

SUB: HYDRAULICS, PNEUMATICS & MECHANICAL

Duration: 36 Sessions = 72 Periods

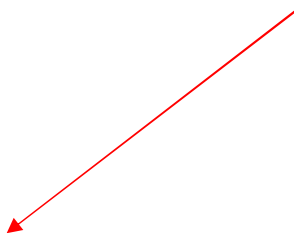
Sub-discipline: Hydraulics (Lessons: 16 Sessions: 21)

Lesson-I: Fundamentals & Hydraulic Symbols

Session-1: Introduction, Advantages of Hydraulic system, Hydraulic Symbols.

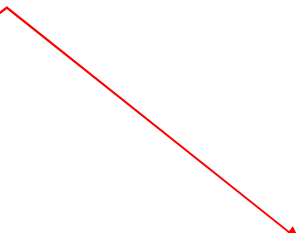
INTRODUCTION: The word hydraulics originates from the Greek. This is made of two words-hydor and aulos. Hydor means water and aulos means pipe i.e. flow of water through pipes. Today the term hydraulic commonly refers to “Power hydraulics” in which fluid is used under controlled pressure to do work. Hydraulic power is used in every branch of industry in a machine tool, missiles, man made satellite, boat, planes, cranes, lifts, track machines etc. So fluid is most versatile means of transmitting power & modifying motions. A fluid is infinitely flexible. It can easily change its shape, it can be divided into parts to do work in different locations, it can move rapidly in one place and slowly in another place. No other medium has the same accuracy, positiveness & power in minimum of volume & weight. It is the science of forces and movements transmitted by means of liquids i.e. generation of forces and motion using hydraulic fluid. It is a part of hydromechanics.

Hydromechanics



Hydrostatics

(Force effect through pressure area)



Hydrodynamics

(Force effect through mass acceleration)

Hydraulic fluid contains two energy: (1) Kinetic energy (2) Potential energy.

Basically hydraulic fluid obeys:

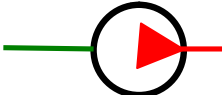
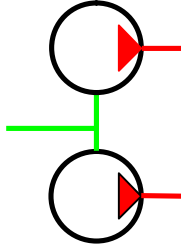
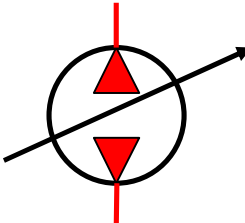
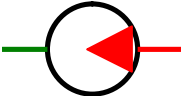
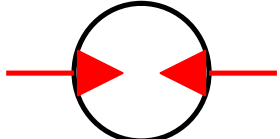
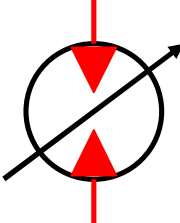
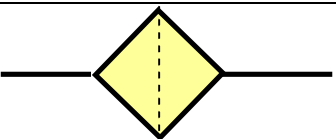
ADVANTAGES OF HYDRAULICS:

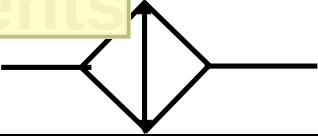
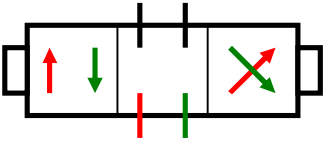
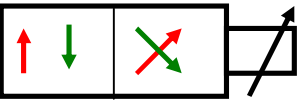
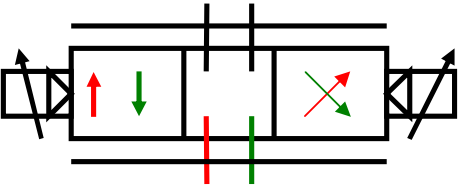
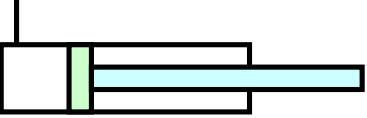
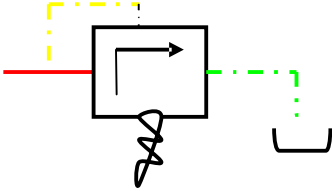
1. **Variable Speed:** The actuator of a hydraulic system can be driven at variable speeds by varying the pump delivery or using a flow control valve.
2. **Reversibility:** An actuator can be reversed instantly while in full motion without damage. A four way directional valve or a reversible pump provides the reversing control.
3. **Overload Protection:** The pressure relief valve in hydraulic system protects it from overload damage. When the load exceeds the valve setting, pump delivery is directed to tank.
4. **Self Lubrication:** In most hydraulic components internal lubrication is provided by the fluid. Pump elements and other wearing parts slide against each other on a film of fluid.
5. **Cooling:** Circulation of the fluid through lines and around the walls of the reservoir allow the fluid to give up the heat that has been generated in the system.

In many instances the fluid is the only seal against pressure inside the hydraulic component. In DC valve there is no seal between the valves spool and the body to minimize leakage. The close mechanical fit and the viscosity of the oil determine leakage rate.

7. **Easy to Install and Handle:** Hydraulic components can be easily installed and handled due to less weight and size in compare to mechanical system.
8. **Portable:** Hydraulic plant can be used in mobile application.
9. **Compactness:** Hydraulic components can provide high power output with very small weight and size.

HYDRAULIC SYMBOLS:

	Single Pump
	Double Pump
	Variable Pump
 	Return Line Pressure Line
	Pilot Line
	Uni-Directional Motor
	Bi-Directional Motor
	Variable Motor
	Stop Cock
	Filter

	Cooler
	4/3 Way Valve
	4/2 Way Valve
	Servo Valve or Proportional Valve
	Single Acting Cylinder
	Double Acting Cylinder
	Relief Valve
	Check Valve/ Non-Return Valve

DISCIPLINE: HYDRAULICS (LESSONS: 16 SESSIONS: 21)

Lesson-II: Hydraulic Oil, Hydraulic Tank

Session-2: Functions and Properties of Hydraulic oil, Functions and Parts of Hydraulic tank.

