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Pneumatic Power Steering

[1]Parth Lad, [2]Vaibhav Wani, [3]Pranit Mehata
[1]Engineering Student , [2]Engineering Student, [3]Lecturer
[1,2,3]Department of Mechanical Engineering,
[1]Dwarkadas J. Sanghvi College of Engineering, Vile Parle, Mumbai, Maharashtra, India, 400056
[2]Sinhgad College of Engineering, Vadgaon (BK), Pune, Maharashtra, India, 411041
[3]St John College of Engineering and Management (St. John Polytechnic), Palghar. Maharashtra, India, 401404

Abstract: The Pneumatic control systems operate on a supply of compressed air, which must be made available in sufficient quantity and at a pressure to suit the capacity of the system. The operational reliability and service life of a pneumatic system depend to a large extent on the preparation of the compressed air.

Index Terms **- Pneumatic, Compressed Air, Reliability.**

I. INTRODUCTION

The steering system of a vehicle allows the driver to control the direction of the vehicle through a system of gears and linkages that connects the steering wheel with the front wheels. The main function of steering system is to convert the rotary motion of steering wheel into angular displacement of front wheels. The steering system must also maintain the straight-ahead motion of vehicle while it encounters potholes bumps and must operate with minimum effort.

Function of Steering System

a) To turn the vehicle at the will of the driver.
b) To control direction of automobile vehicle.
c) To control wear and tear of tyres.
d) Change direction of vehicle.
e) Provide a degree of 'feel' of the road for the driver.
f) Not transmit excessive shock back to the driver due to an uneven road.
g) To multiply effort of driver for easy operations.

Pneumatic Power Steering

Pneumatic apparatus are machines and instruments which utilize air energy to do work. Substantial gear is a typical illustration. In this sort of machine, high weight Compressed air is transmitted all through the machine to different Pneumatic engines and Pneumatic barrels. The air is controlled specifically or consequently by control valves and disseminated through hoses and tubes. The notoriety of Pneumatic apparatus is because of the huge measure of energy that can be exchanged through little tubes and adaptable hoses, and the powerful thickness and wide cluster of actuators that can make utilization of this power. This hardware depends on the Cylinders, Compressor, and Pump. Pneumatic barrels are pressurized by Pneumatic weight and get their energy for the Pneumatic air under strain. They change the air's vitality to direct work. Pneumatic chambers work in a Pneumatic framework and are the engine side of this framework. The generator side of the air Pneumatic framework is the pump or Compressor that brings a settled or managed wind stream into the framework. The Pneumatic barrel starts the weight of the air, which can never be bigger than the weight that is asked by the heap.

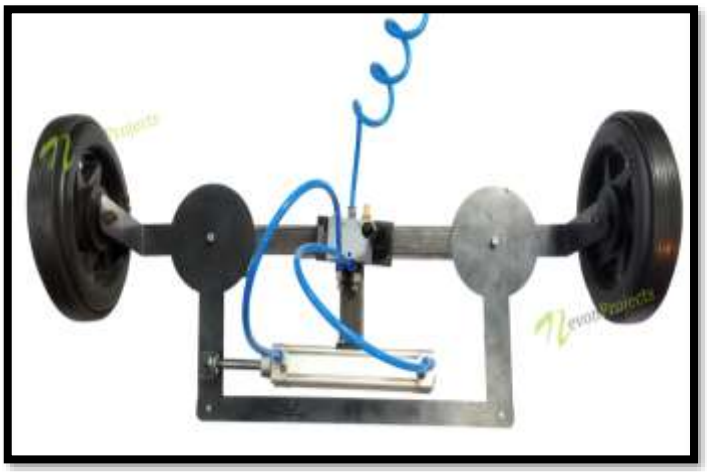

Fig. Pneumatic Power Steering

The chamber comprises a barrel, in which a cylinder associated with a cylinder bar is moving. The barrel is shut by the chamber base at the base side and by the barrel head along the edge where the cylinder bar leaves the barrel. Mounting section or clevises are mounted to the barrel base and also the cylinder bar. The cylinder has sliding rings and seals. The cylinder partitions within the barrel in two chambers, the base chamber and the cylinder bar side chamber. By drawing Pneumatic air to the base side of the Pneumatic barrel, the cylinder pole begins moving out. The cylinder pushes the air in the other chamber back to the air repository. On the off chance that we accept that the gaseous tension in the cylinder pole chamber is zero, the weight in the barrel is currently Force/Piston zone. In the event that the air is drawn into the cylinder bar side chamber and the air from the cylinder territory streams back to the air repository without weight, the weight in the cylinder pole zone chamber is Load/(cylinder region – cylinder pole zone). In such a way the Pneumatic barrel can push and draw. At the point when the vehicle weight expands, the power required to direct the vehicle likewise increments. The vast majority of the vehicles have liquid power for guiding. In this venture pneumatic power (compacted air) is utilized as a part of the place of Mechanical power.

