

## ***Comparative Study of Different Steering System***

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### ***Abstract***

*Manual rack and pinion steering systems are commonly used in small cars like nano and maruti800. The main aim of this paper is to create comparison between manual rack and pinion steering system and power steering system. The comparison of steering system factors like compactness, maintenance, power consumption.*

*Electric Power Steering for automobiles is primarily an energy saving scheme. Electric Power Steering (EPS) is a combination of electric and mechanical system, which reduces steering effort on wheel by applying the power from an electric motor to the steering system. A EPS system has been established, including full vehicle mechanical system, EPS mechanical system, and EPS electric control system. Electrical power steering will become most efficient, safe and reliable power steering system.*

***Keywords:*** *Rack and Pinion steering, EPS, Mechanical system*

### **INTRODUCTION**

The rotary motion of the steering wheel is converting to the linear motion of the drag link through the steering gear box & pitman arm. The drag link pulls & pushes the steering centre level. So that this lever turns the right and left front wheels around

their kingpins through the two tie rods and knuckle arm. The whole system has a self restoring property & is designed for easy steering and high durability. The self restoring action is reliable the operating effort required for turning the hand wheel is small & the system components are easy

to service. The rotary joints of the steering linkage are of ball & socket type.

There are mainly three types of steering systems:

- 1) Re-circulating ball screw type manual steering system
- 2) Rack & Pinion type manual steering system
- 3) Rack & Pinion type power steering system.

### **1. Re-Circulating Ball Screw Type Manual Steering System:**

#### **Construction & Operation**

The pitman arm is rigidly connected to the outer end of the shaft integral with the sector gear that is inside the gearbox & meshed with the teeth of nut capable of sliding along with the worm. Between the nut and the worm is a row of steel balls (actually a total of 52 balls are used), which serves two purposes: to provide rolling contact between nut & worm & to keep the nut engaged with the worm as if the threads of the two were engaged. With the nut prevented from turning the rotation of the worm causes the nut to move up or down worm.

The worm is an extension of the steering shafts. As the hand wheel is turned the steel balls roll along in the groove and the nut moves up and down. The steel ball that has reached the end of the groove in the nut enters the return guide. The guides send the ball back to the other end of the same groove. In this way row of balls re-circulated. By so moving the nut turns the sector gear and hence the pitman arm. It should be noted here that it is through the steel balls that a rotary motion of the worm is converted into a linear motion of the nut that is then converted into another rotary motion of the sector gear.

The steering gear box is a precision-machined device, each part of it being machined to a closer tolerance for smooth conversion motion & is built sturdy for long service life. Special tools & instruments are needed in addition to specialized skill if the gearbox is to be overhauled. For this reason a gear box is found to be defective condition should be replaced by a new one, replacement is more economical & what is perhaps more safer.

Gear ratio= Angle by worm shaft / Angle rotated by pitman arm.



**Figure 1: Re-Circulating Ball Screw  
Type Manual Steering System**

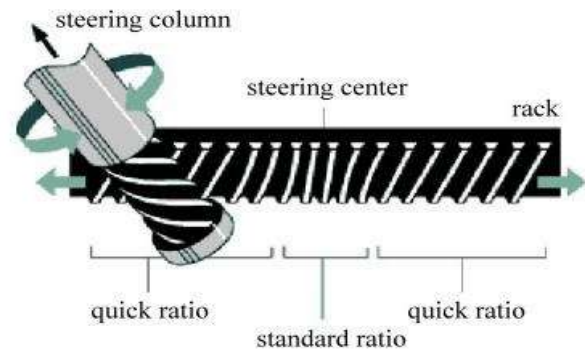
## 2. Rack And Pinion Steering:-

Rack and pinion type steering system basically consists of:

1. Rack bar
2. Pinion
3. Outer ball joint
4. Gear housing and other parts.

The fitment of this steering is shown in figure. The serration part of steering pinion is fitted with the UJ of the steering column. The teeth of pinion are engaged with teeth of rack bar. When the steering wheel is turned, the pinion gear is rotated and rack bar that engaged with pinion gear moves either right or left. The axial movement of rack bar is transmitted through I.B.J and O.B.J to steering arm or knuckle arm that turns the vehicle wheel either right or left. This highly rigid system provides direct steering responses.

The movement of steering wheel at the hand of driver is transmitted to the steering system of this type to ensure quick response and stable operation of the steering. These types of steering are widely used in light vehicles.



**Figure 2: The rack and pinion steering**

## 3. Rack And Pinion Type Power Steering Gear:-

### (i) Hydraulic Power Assisted Steering Systems

This is a modern type of steering system. It consists of a compact rotary type hydraulic valve, which is automatically adjusts hydraulic pressure to desired steering effort as necessary for improved comfort and drivability in all circumstances.

