

An Overview of Hydraulic Power Steering Gear System

¹Nikhil B. Salve, ²Shivani D. Patole, ³Nitin A. Lawate, ⁴Prof. Anurag D. Girdhar
Student¹, Student², Student³, Assistant Professor⁴

Department of Mechanical Engineering, P.E.S's Modern College of Engineering, Pune, India¹

Department of Mechanical Engineering, P.E.S's Modern College of Engineering, Pune, India²

Department of Mechanical Engineering, P.E.S's Modern College of Engineering, Pune, India³

Department of Mechanical Engineering, P.E.S's Modern College of Engineering, Pune, India⁴

Abstract : This paper has been created to assist engineers while studying and designing hydraulic power steering gear system for automobile applications. In vehicles, power steering is equipment that helps driver steer by raising steering effort of the steering wheel. Hydraulic actuator adds controlled energy to the steering mechanism, so that, the driver has to apply minimum effort to turn the wheels when driving at any speeds and considerably reduce the human effort required to turn the wheels when a vehicle is stopped or moving at any speed. The paper also covers basic construction and working of hydraulic power steering gear system, related to the movement of the piston engaging with sector shaft inside the housing.

IndexTerms - hydraulic power steering gear, recirculating ball screw, sector shaft, piston, drop arm.

I. INTRODUCTION

The steering system is used in automobiles to change the direction of the automobile in the smallest time, without causing any damage to any parts of the automobile or any discomfort to the passengers in the automobile. As an automobile does not necessarily travel in a straight path while moving from one point to another. This brings about the need of an efficient, safe and economical steering system to be used considering various restrictions which are an unavoidable part of the system. A conventional steering system which was used previously proved to be very non-ergonomical in terms of energy spent while steering the vehicle. This sometimes prove to be very tiring to the driver and also sometimes unsafe. To avoid this drawback, research was being constantly carried out which led to the improvement of the power steering. Hydraulic Assisted Power steering Gear System is a kind of power steering. This system proves to be very useful in terms of human effort applied to the steering system. Hydraulic power steering systems work by using hydraulic actuator to intensify the force applied to the steering wheel. This paper deals with the study of hydraulic power steering gear system, its materials, construction and working.

II. HYDRAULIC POWER STEERING GEAR SYSTEM

An integral hydraulic power steering gear system is basically a mechanical steering gear, wherein the hydraulic cylinder and valve are integral parts. On steering, road wheels are turned mechanically. But, the hydraulic valve, which has the ability to sense the requirement of torque by road wheels, generates pressure on one side of the piston. This differential of pressure helps the piston to move and we get hydraulic assistance. The hydraulic assistance is proportional to the required torque of turning of road wheels.



Figure.1: Hydraulic power steering gear system

2.1 Power steering offered three principal advantages:

1. Reduction in the effort on steering wheel by around 85 %.
2. High steering velocity (1.5 t/sec or more), and
3. Absorption of road shocks.

However, these advantages come to us at the expense of fuel. For every 100 km run of a normal truck, 1.4L of diesel is burnt for the usage of power steering gear alone.

III. SCHEMATIC REPRESENTATION OF HYDRAULIC POWER STEERING SYSTEM

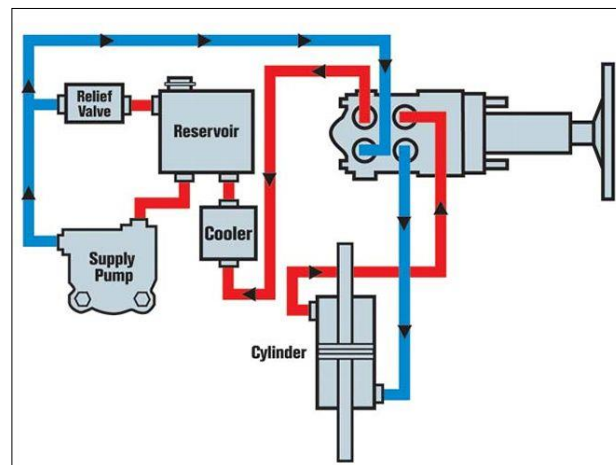


Figure.2: Block diagram of Hydraulic Power Steering gear System

- 3.1 Steering Column:** The vehicles steering column is a device considered mainly for joining the steering wheel to the steering mechanism.
- 3.2 Steering Box:** The steering box converts users input from the steering wheel into a rotational force for mechanical steering linkages. Generally, this is the most intricate part of the system. Most steering boxes are made from cast iron and have a decent life span.
- 3.3 Double-Ended Cylinder:** This is the hydraulic linear actuator commonly known as ram. Technically, they're referred to as non-differential actuator, or double-acting piston-type actuator. They replace the mechanical linkage mechanism in a traditional manual steering setup. The size of the ram depends on the mechanical effort that the system requires to steer the tires.
- 3.4 Cooler:** The power-steering cooler helps keep the steering system's oil temperature in check.
- 3.5 Reservoir:** This is the component which stores the hydraulic fluid inside the system. It can also be called as oil drum. Most power-steering pumps have a reservoir very near to them.
- 3.6 The Pump:** Hydraulic pump translates mechanical energy into fluid pressure energy. They operate on the displacement principle, in which, fluid is taken in and displaced to another point.
- 3.7 Relief Valve:** If the system shuts down then the pressure inside the cylinder increases rapidly, then the relief valve opens and the pressure is sent back to the reservoir.
- 3.8 Pressure Line or Supply Hose:** This is also called as veins of steering system. These lines carry operating fluid to all the components of the system.
- 3.9 Oil:** Oil performs two functions in a hydraulic system, i.e., lubrication and transmission of power.
- 3.10 Drag Link or Drop Arm:** In a drop arm as a linkage attached to the sector shaft, it converts the angular motion of the sector shaft into the linear motion which is required to steer the wheels, causing it to move left or right to turn the wheels in the particular direction.
- 3.11 Tie Rod:** A tie rod consists of an inner and outer end. The tie rod translates force from center link arm or rack gear to the steering knuckle.
- 3.12 Steering Knuckle:** A steering knuckle is steering part which contains the wheel hub or spindle, and connect to the suspension and steering parts.