Proper selection and care of hydraulic fluid for a machine will have an important effect on machine performance and on the life of the hydraulic components. Any liquid is essentially incompressible and therefore will transmit power instantaneously in hydraulic system. The most common liquid used in hydraulic system is petroleum based oil. Oil transmits power readily because it is only very slightly compressible, a negligible amount in most systems. The most desirable property of oil is its lubricating ability.

FUNCTIONS:

1. To transmit power from one point to another
2. To lubricate moving parts
3. To cool or dissipate heat
4. To seal clearance between parts
5. Cushioning of oscillations caused by pressure jerks.
6. Corrosion protection.
7. Scuff removal.

PROPERTIES:

- 1.1 Suitable viscosity:-viscosity is measure of fluid's resistance to flow. If a fluid flows easily, its viscosity is low. Fluid flows with difficulty have a high viscosity. Some methods of define viscosity are: absolute viscosity, kinematic viscosity, and relative viscosity and SAE numbers. Kinematic viscosity is the most common way of measuring viscosity. It is measured by the amount of time needed for a fixed volume of oil to flow through a capillary tube. The unit for kinematic viscosity is mm^2/sec or centistokes.

Too high a viscosity increases friction, resulting in –

1. High resistance to flow
2. Increased power consumption due to friction loss
3. High temperature caused by friction
4. Increased pressure drop due to resistance
5. Possibility of sluggish or slow operation
6. Difficulty in separating air from oil in reservoir.

Too low a viscosity resulting in –

1. Internal leakages increases
2. Excessive wear and even seizure may occur under heavy load due to break down of oil film between moving parts
3. Pump efficiency may decrease causing slower operation of the actuator
4. Leakage losses may result in increased temperatures.

- 1.2 Anti-rust and anti-corrosive:-rusting is the chemical union of steel with oxygen. Corrosion is chemical union between a metal and acid. Corrosion occurs as the acid acts on the metals. Rusting is caused by air bubble in the system. It is usually not possible to keep air and atmosphere born moisture out of hydraulic system. They contaminate the system and promote wear. There are several ways of preventing rust and corrosion. The best way is that hydraulic system may work at proper temperature and pressure. A fluid should be filtered properly

- 1.3 Oxidation resistance :- Fluid oxidation is the chemical reaction of the fluid with air which forms new substances or compounds, when hydraulic oil oxidized, it form gum, sludge. Some of these soluble compounds are acids which bites the metallic

is in the system. It is the most common factor that reduces the fluid life. These contaminants close the orifice, increases wear and tear and causes valves to stick. The best control is through the good maintenance.

1.4 Resistance to foaming:- A small air bubble get entrapped during course of suction and delivery of released oil from circuit. Air also enters through vent hole and mixes with oil and affects the efficiency. Air also causes heating of the oil and hydraulic assemblies. Return pipe should be located well below in the hydraulic tank.

1.5 Low pour point: Pour point is the lowest temperature at which a fluid will flow. Beyond this it becomes so thick that it won't flow any more.

Method of identifying hydraulic oil:

One important method of identifying hyd. oil is the specification of viscosity class. The ISO standard and new draft of DIN 51524 explain that the viscosity classes lay down the minimum and maximum viscosity of hyd oil at 40°C

ISO VISCOSITY CLASSES	KINEMATIC VISCOSITY (MM ² /S) AT 40°C	
	MIN	MAX
ISO VG 10	9.0	11.0
ISO VG 15	13.5	16.5
ISO VG 22	19.0	24.8
ISO VG 32	28.8	35.2
ISO VG 46	41.4	50.6
ISO VG 68	61.2	74.8
ISO VG 100	90.0	110.0
ISO VG 150	135	165

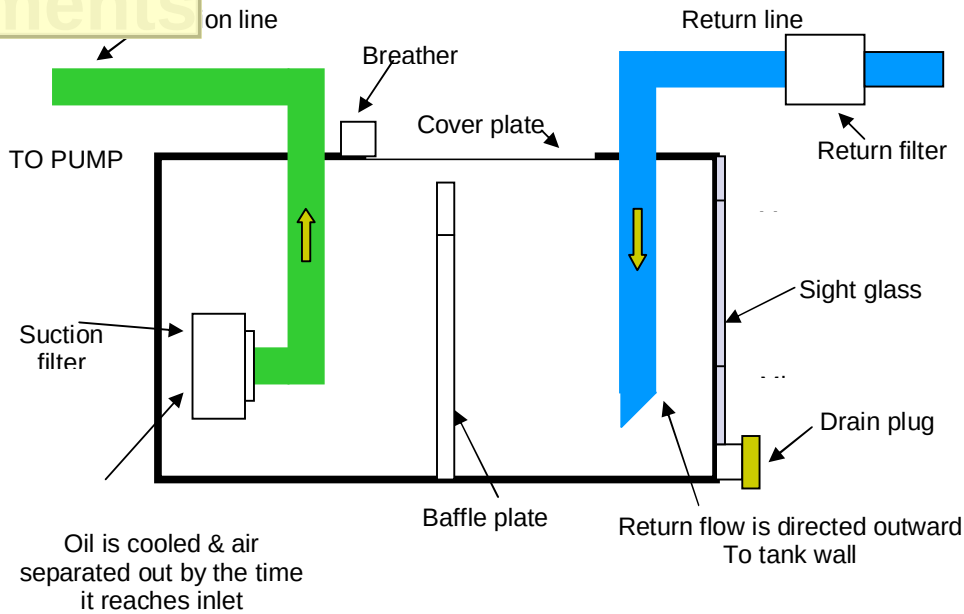
Qualities of hydraulic fluid:

1. Lowest possible density
2. Minimal compressibility
3. Viscosity not too low
4. Good viscosity temperature characteristics.
5. Good viscosity-pressure characteristics.
6. Good aging stability.
7. Low flammability.
8. Good material compatibility.