Main parts of this steering system are:

1. Safety steering columns
2. Hydraulic tank
3. Hydraulic hose
4. Hydraulic pump

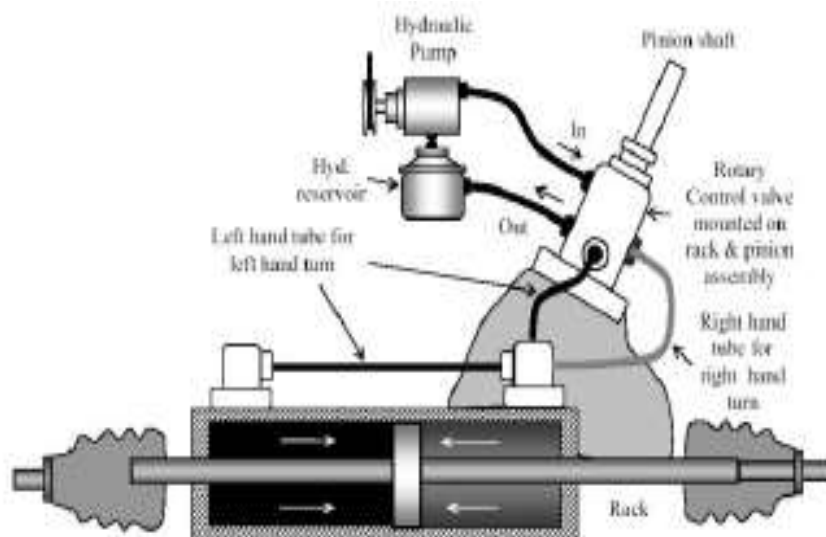
5. Power steering gear

**(ii) Electric Power Assisted Steering (EPAS)**

**Introduction**

Electric power steering (EPS) system is a precision component for improving automotive handling and stability. One of the most important parts of the EPS

system is the electric control system, which receives signals collected by sensors for vehicle speed, steering angle, steering torque and controls the assistant motor for giving required torque. An EPS system includes mechanical subsystem and electronic and control subsystem, and it has to work in the full vehicle mechanical system.



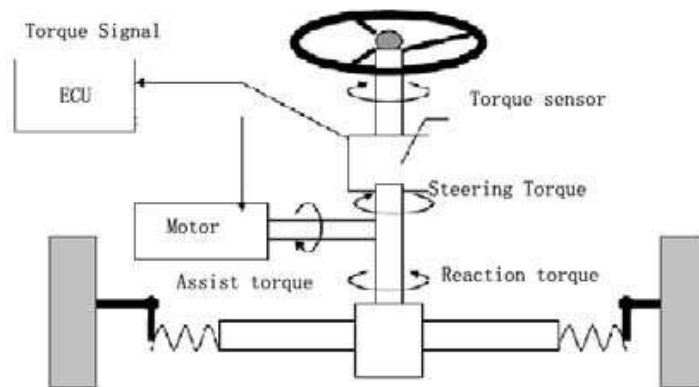
*Figure 3: Functional schematics of a hydraulic power assisted steering systems*

The steering system of an automobile has two main functions: firstly it allows the driver to make the vehicle follow a desired path or trajectory without requiring excessive physical effort and secondly, it assists the driver to determine the driving conditions by allowing some feedback.

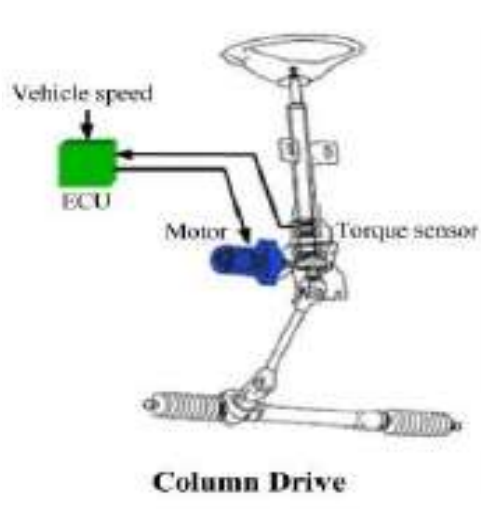
The EPS subsystem model is described by the angular rate and position of the steering column and motor, the linear velocity and displacement of the steering rack. Fig. 4 shows the schematic diagram of a steering mechanism equipped with EPS. It can be formally subdivided into three subsystems:

- 1) Mechanical steering system consisting of steering wheel, steering column, torsion bar, and steering rack
- 2) Brush-type direct current (DC) motor, which provides assisting torque
- 3) Electronic control unit (ECU) with related sensors, such as steering torque, steering angle sensor, and motor current sensor.