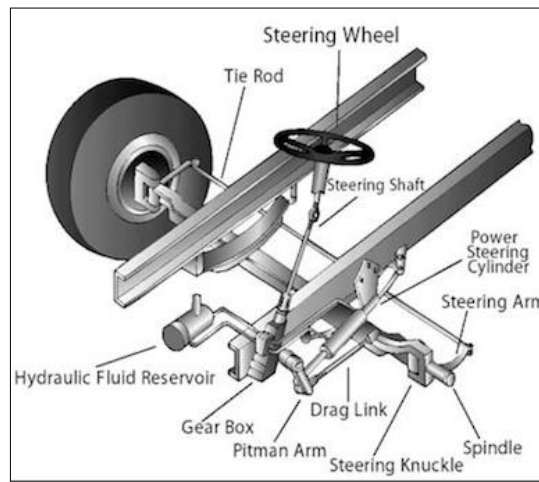


Figure.3: Schematic representation of Hydraulic Power Steering System

IV. COPMONENTS

For accurate functioning of hydraulic power steering gearbox system, the following components are used:

- 4.1 **Worm or Recirculating Ball Screw:** The radial and axial roller bearings are mounted in the cover. Worm Shaft with grooved socket for ball circulating motion, is mounted in the cover and loaded with threaded ring.
- 4.2 **Steering Nut:** Longitudinal bore hole for worm engagement with grooves for ball circulating motion is provided.
- 4.3 **Sector shaft:** It is a type of shaft which is integrated with semi circular gear in order to accommodate service engagement in the axial direction.
- 4.4 **Piston:** Piston is a reciprocating part inside the cylinder. The underside of the piston is machined as a gear rack, which engages with the semicircular gear on the sector shaft.
- 4.5 **Housing:** The housing has integrated part for the pressure and return lines and, a built-in pressure limiting valve.
- 4.6 **Housing cover:** It contains adjustment screw for supporting the sector shaft and two built-in adjustable valves for limiting the pressure at wheel lock.

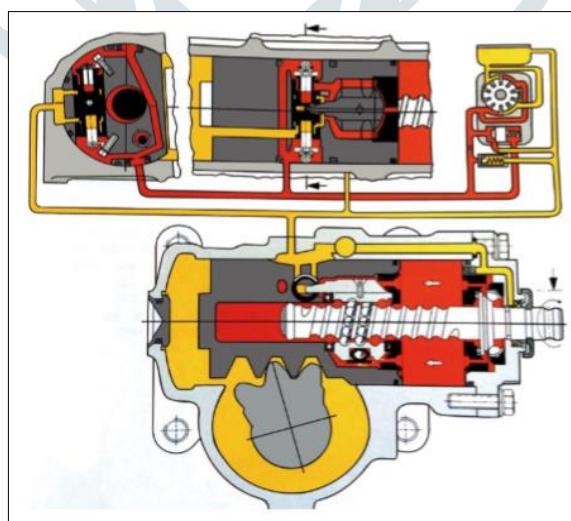


Figure.4: Section view of ball and nut hydraulic power steering gear

V. FUNCTIONS

Figure.4 describes the cross section of an existing integral hydraulic power steering gear, which comprises of a housing and has suitable bore to accommodate piston assembly. The piston assembly has worm running through it, and is supported in the housing. One end is formed by the end cover, and a nut is fixed in the cavity of the piston. This is responsible for reciprocation of piston in the bore of housing as the worm is turned by the driver either clockwise or anticlockwise. The nut is assembled on the worm with recirculation balls and “driver” is press-fitted on the nut. The “driver” then engages with the valve. This valve movement to the left or to the right is responsible for the generation of pressure in the system. The piston is engaged by suitable gearing with the sector shaft, which is supported on roller bearing on which drop arm is mounted (not shown). The valve controls the flow as the worm is turned, otherwise, this allows oil to go to the tank in neutral position. When the worm is turned, piston moves left or right, depending on the hand of the worm, and chambers or are pressurised to help piston move. If chamber is pressurised, chamber is at low pressure and vice-versa. Pressure level depends upon load on the tyre, which is communicated to the valve via sector shaft. The sector shaft develops the necessary torque to move the road wheel as it is connected to it via pitman arm, drag link and steering arm.

VI. MATERIALS

Hydraulic power steering gear system can be manufactured from different material which are as follows:

- 6.1 **Worm:** Material used in manufacturing of worm is Case Hardening Steel.
- 6.2 **Steering Nut:** Material used in manufacturing of Steering Nut is Steel alloy.
- 6.3 **Sector Shaft:** Material used in manufacturing of sector shaft Special Steel alloy.
- 6.4 **Piston:** Material used in manufacturing of Piston is Special Steel alloy Round steel.
- 6.5 **Housing:** Material used in manufacturing of housing is Cast iron.
- 6.6 **Drop Arm:** Material used in manufacturing of drop arm is Chromium Steel.

VII. CONCLUSION

This article can be used as a reliable initial study material by any researcher for studying or designing the steering system. It gives mainly the information of materials and components used in hydraulic power steering gear system. It also elaborately discusses the working of hydraulically assisted power steering gear system in automobile applications.

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