HYDRAULIC TANK

FUNCTIONS: The reservoir in the hydraulic system fulfils several task--

1. Acts as intake and storage reservoir for the hydraulic fluid required for the operation of the system.
2. Dissipates heat.
3. Separates air, water and solid materials.
4. Supports a built – in or built – on pump and drive motor and other hydraulic components such as valves, accumulator etc.



PARTS:

- ◆ **Baffle plate:** - It separates pump inlet line and return line. It is usually about 2/3 of the total height of the tank lower corner of the plate may be cut away to permits circulation. Thus the baffle plate
 1. Prevents local turbulence
 2. Allows foreign material to settle to the bottom.
 3. Give the fluid an opportunity to free of entrapped air.
 4. Helps heat dissipation.
- ◆ **Inlet and Return line:**-Most line of the tank terminates below the oil level. The line connections are often sealed. This prevents dirt from entering through these openings. Pumps inlet and return line must be below the oil level otherwise oil may be aerated and foaming may start. Connections above the oil level must be tightly sealed to prevent the entry of air in the system.
- ◆ **Air breather:** - An air breather is installed at the tank to vent air to the atmosphere and also atmosphere air exerts pressure on the oil surface through air breather, so screening element of air breather should be cleaned regularly.
- ◆ **Sight glass:** - This is provided to see the oil level in the hydraulic tank and oil is filled accordingly.
- ◆ **Drain plug:** - It is provided at the bottom of the tank to drain oil from tank at the time of cleaning the tank. Generally magnetic drain plug is provided to trap iron particles present in the oil.
- ◆ **Return filter:** - It is provided on the top of the tank. It traps contaminants present in oil which is returned from the hydraulic circuit to tank.

DISCIPLINE: HYDRAULICS (LESSONS: 16 SESSIONS: 21)

Lesson-III: Hydraulic Filter and Hydraulic Cooler

Session-3: Functions, Types, Importance of filtration, function of Hydraulic Cooler, Maintenance aspects.

FUNCTION & IMPORTANCE OF FILTRATION:

About 75% of hydraulic maintenance is caused by dirty oil. Dirt can cause untold damage to the entire system. The use of a filter is an important stage in keeping dirt cut off the system and hence reducing hydraulic maintenance.

Filter is a device whose primary function is retention, by some porous medium, of insoluble contaminants from a fluid. Porous medium simply refers to a screen of filtering material that allows fluid to flow through it but stops other materials by porous medium. A simple screen or wire strainer is rated in microns for filtering fineness or a mesh number or its nearest sieve number. The higher the mesh or sieve number, the finer the screen. When a filter is specified as so many microns, it usually refers to the filter's nominal rating and its value is in microns such that a 10 micron filter can trap particles having size more than 10 micron. So filters are of great significance in hydraulic systems for the reliable functioning and long service life of component.

It is the task of the filter to reduce the contamination to an acceptable level in order to protect the various components from excessive wear. It is necessary to use correct grade of filter and a contamination indicator is required in order to check the efficiency of the filter. Systems are often flushed using economical filters before commissioning.

TYPES:

1. **Inlet strainer & filter:-** Strainer is installed on pump inlet lines inside the tank, it is relatively coarse as filter being constructed of fine mesh wire. A 100 mesh strainer is suitable for thin oil, protects the pump from particles above about 150 μ in size. There are also inlet line filters usually mounted outside the tank near pump inlet. A fine filter (unless it is very large) creates more pressure drop that can be tolerated in on inlet line of a pump.
The filter must pass the full pump volume within the permitted inlet vacuum for that pump. The filter must provide bypass flow which is still within that limit where the filter element is blocked. Inlet filters should be used only to prevent large particles from entering the pump & causing catastrophic failure.
2. **Pressure line filter:-** This filter can trap much smaller particles than inlet line filter. Such a filter is used where system components such as valves are less dirt tolerant than the pump. The filter traps fine contaminants from the fluid as it leaves the pump and also protects the system in the event of a catastrophic failure of the pump. Pressure line filters must be able to withstand the operating pressure of the system as well as any pump pulsation.
3. **Return line filter:-** These filters can also trap very small particles before the fluid returns to the tank. Return line filter is necessary in a system with a high performance pump which has very close tolerance & usually cannot be sufficiently protected by an inlet line filter. Full flow return filter should have enough capacity to handle max. return flow without opening the bypass valve (non return valve) the performance of any return line filter depends on magnitude of flow and pressure changes.
The term "full flow" applied to a filter means that all the flow into the filter inlet port pass through the filtering element. In most full flow filters there is a bypass valve preset to open at a given pressure drop to divert flow past the filter element. This prevents the element from being subjected to excessive pressure which could cause collapse. The bypass opens when total flow can no longer pass through the contaminated element without raising the pressure.

MATERIALS:

There are two basic classifications of filtering material viz. (1) Absorbent (2) Adsorbent.

1. **Absorbent filter:** Absorbent filter medium traps particle by mechanical means. Absorbent media are divided into two basic types viz. surface & depth. Surface media is most commonly used for coarse filtration. These are usually used with strainers. These are made of closely woven fabric. Depth media are generally used for finer filtration and are made of a wide range of materials. It has layers of a fabrics or fibers which provide paths for the fluid to flow through. These are usually used with filters. Particles collect on a number of surfaces arranged in layers.
2. **Adsorbent filter:** Such a charcoal & fuller's earth should be avoided in hydraulic system, since they may remove essential additives from the hydraulic fluid.

SOURCES OF CONTAMINATION:

1. **Built-in contamination:** Hydraulic system manufacturers generally are careful to provide internally clean products but, in spite of these efforts, new equipment usually contains some built-in contamination. These contaminants might include burrs, chips, flash, dirt, dust, fibers, sand, moisture, pipe sealants, weld splatter, paints and flushing solutions.
2. **Ingress or environmental contamination** is contamination that is added to the hydraulic system during servicing or maintenance (or from lack of maintenance) or is introduced to the system from the environment surrounding the equipment. Dirt contamination during operation owing to wear, ingress via seals and tank ventilation, filling up or changing hyd. fluid, exchanging components, replacing hoses.
3. **Self-generated contaminations-** This type of contamination is created internally within the system by the moving parts of hydraulic components. These contaminants are produced by wear, corrosion, cavitations and decomposition and oxidation of the system fluid. Every internal moving part within the system can be considering a source of self-generated contamination for the entire system.