Objectives

a) The popularity of pneumatic machinery is due to very large amount of power that can be transferred through small tubes and flexible hoses.
b) It requires the implementation of safety factors in the automobile at low cost which can be afforded even by a common man.
c) The invention is to provide a steering assembly which is relatively simple in construction.
d) Economical to manufacture as the parts are readily available it can be easily manufactured
e) Reliable in operation and is otherwise ideally suited to its intended purposes.
f) To describe how power steering system operates.
g) To innovate new steering system in the field of automobiles.

II. METHODOLOGY

Components

1. Double Acting Pneumatic Cylinder

Pneumatic cylinders convert the potential energy of compressed air into mechanical energy of applied force or the kinetic energy of motion. Within the cylinder, two chambers are maintained at different air pressures. A piston, sometimes called a rod, attached to the dividing wall is set in motion as the volume of the chambers changes in response to the relative pressure of the two chambers. At least one of the chambers is connected to a port that allows for the flow of air in and out of the cylinder. Double acting cylinder (DAC) use the force of air to move in both extend and retract strokes. They have two ports to allow air in, one for outstroke and one for in stroke. Stroke length for this design is not limited, however, the piston rod is more vulnerable to buckling and bending. Additional calculations should be performed as well. Cylinder is a device which converts fluid power into liner mechanical force and motion. These cylinders are widely used in industrial pneumatic systems. These cylinders are also called as linear motors and reciprocating motors. Pneumatic cylinders are designed for a variety of services. Pneumatic cylinders transform the flow of pressured fluid into a push or pull of the piston rod since out system uses double acting cylinders, we shall see some details about them.

Double acting cylinders are in one in which fluid force can be applied to the movable element in two directories. The force exerted by the compressed air moves the piston in two directories in a double acting cylinder. The piston is required to perform work not only on the advance movement but also on the return. In principle, the stroke length is unlimited, although bucking and bending must be considered before we select a particular size of piston diameter, rod length and stroke length. The main component of any pneumatic system is the cylinder, which receivers air under pressure and the pressurized air helps to move the piston to and fro. The force acting on the piston will be equal to the product of the pressure of air and the area of the cylinder.

The amount of air delivered into the cylinder into the cylinder decides the rate of doing work. A cylinder is a hollow circular section with the top and bottom flange provided to prevent the leakage of air. The compressed air is used to actuate the piston. In order to move the piston to and fro, the air is supplied to the top and bottom of the cylinder alternatively.

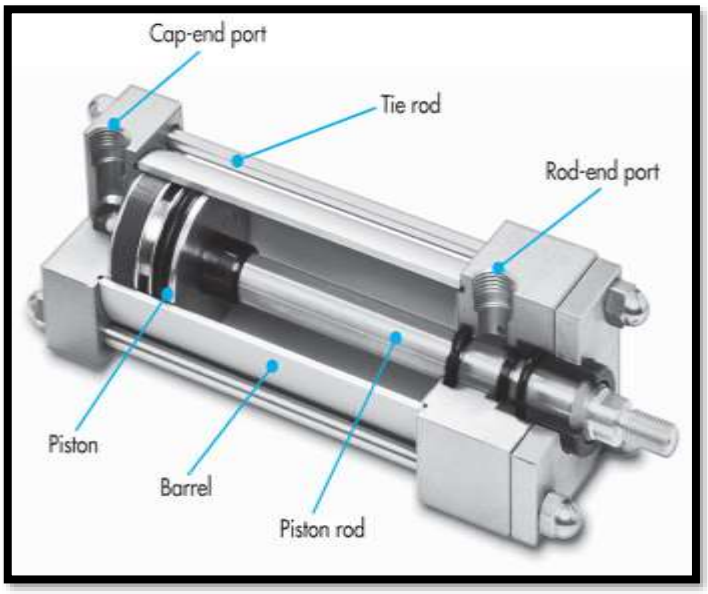

Fig. Double Acting Cylinder (DAC)

2. Calculation of Piston Force

Consider DA cylinder having:

a) Piston Diameter = D
b) Piston Rod Diameter = d
c) Presser of Compressed air = P
d) Stroke length = L

In a DA cylinder, when oil is admitted through piston side then this stroke will move from left to right. This stroke is called advance stroke and piston is said to be 'Advancing". In a DA cylinder, when oil is admitted into DA cylinder from piston rod side then piston will move from right to left. Then this stroke is called retract stroke and piston is said to be 'Retracting'. Now we will find out the force with which the piston will advance (F_A) and the force with which piston will retract (F_R).

