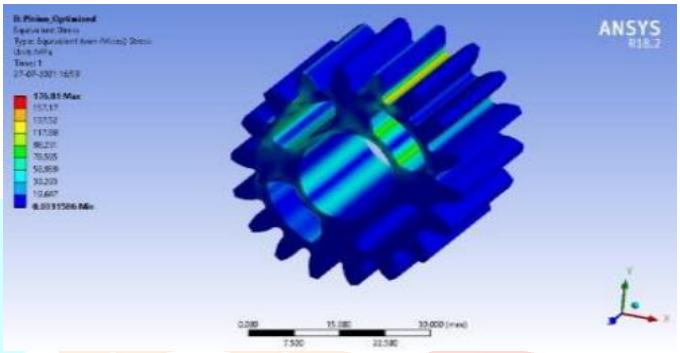
Solid works is used to model the steering system in CAD.

Finite element models are developed using Ansys 16.0.

To determine the stress in rack and pin, a stress analysis can be performed. The CAD models of rack & pinion before and after assembly.

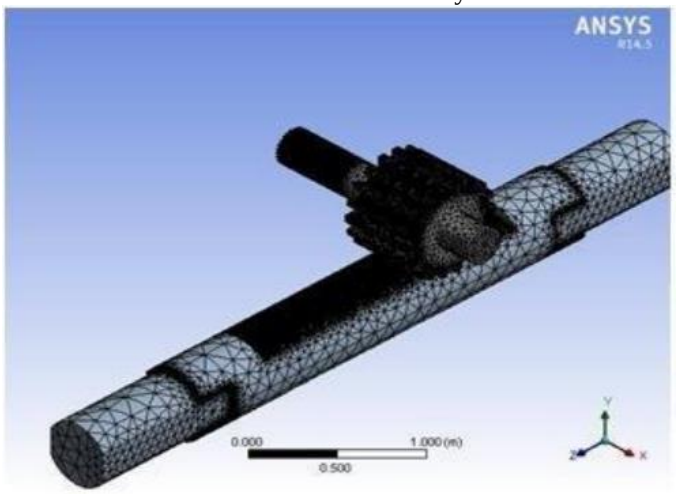


Cad model of pinion



Ansys of Pinion

CAD Model Assembely



Meshing of Assembely of Rack and Pinion

V. COMPONENTS OF STEERING SYSTEM

5.1Rack and Pinion

A rack and pin is a type linear actuator consisting of a circular gear engaging with a linear gear that converts rotational motion into linear movement. The rack can be driven linearly by turning the pinion. The rack will be driven linearly if the pinion is in rotation.

Rack and Pinion

5.2 Tie Rod

A tie rod, or tie bar, is a thin structural unit that can only carry tensile loads. This is any rod- or bar-shaped structural component that prevents the separation of two pieces, such as in a vehicle.

Tie rod

5.3 Ball Joint

Ball joints, which are spherical bearings connecting the control arms and the steering knuckles in an automobile, are used on almost every model. They are bionically similar to the ball-and socket joints found most tetrapods.

Ball Joint

5.4 Steering Column

Steering Column

5.5 Steering Knuckle

A steering knuckle (or upright) is a part of automotive suspension that contains the wheel hub, spindle, or spindle. It attaches to suspension and steering components. Although the terms hub and spindle are often interchangeable, they refer to separate parts.

Steering Knuckle

VI. ADVANTAGES

Easy to make and economically viable.

It is simple to use with accuracy.

Internal damping is maintained.

Low steering elasticity and compact, so used mainly in front-engine Front wheel drive

If your vehicle experiences a power failure, the power steering could be blocked. There is also the possibility of an accident. In rack and pinion steering systems, such an event is rare.

VII. DISADVANTAGES

Leakage.
Rack and pinion steering is simple to use because it requires less parts.

Less Durability.

Rack and pinion steering, when installed in a four wheel-drive vehicle can cause problems when driving offroad.

Vibration

VIII. APPLICATIONS

Rack and pinion steering is a method of turning the wheels by using a gear-set. It converts the circular motion of the steering steering wheel into the linear motion.

You can also reduce the gear, making it easier to turn the wheels.

Used in all terrain vehicles

IX. ACKNOWLEDGMENT

We want to thank everyone who supported us in completing our project. We are grateful to Prof. DURGESH Y. BORASE for all his suggestions, encouragement and help during the completion of our project. We are also grateful for your time in proofreading and correcting many of our mistakes. Our college provided us with the opportunity to work on our project. We are grateful. We also want to thank our friends who supported and contributed in the development of our project.

X. CONCLUSION

We compare values therotically and also ansys software from we can conclude that deformation produced will be negligible and it can sustain at above mentioned stress. so design is safe.The manual rack and pinion steering system not used in heavy weight vehicles due to high axle loads but it is simple in design and easy to manufacture. Therefore, it is commonly used in light vehicles.

Table 10.1: Comparision of Rack and Pinion Steering System and Power Steering System

Sr. no.	Power Steering System	Manual Rack and Pinion Steering System
1.	Power used from electric motor or hydraulic oil	No any external system added to have apower.
2.	Possibility of accident due to failure inpower from motor or hydraulic.	No possibilityof accident because no anychances of power failure.
3.	Power steering is more and more complex system	Very easy and simple system
4.	Requires high expenses in maintainance	Less maintainace
5.	Can be used in heavy vehicles	Can not used in heavy vehicles
6.	This sytem requires high manufacturingcost.	This system requires low manufacturingcost.
7.	More sensitive speed causes accident.	Hard while stopping and normal in speed .

Final Product Manufactured

REFERENCES

[1] Research on"Four Wheel Steering" Author Abhinav Tikley and Mayur Khangan https://doi.org/10.1155/2020/2625301.

[2] Study of 4 wheel steering systems to reduce turning radius and increase stability", International conference of advance research and innovation (ICARI-2014) Author Arun Singh, Abhishek Kumar, Rajiv Chaudhary, R.C. SinghAhmed s. Shehata1, khalid m. saqr2, Qing xiao3, "sandy day4, wells turbine for wave energy conversion " in International Journal of Energy Research · January 2017.

[3] Orrin Lancaster1, Tom Bladock2, Remo Cossu3, "Scour prediction around an oscillating water energy converter" in research gate publication January 2011.

[4] Rameez Badhurshah1, Karthikeyan.

[5] Thandayuutham2, Abdus Samad3, "oscillating water column wave energy system " in research gate publication January 2011.

[6] T. V. HEATH, "A review of oscillating water columns" in Phil. Trans. R. Soc. A (2012) 370, 235–245 doi:10.1098/rsta.2011.0164.

[7] Ahad Sedaghat1, Ahmadreza Zamani 2, "design of chamber and wells turbine for oscillating of water for extracting wave energy from anzali port" in research gate publication December 2012.

[8] Y T. V. HEATH, "A review of oscillating water columns" in research gate publication January 2016.

[9] Antonio Falcao1, Joao c. c. henriques " oscillating water column wave energy converters and air turbine " in research gate publication January 2016.