CONTAMINANTS CONTROLS: Contaminants can be controlled in following ways –

- i. Preventing contamination by keeping the system tight and using proper air and fluid filtration devices and procedures.
- ii. Establishing fluid change intervals so the fluid will be replaced before it breaks down. If necessary the fluid can be tested in the laboratory at specific intervals to help establish the frequency of change.
- iii. Keeping the reservoir filled properly to take advantage of its heat dissipating characteristics and to prevent moisture from condensing on inside walls.
- iv. Repairing all leaks immediately.
- v. The filters must provide sufficient dirt holding capacity for an acceptable interval between element changes

Beta Ratio: The beta ratio is also known as filtration ratio, is a measure of the particle capture efficiency of a filter element. It is therefore a performance rating.

$$\beta_x = \frac{\text{Number of particles in upstream}}{\text{Number of particles in downstream}}$$

Where,

x= size of particle in micron

Let no. of particles in upstream=5000, no. of particles in downstream=1000, x=10μ, then

$$\text{Beta Ratio, } \beta_{10} = \frac{5000}{1000} = 5$$

Now, particle capture efficiency of filter $\eta_{10} = (1 - 1/\beta) \times 100 = (1 - 1/5) \times 100 = 80\%$.

So the particular filter tested is 80% efficient at removing 10 micron and larger particles.

DISCIPLINE: HYDRAULICS (LESSONS: 16 SESSIONS: 21)

Lesson-IV: Hydraulic Hose and Fitting.

Session-4: Functions, Types, Hose specification: DIN, SAE & EN standards, Hydraulic Fittings, Precautions during mounting Hydraulic Hoses and Fittings.

FUNCTION: Piping is a general term which embraces the various kinds of conducting lines that carry hyd. oil between components plus the fittings or connectors used between the conductors. Flexible hoses are mostly used in track machines to carry hyd. oil from one point to another. These offer more convenience in making connections and servicing. These are used when the hyd. lines are subjected to movement. Hoses are fabricated in layers of synthetic rubber and braided fabric or wire braids. Wire braided hoses permit high pressure. The inner layer of hose must be compatible with hyd. oil used. The outer layer is usually of rubber to protect braid layer. Low pressure hoses i.e. suction and return line hoses are reinforced with single wire braid while medium and high pressure hoses have double or multiple wire braid.

TYPES:

1. **Suction Hose:** This hose is provided between tank and pump. This is low pressure hose and has single wire braid. Dash no. of hoses used in suction line are 32, 48 and 64.
2. **Pressure Hose:** This hose is provided between pump and actuator. This is medium and high pressure hose and has double wire braid or multiple wire braid. Dash no. of hoses used in pressure line are 4, 6, 8, 10, 12, 16 and 20.
3. **Return Hose:** This hose is provided between actuator and tank. This is low pressure hose and has single wire braid. Dash no. of hoses used in return line are 6, 12, 16, 20, 24 and 32.

HOSE SPECIFICATION

- i. EN (European Norm)- EN 853- 1 SN-Single wire braid, 2 SN-Double wire braid
- ii. DIN (Deutsch Industry Norm) –DIN 20022-2 Wire braid, DIN 20023- spiral wire
- iii. SAE (Society of Automotive Engineers) -100R1 – single wire braid, 100R2 – two wire braid, 100R5 – single wire braid, 100R9 – 4 spiral wire reinforced.

SAE 100R1:

Type A: This hose shall consist of an inner tube of oil resistant synthetic rubber, a single wire braid reinforcement, and an oil and weather resistant synthetic rubber cover. A ply or braid of suitable material may be used over the inner tube and/or over the wire reinforcement to anchor the synthetic rubber to the wire.

Type AT: This hose shall be of the same construction as Type A, except having a cover designed to assemble with fittings which do not require removal of the cover or a portion thereof.

SAE 100R2:

The hose shall consist of an inner tube of oil resistant synthetic rubber, steel wire reinforcement according to hose type as detailed below, and an oil and weather resistant synthetic rubber cover. A ply or braid of suitable material may be used over the inner tube and/or over the wire reinforcement to anchor the synthetic rubber to the wire.

Type A: This hose shall have two braids of wire reinforcement.

Type AT: This hose shall be of the same construction as Type A, except having a cover designed to assemble with fittings which do not require removal of the cover or a portion thereof.

SAE 100R5:

The hose shall consist of an inner tube of oil resistant synthetic rubber and two textile braids separated by a high tensile steel wire braid. All braids are to be impregnated with an oil and mildew resistant synthetic rubber compound.

SAE 100R9:

hose shall consist of an inner tube of oil resistant synthetic rubber, 4-spiral plies of wire wrapped in alternating directions, and an oil and weather resistant synthetic rubber cover. A ply or braid of suitable material may be used over the inner tube and/or over the wire reinforcement to anchor the synthetic rubber to the wire.

Type AT: This hose shall be of the same construction as Type A, except having a cover designed to assemble with fittings which do not require removal of the cover or a portion thereof.

Hose Parameters:

- i. Dash size- Pipes are represented generally in dash no. E.g. 4, 6, 8, 10, 12, 16, 20, 24, 32, 48, 64.
- ii. Inside diameter- Inner dia. of hose = dash no. $\div$ 16 (in inches)
- iii. Reinforcement over diameter
- iv. Maximum working pressure
- v. Minimum bend radius
- vi. Burst pressure

Hose failure due to:

1. Using wrong hose for the job.
2. Improper assembly & installation.
3. External damage.
4. Faulty hose.
5. Faulty equipments.