We know that

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

$$Force = pressure\ x\ Area$$

So, force on piston is advance stroke which will be:

$$F_A = P \times Area\ on\ which\ pressure\ is\ being\ applied$$

$$F_A = P \times \frac{\pi}{4} \times D^2 \quad \ldots \text{D = diameter of piston}$$

Force on piston is retract stroke which will be:

$$F_R = P \times Area\ on\ which\ pressure\ is\ being\ applied$$

$$F_R = P \times \frac{\pi}{4}(D^2 - d^2) \quad \ldots \text{Deducting cross-sectional area of piston rod}$$

In case of small pistons, the diameter of piston rod can be neglected.

3. Lever operated 5/2 Directional Control Valve (DC Valve)

Lever operated 5×2 DC valve has a lever. Ports A and B are attached to actuator to obtain useful work. P is Pressure port, R is normal exhaust port and S is easy exhaust port.

The normal position shows that:

a) Port P is connected to port B.
b) Port A is connected to port R.
c) Port S is closed or disconnected.

Now if lever is operated,

a) Port P will get connected to port A.
b) Port B will get connected to port S.
c) Port R will close or will be disconnected

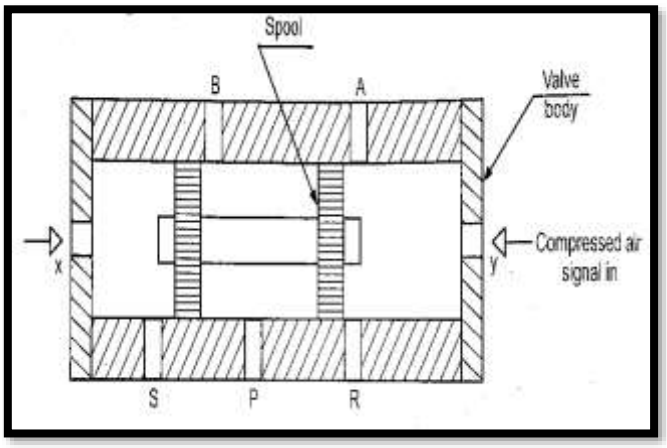

Fig. 5/2 Directional Control Valve

Five-by-two DC valve means there will be 5 ports and 2 positions. 2 positions means 2 squares and 5 ports are shown as below

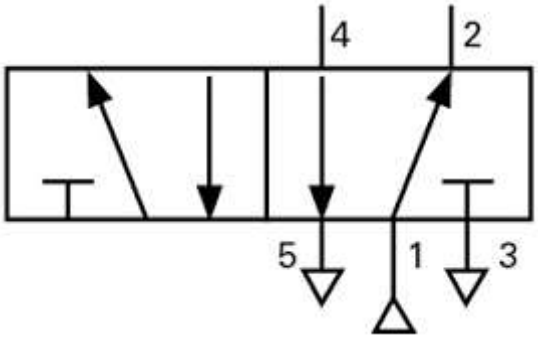

Fig. Symbol of 5/2 DC Valve

4. Pneumatic Fittings

Pneumatic fittings provide the essential link between tubes, hoses and other components in a pneumatic system. Air fittings feature tighter seals and have lower pressure requirements than hydraulic fittings and are typically offered in various connector types. In addition to connecting pneumatic components and stopping the flow of unused ports, miniature fittings are also used to control air flow pressure and directional flow. Fittings help control the force and directional flow of compressed gas or air used in pneumatic systems. One of the first considerations in choosing a connector is the type of vessel that you will be connecting to such as the flexibility of the hose or tube, as well as the inner diameter (ID) and outer diameter (OD) of the vessel to ensure an adequate seal and secure connection. Fitting material choice for your pneumatic connector is also important, including gas compatibility or resistance to heat or corrosion.