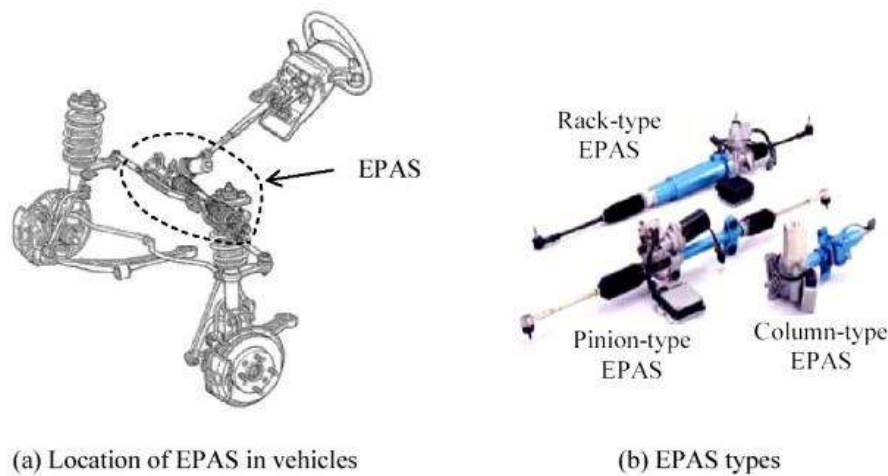
The principal mode of operation can be summarized as follows. If driver turns the steering wheel, the torsion bar is twisted and a steering torque is generated, which in turn moves steering rack. The change of the vehicle direction depends on the change of steering rack position, which causes the change of the rack force. In order to provide a power steering, there is some amount of rack force compensated by servo force generated from motor.



**Fig.4: A steering mechanism with EPS**



**Figure 5: Illustration of an CEPAS.**



**Figure 6: (a) Location and (b) types of EPAS systems**

## ESSENTIAL COMPONENTS OF AN EPAS SYSTEM

Details of EPAS system designs however there are certain components that are

- Torque sensor
- Electric motor
- Rotational angle sensor
- Controller
- Vehicle speed sensor

### Torque Sensor:

The torque sensor is the most important component; it measures the effort being applied by the driver to steer the steering wheel of vehicle. The torque sensor sense is used to drive a motor to reduce the effort, while achieving the desired steering. The motor may be located at a

number of locations to achieve this. The purpose of the motor controller is essentially to control the torque delivered to the steering mechanism. The vehicle speed must be used to adjust the sensitivity of the torque controller. The angle of rotation of the steering wheel of vehicle must also be used to adjust the sensitivity and performance around the zero position of the steering wheel.

Torque sensor Sens the steering wheel movement. It detects the twisting force of torsion bar and converts it into corresponding electrical signal. There are two outputs of the sensor. Being a torque controlled system, the EPAS requires a sensor for the rotational effort or torque that the driver exerts on the steering wheel

in order to steer the vehicle. It is a heart of the EPAS system. The sensors signal is then passed on to a motor controller to develop the torque that is required to assist the driver. The magnitude of the required torque is determined by the driver who is in the control loop. The relationship between the output of the torque sensor and the developed torque of the motor should be linear. The driver responds to the movements that the vehicle makes based on his/her visual observation and perception of vehicle movement received through the steering wheel.

**Electronic Control Unit (ECU):**

It performs the calculation on assisting force based on torques sensor signal and

vehicle speed. The electronic control unit is different for different projects.

**Motor:**

It produces turning force according to the output from the ECU.

**Reduction Gear:**

Worm gear is used in the CEPS. It increases the turning force from the motor and transfers it to the steering mechanism.

**ELECTROMECHANICAL SPECIFICATIONS OF A TYPICAL PINION TYPE P-EPAS**

*Table1: Specifications of EPAS system*

| Items                                   | Specification                  |
|---|--------------------------------|
| Rack stroke                             | 144 mm                         |
| Rack force                              | 7747 N                         |
| Stroke ratio                            | 45.335 mm/rev                  |
| Reducer<br>Type<br>Reduction gear ratio | Worm & Resin wheel<br><br>15.1 |

|   |  |
|---|--|
| Rack & pinion<br>Module<br>Number of teeth  | 2.3<br>6   |
| Motor<br>Type<br>Rated voltage<br>Rated current<br>Rated torque<br>Rated rotational speed | Brushed DC motor<br>12 V<br>65A<br>3.4 Nm<br>1,180 rev/min |

**COMPARISON OF DIFFERENT STEERING**

*Table2: Comparison of different steering*

|    |                       | Manual Steering | Power  |                          |
|----|-----------------------|-----------------|--|--------------------------|
|    |                       |                 | Hydraulic  | Electric                 |
| 1  | Assistance            | No              | Yes  | Yes                      |
| 2  | Physical Exertion     | More            | Comfortable  | Comfortable              |
| 3  | Power Consumption     | No              | More   | Consumes Power when reqd |
| 4  | Maintenance           | No              | Required   | Not Required             |
| 5  | Environmental Hazards | No              | Environmental Hazards posed by leakage and disposal of fluid | Environmental Friendly   |
| 6  | Feeling               | Heavy           | Light  | Light                    |
| 7  | Tuning                | NA              | NA   | Tunable                  |
| 8  | Compactness           | Compact         | Bulkier and Heavy  | Compact                  |
| 9  | Cost                  | Cheap           | Expensive  | Less Expensive           |
| 10 | Failsafe Function     | NA              | NA   | Yes                      |

**CONCLUSIONS**

These drawbacks are however only temporary barriers for the large scale introduced of these systems in today’s car’s and it can be uniquely stated that EPAS is the future in power steering. The comparison of steering system factors like compactness, maintenance, power

consumption is shown in table, Electrical power steering will become most efficient, safe and reliable power steering system as compare to other steering system.

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