PRECAUTIONS WHILE MOUNTING HOSES:

1. The hose should be provided in the end filling properly.
2. It should be made long enough without tension.
3. It should be avoided to exceed the min bend radius.
4. Twisted hose should not be installed.
5. At vibrated place the hoses should be secured with proper packing.

FITTINGS:

Hose fittings may be either reusable (screw-together, bolt-together, etc.) or non reusable (crimp or swage). It is recommended that hose fittings have a swivel nut or an SAE split flange on each end so that hose assembly does not have to be turned or twisted for proper installation.

Two types of fittings are manufactured for hoses:

1. Swaged type or crimped type- which is non reusable.
2. Detachable type which has as socket and threaded nipple. This fitting can be used again and again until hose wear out or damages. The socket grips the hose & a nipple is inserted into this hose & screwed into the socket. This gives a firm strong attachment of the hose to the fittings.

PRECAUTIONS WHILE PROVIDING FITTING ON HOSE:-

1. The place of work should be cleaned first.
2. Rubber and wire cuttings should not be left in pipes.
3. Before providing fitting compressed air should be passed through pipes.
4. The other end of the pipe should not be left loose on the ground.
5. After preparing the pipe compressed air should be passed through pipes to remove any foreign material remaining inside.

Lesson-V: Hydraulic Seal and 'O' Ring **Session-5:** Functions, Types, Precautions during providing hydraulic Seals, Causes of Failure..

FUNCTION:

Seals are required to maintain pressure, to prevent fluid loss and to keep out contamination. Excessive leakage any where in a hydraulic circuit reduces efficiency and result in power loss. Mostly hydraulic components are built with operating clearances which allow a certain amount of internal leakage for lubrication purpose. Additional internal leakage occurs when component begins to wear. Internal leakages may cause temperature rise of hydraulic oil.

TYPES:

There are various types of seals used in hydraulic components.

(a)	Positive seals	These prevent even a minute amount of fluid from getting past.
(b)	Non positive seals	These allow a small amount of material leakage, such as the clearance of a spool in its bore to provide a lubricating film.
(C)	Dynamic seals	These are installed between parts which do move relative to one another, thus one of the part must rub against seal. Therefore, these seals are subject to wear.
(d)	Static seals	A seal that is compressed between two rigidly connected parts like flange joints. These do not wear fast and usually remain trouble free.

O-Ring Seals:

Probably the most common seal in use in modern hydraulic equipment is the O-ring. And O-ring is a molded, synthetic rubber seal which has a round cross-section in the free state. The O-ring is installed in an annular groove machined into one of the mating parts. At installation, it is compressed at both the inside and outside diameters. However, it is a pressure-actuated seal as well as a compression seal. Pressure forces the O-ring against one side of its groove and outward at both diameters. It thus seals positively against two annular surfaces and one flat surface. Increased pressure results in a higher force against the sealing surfaces. The O-ring, therefore, is capable of containing extremely high pressure. O-rings are used principally in static applications. However, they are also found in dynamic applications where there is a short reciprocating motion between the parts. They are not generally suitable for sealing rotating parts or for applications where vibration is a problem.

Backup (Non extrusion) Rings:

At high pressure, the O-ring has a tendency to extrude into the clearance space between the mating parts. This may not be objectionable in a static application. But this extrusion can cause accelerated wear in a dynamic application. It is prevented by installing a stiff backup ring in the O-ring groove opposite the pressure source. If the pressure alternates, backup rings can be used on both sides of the O-rings.

T-Ring Seals:

The T-ring seal is used extensively to seal cylinder pistons, piston rods, and other reciprocating parts. It is constructed of synthetic rubber molded in the shape of a "T", and reinforced by backup rings on either side. The sealing edge is rounded and seals very much like an O-ring. Obviously, this seal will not have the O-ring's tendency to roll. The T-ring is not limited to short-stroke applications.

Lip Seals:

Lip seals are low-pressure dynamic seals, used principally to seal rotating shafts. A typical lip seal is constructed of a stamped housing for support and installation alignment, and synthetic rubber or leather formed into a lip which fits around the shaft. Often there is a spring to hold the lip in contact with the shaft. Lip seals are positive seals. Sealing is aided by pressure up to a point. Pressure on the lip (or vacuum behind the lip) “balloons” it out against the shaft for a tighter seal. High pressure cannot be contained because the lip has no backup. In some applications, the chamber being sealed alternates from pressure to vacuum condition. Double lip seals are available for these applications to prevent air or dirt from getting in and oil from getting out.

Cup Seals:

A cup seal is a positive seal used on many cylinder pistons. It is pressure actuated in both directions. Sealing is accomplished by forcing the cup lip outward against the cylinder barrel. This type of seal is backed up and will handle very high pressures. Cup seals must be clamped tightly in place. The cylinder piston actually is nothing more than the backing plate and retainers that hold the cup seals.

Piston Rings:

Piston rings are fabricated from cast iron or steel, highly polished, and sometimes plated. They offer considerably less resistance to motion than leather or synthetic seals. They are most often found on cylinder pistons.

One piston ring does not necessarily form a positive seal. Sealing becomes more positive when several rings are placed side by side. Very high pressures can be handled.

Choice Of Seal:

A seal should have effective performance which has become a challenge of the high working pressure and fast cylinder speed. The choice of the seal is guided by following:-

- i. Surface finish
- ii. Loads
- iii. Temperature
- iv. Pressure

A seal may be of very good quality, but its surface life does not depend merely on seal material but is greatly influenced by surface finish and method of installation.

SEAL MATERIAL:- PTFE (Poly Tetra Fluoro Ethylene) SEAL

The material did not exhibit any change whatsoever when subjected to practically all known chemicals and its surface was so smooth that hardly any foreign substances remained. Moisture and solar radiation (sunshine) caused neither volumetric change nor disintegration and brittleness. The crystalline change associated with the melting point of the material starts at 327°C without there being any typical thermoplastic liquefaction. For the above reasons, process technology similar to powder metallurgy is utilized. PTFE powder is compressed into blocks or rods, sintered and then mechanically machined to the required shapes. Based on experience over the last 30 years, the materials industry has developed PTFE types that for certain defined applications can also thermo-plastically processed. The possibility of compounding i.e. matching physical properties to specific applications through the addition of fillers, is an important factor for the use of PTFE in the manufacture of seals and guide elements. In spite of its remarkable properties, pure unmixed PTFE has limited use for applications where high mechanical loading is required due to its tendency towards cold extrusion (creep)

Filler materials is particularly illustrated by:

- Ø Improvement in the flow strength.
- Ø Reduction of friction and wear.
- Ø Increase in strength.
- Ø Increase in thermal shape stability.
- Ø Increase in hardness.