Fig. Pneumatic Fittings

Considerations in choosing the right pneumatic system connector include:

a) Type of connection and the function it performs
b) Operational pressure of the pneumatic system
c) Operating temperature range
d) P.S.I. requirements for your application
e) Amount of vibration produced by the pneumatic system
f) Thread type of the receiving fitting

5. Pneumatic Tubes and Pipes

The basic function of pneumatic tubing and hose is to convey pressurized air to actuators, valves, tools and other devices. But there are countless types and sizes of tubing and hose on the market, so engineers should consider a number of important factors to select the right one for a given task. Start with construction. Tubing for air applications may be extruded of a single material or reinforced internally, typically with textile fibers, for higher strength. Pneumatic hose generally consists of an inner tube, one or more layers of reinforcing braided or spiral-wound fiber, and an outer protective cover. In broad terms, hose is more rugged than tubing but costs more. Pneumatic tubes or capsule pipelines also known as pneumatic tube transport or PTT) are systems that propel cylindrical containers through networks of tubes by compressed air or by partial vacuum. They are used for transporting solid objects, as opposed to conventional pipelines, which transport fluids. Pneumatic tube networks gained acceptance in the late 19th and early 20th centuries for offices that needed to transport small, urgent packages (such as mail, paperwork, or money) over relatively short distances (within a building or, at most, within a city). Some installations grew to great complexity, but were mostly superseded. In some settings, such as hospitals, they remain widespread and have been further extended and developed in the 21st century. A small number of pneumatic transportation systems were also built for larger cargo, to compete with more standard train and subway systems. However, these never gained popularity.

Fig. Pneumatic Tubes and Pipes

6. Frames

Material Used: Galvanized Iron (G.I)

Why select Galvanized Iron rectangular tubes as frame material?

a) Zinc coating provides high corrosion resistance.
b) Tubes are hollow. So, they are lighter in weight.
c) High fatigue strength
d) The zinc coating on galvanized steel is resistant to cracking and loss of adhesion when the steel is formed into a product.
e) The zinc coating does not require special handling to protect it during transport or use. It is extremely durable and resistant to scratches from abrasion.
f) Lower cost than stainless
g) Less maintenance/Lowest long-term cost.
h) Coating life and performance are reliable.
i) Outstanding resistance to mechanical damage
j) Protection to small areas of steel exposed through damage.
k) No other coating can provide the same protection.
l) No lost time in surface preparation, painting and inspection.

III. MECHANISM

In pneumatic power steering system, we have used four bar chain or four bar linkages. It consists of four bodies, called as bars or linkages connected in loop by four joints. The four bars of this mechanism, has two equal length bars and two of different length. To operate four bar chain mechanism one link or bar must be fixed or constrained to obtain desire motion. In pneumatic power steering system, we have fixed one of the links i.e., frame. Another one link is connected to piston rod. When piston reciprocates, reciprocating motion gets converted into angular motion by means of four bar linkages. Using this mechanism adequate turning of wheel can be achieved. This mechanism is also used to maintain proper input angle. It minimizes complex motions. It is able to extend very far with very little space consumed.

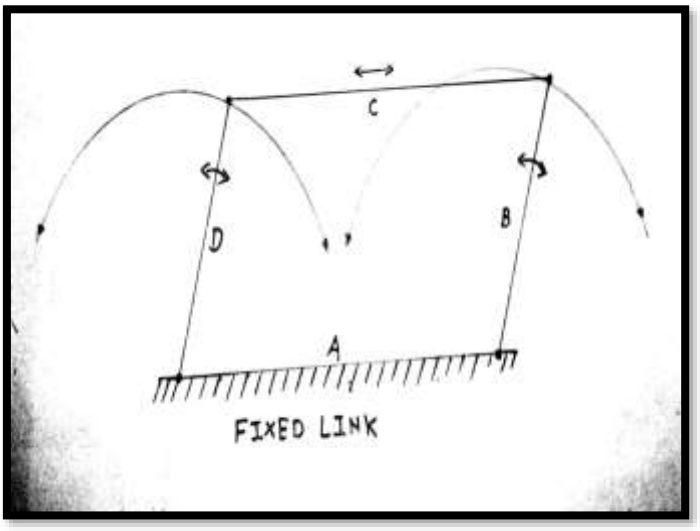

Fig. Four Bar Mechanisms

Let us consider ABCD as a four-bar chain mechanism. Here frame i.e., link A is fixed or constrained. Motion of piston is given to one of the links, link B. Due to this linear motion is converted into angular motion and link C and link D moves thereby turning the wheel to desire angle.

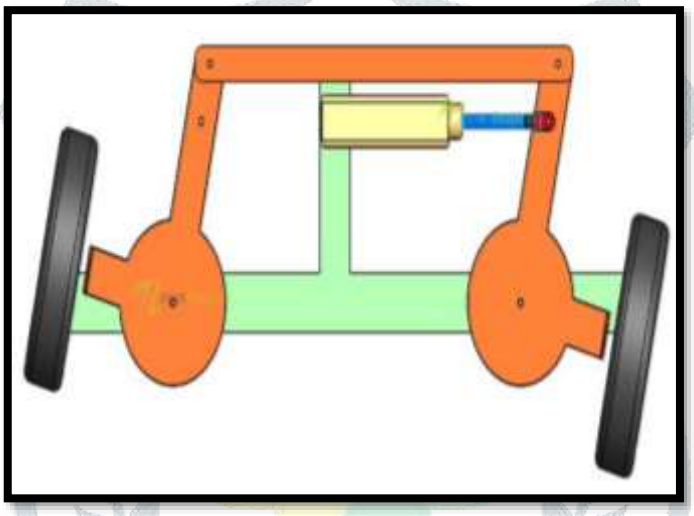

Fig. Actual 4 Bar Mechanisms

IV. FABRICATION

a) Cutting Operation

This process involves the use of physical forces to cut an object by means of cutting tools like hacksaw. Cutting is a collection of processes wherein material is brought to a specified geometry by removing excess material using various kinds of tooling to leave a finished part that meets specifications. The net result of cutting is two products, the waste or excess material, and the finished part. In cutting metals, the waste is chips or swarf and excess metal.

b) Welding

Welding is a fabrication or sculptural process that joins materials, usually metals or thermoplastics, by using high heat to melt the parts together and allowing them to cool causing fusion. Welding is distinct from lower temperature metal-joining techniques such as brazing and soldering, which do not melt the base metal. These processes use a welding power supply to create and maintain an electric arc between an electrode and the base material to melt metals at the welding point. They can use either direct current (DC) or alternating current (AC), and consumable or non-consumable electrodes. One of the most common types of arc welding is shielded metal arc welding (SMAW) it is also known as manual metal arc welding (MMAW) or stick welding. Electric current is used to strike an arc between the base material and consumable electrode rod, which is made of filler material (typically steel) and is covered with a flux that protects the weld area from oxidation and contamination by producing carbon dioxide (CO_2) gas during the welding process.

c) Drilling

Drilling is a cutting process that uses a drill bit to cut a hole of circular cross-section in solid materials. The drill bit is usually a rotary cutting tool, often multi-point. The bit is pressed against the work-piece and rotated at rates from hundreds to thousands of revolutions per minute. This forces the cutting edge against the work-piece, cutting off chips (swarf) from the hole as it is drilled.

d) Machining

Turning

The general process of turning involves rotating a part while a single-point cutting tool is moved parallel to the axis of rotation. Turning can be done on the external surface of the part as well as the internal surface The starting material is generally a workpiece generated by other processes such as casting, forging, extrusion, or drawing.

Boring

Enlarging or smoothing an existing hole created by drilling, moulding etc. i.e., the machining of internal cylindrical forms (generating) by mounting workpiece to the spindle via a chuck or faceplate or by mounting workpiece onto the cross slide and placing cutting tool into the chuck. This work is suitable for castings that are too awkward to mount in the face plate. On long bed lathes large workpiece can be bolted to a fixture on the bed and a shaft passed between two lugs on the workpiece and these lugs can be bored out to size.

e) Assembling

Assembling is a process in which all the parts or components of a system or machine are integrated to perform a specified task or work. Assembly is the last process of any product to be manufactured. Assembly is carried out when all the required components or parts are completely manufactured.

IV. RESULTS AND DISCUSSION

Power steering is a system that helps in steering the wheels by using some auxiliary network of power. Normal steering is a steering system in which manual force is used for steering. Normal steering is also known as manual steering or non-power steering. In pneumatic power steering four bar linkage is used to control turning motion of wheels. Normal steering uses a rack and pinion, worm and roller and recirculation ball and nut. Quick response can be achieved by using pneumatic system. Due to use of various mechanisms, like rack and pinion comparatively slow response is achieved. Driver effort reduces when using pneumatic power steering whereas in normal steering more efforts will be required by driver to operate steering wheel. Pneumatic power steering can be used in both light duty and heavy-duty vehicles and manual steering can only be used in light duty vehicle. Pneumatic power steering is economical because it requires less manufacturing cost and maintenance cost. It does not require any refilling and return lines as air is working medium which is available in abundance. Manual steering has many linkages, gears and other moving parts which increase its manufacturing cost and maintenance cost. Due to more moving parts in manual steering rate of wear and tear is more whereas in pneumatic rate of wear and tear is much lesser. Pneumatic power steering is noisier in operation but by using muffler noise can be reduced up to certain extent. Air can be transported through flexible pipes so arrangement of pipes can be done without disturbing any other system of automobile.

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