The most important standard fillers are:

- Ø Glass fibers
- Ø Carbon/Graphite
- Ø Molybdenum disulphide (MoS_2)
- Ø Bronze
- Ø Polymers
- Ø Pigments

Special characteristics of PTFE:

At low temperatures : Even at -269°C (boiling point of Helium) PTFE still has residual extensibility, so that it can also be used under extreme conditions, e.g. in space. The temperature-dependent elongation or shrinking that occurs as with other plastics is reduced by the fillers.

At high temperatures: PTFE has exceptional thermal resistances, so that it can be used at temperatures up to 269°C (dependent on working conditions). Fillers have no influence on the PTFE's own thermal resistance. Most of the fillers are stable up to 400°C , so that they do not restrict high temperature use.

PRECAUTIONS DURING PROVIDING HYDRAULIC SEALS:

1. A special driver should be used for inserting lip-type shaft seals.
2. Cup seals must be clamped tightly in place.
3. Several piston rings are placed side by side for more positive sealing.
4. The packing is compressed by tightening a flanged follower ring against them.
5. There should be no dent mark on groove where seal is to be provided.
6. Seal of proper size should be used.
7. The operating temperature should always be kept well within the temperature range of the seals being used. At very low temperatures, a seal may become too brittle and at too high temperature, a seal may harden, soften or swell.
8. Seal must be lubricated prior to installation, otherwise the seal will wear quickly and leak.

CAUSES FOR SEAL AND 'O' RING FAILURES

1	Freedom to roll	Unsatisfactory groove shape and not following the groove completely causes early wear and leakage.
2	Reduced contact area	Due to unsatisfactory design causes single point contact causing early wear and leakage.
3	High temperature	Attacking the rubber material causing early damage.
4	Poor rubbing surface	Unclean surface, scratches on cylinder surfaces cause seals & O-rings to wear very fast.
5	Eccentricity	Cause loading one side only, due to which the seals wear on one side and get damaged.
6	Side loads	Cause loading one side only, due to which the seals wear on one side and get damaged.
7	Excessive stretching	Less in size as such O-ring have to be stretched too much causing early wear and sometimes even breaking.
8	Poor quality of rubber.	Seals wear due to poor quality of rubber and improper hardness.

Lesson-VI: Hydraulic Pump

Session-6: Definition, Functions and Classification, Working and Construction of Vane pump & Gear pump, Axial Piston Pump.

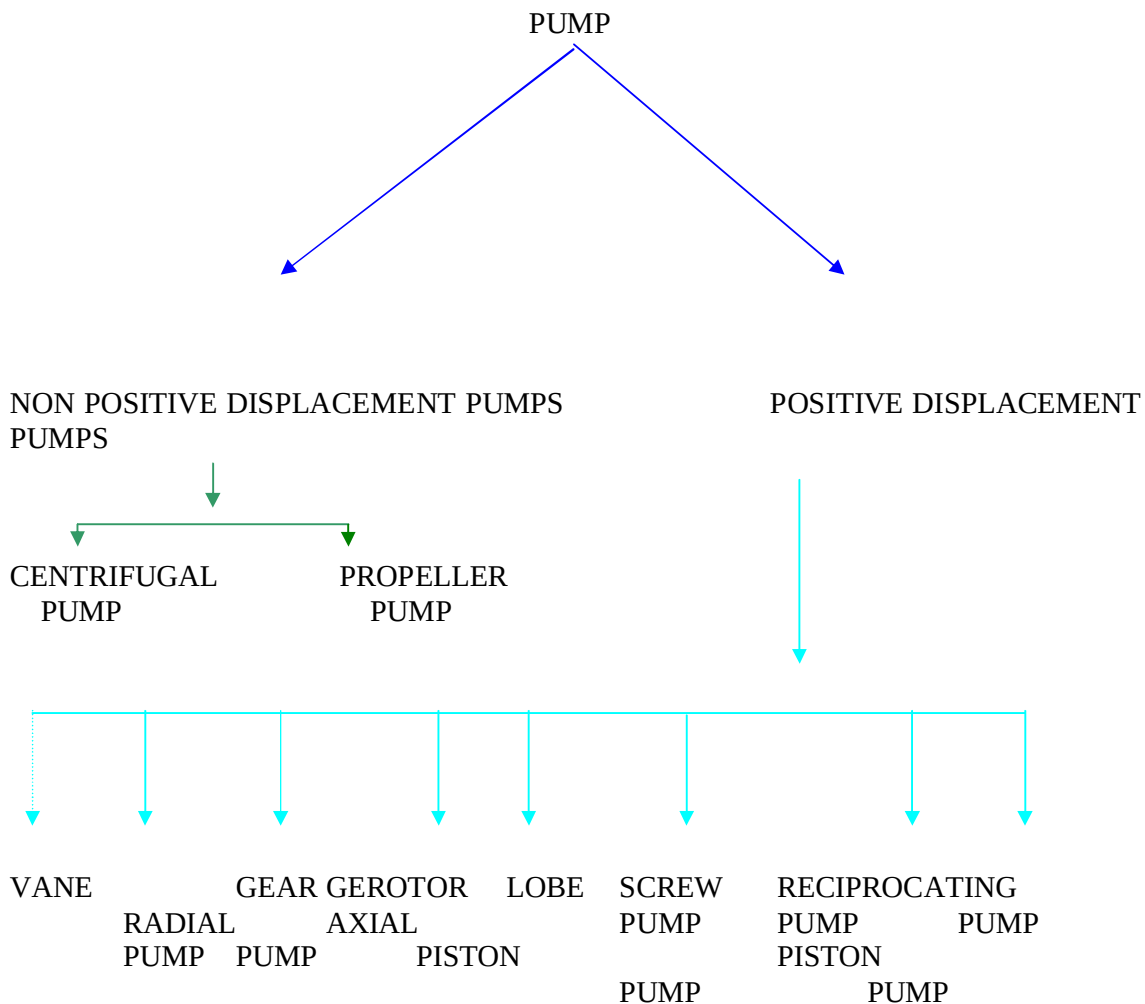
DEFINITION:

Pump is a device which converts mechanical energy into hydraulic energy. Basically pump creates flow from hydraulic tank to system.

FUNCTION:

The hydraulic pump in a hydraulic system converts mechanical energy in a drive unit into hydraulic energy (pressure energy). The pump draws-in hydraulic fluid due to partial vacuum and drives it out into a system of lines. The resistances encountered by the flowing hydraulic fluid cause a pressure to build up in the hydraulic system. Thus the fluid pressure in a hyd. system is not predetermined by the pump. It builds up in accordance with the resistances in extreme cases until a component is damaged. In practice it is prevented by installing a pressure relief valve directly after the pump or in the pump housing at which the max operating pressure recommended for the pump is set.

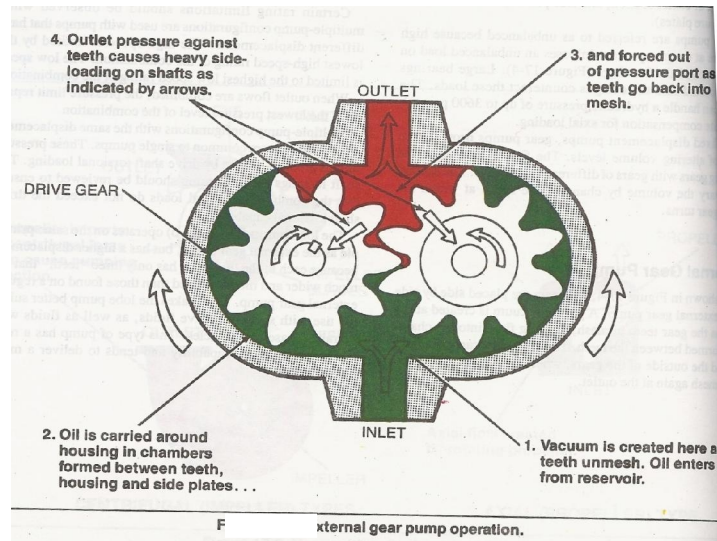
CLASSIFICATION:



Displacement:

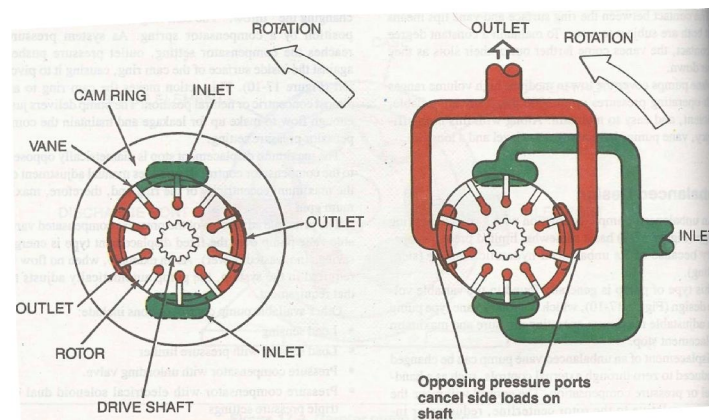
of a pump can be expressed as displacement per revolution or output in GPM. Displacement is the volume of liquid transferred in one revolution. It is equal to the volume of one pumping chamber multiplied by the number of chambers that pass the outlet per revolution. It is expressed in cubic inches per revolutions.

EXTERNAL GEAR PUMP:-



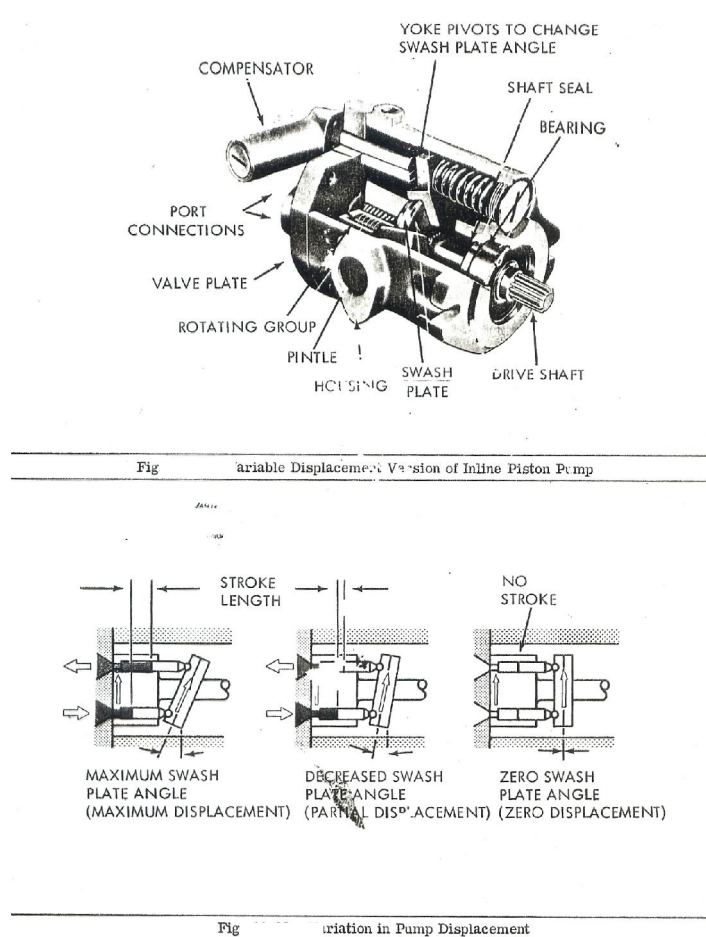
The pump consists of drive gear and a driven gear and closed in closely fitted housing. The gears rotate in opposite direction and mesh at a point in housing between inlet and outlet ports as the teeth of gear separate, fluid is drawn into the inlet chamber, due to partial vacuum the fluid is trapped between the gear teeth and housing and carried through two separate paths around the outlet chamber. As the teeth re-mesh, fluid is forced through the outlet port. Close fit of the gear teeth within the housing is required to provide a seal between inlet and outlet ports, minimizing internal leakage. High pressure at pump outlet imposes an unbalanced load on the gears and bearing supporting them. Most gear pump are fixed displacement pump. Internal leakage increases with wear. However the units are fairly durable and more dirt tolerant than other type.

VANE PUMP:



Basically this pump consists of a cam ring and a splined drive shaft carrying a slotted rotor. In each slot of rotor vane is fitted which is free to slide. Thus following the ring profile as the rotor rotates. The vanes are held against the ring contour by a combination of centrifugal force and system pressure. Since system pressure is not usually present until the pump develops flow, centrifugal force is necessary to eject the vanes when the unit is started. Once the pump is in operation fluid at system pressure is directed to each rotor slot to hold the vanes against the ring contour. The vanes divide the area between the rotor and cam ring into a series of varying size of chambers. The pump inlet is situated in that part of pump where the chambers are expanding in size and the vanes are moving outward from rotor. Fluid is drawn into the pump by the partial vacuum, caused by this expansion. At the pump outlet the chambers are reducing in size, the vanes moving inwards and the trapped fluid being forced through the outlet port..

PUMP:-



The circular arrangement of a piston is located parallel to the drive shaft in a fixed housing. The pistons run in a cylinder barrel which is firmly attached to the drive shaft by means of a key. The piston ends are of ball and socket design and run on slipper pads. These are held on a swiveling swash plate by means of holding discs. On the fixed displacement model the swash plate forms a part of the housing and therefore has a fixed swash angle. On the variable displacement model the swash plate is built into the housing and can be swashed to an angle of $\pm 15^\circ$ from centre. The piston travels a stroke relative to the swash angle which determines the pump displacement. When the swash plate is in centre position i.e. vertical to the drive shaft, the piston stroke and thus the pump displacement are zero. Swashing the pump over center changes the direction of flow without changing the direction of rotation. Control of the axial piston pump is via inlets in a port plate. At any one time four of these moving pistons are connected via these inlet ports with the tank side. Further four pistons are connected with the pressure side and displace fluid. A charge pump is mounted on the same shaft of the axial piston pump. This pump draws oil in from the hydro. tank and supplies it to the hydrostatic loop to keep it charged. The charge pump relief valve is set at 30 bar. The inlet ports of the axial piston pumps are known as low pressure port and high pressure port and denoted by the letters 'A' & 'B'. In either side a pressure relief valve is provided which is set at a certain pressure to suit that hydraulic circuit. Such relief valves are called cross relief valves.

DISCIPLINE: HYDRAULICS (LESSONS: 16 SESSIONS: 1)

Lesson-VI: Hydraulic Pump.

Session-7: Precautions during mounting, Troubleshooting, Aeration & Cavitation

PRECAUTIONS FOR INSTALLING HYDRAULIC PUMPS:

- 1) Clean entire oil from tank, remove scaling paint, dirt etc. flush it with fresh oil.
- 2) Clean the filter (choked filter may cause cavitation.)
- 3) Check suction and return lines for air Leakages, loose connection and loose connection in delivery will cause fluid leakage.
- 4) Sealant tape and shellac with pump should be used while providing fittings on the pump.
- 5) While assembling direction of rotation should be checked carefully.
- 6) Suction and delivery ports to be kept in desired directions.
- 7) All the bolts, O-rings should be properly fitted at proper torque.
- 8) All blades should be properly fitted. Keeping attention on their direction.
- 9) All bolts should be properly tightened at a uniform pressure.
- 10) Oil seal and bearing should be properly fitted.
- 11) Driving shaft should not be eccentric to the pump shaft.
- 12) All joints and pipe connection should be preferably applied with hard grease.
- 13) There should be no seepage from the pipes and pump premises should remain dry.
- 14) Start the pump at low r.p.m. preferably not more than 1000 r.p.m.
- 15) Run the pump at this rpm for about 20 min.. and then apply pressure to it.
- 16) observe the sound if it is taking air the sound is unpleasant and abnormal, at this stage stop the pump and check for air leakage.
- 17) If suction pipe is getting squeezed it means suction is choked, stop the pump and check filter and suction pipe.
- 18) After applying pressure if there is no sound, see heating effect on the pump this should be normal.
- 19) Now the pump is ready for working.
- 20) Do not start pump immediately after filling the tank a period of at least 12 hrs. so that entrapped air may escape from the oil. Normal recoument of oil should also be done after working hours.
- 21) During severe winter the pump must run idle before putting load, for 15-30 min., so that cavitation effect due to high viscosity at lower temperatures is avoided.
- 22) Max. running temperature of hydraulic fluid for day of working must not cross 80⁰ C.

AERATION: Aeration occurs on account of presence of air in dissolved and free form in the hydraulic oil and renders the oil spongy. Air is always present in small quantity in the oil say up to 10% but this increased inclusion of air in oil reduces its lubricating properties and ultimately reduces the life of the pump.

CAUSES: The following are the reasons of air inclusion in the oil.

1. Low oil level in the reservoir causes whirl pool at the intake and air is sucked by the pump along with the oil.
2. Restrictions in inlet pipe cause pressure to drop, which helps suction of air into pump.
3. If the return pipe opens above the hydraulic oil level in the reservoir it accompanies foaming in the tank and air inclusion.
4. Turbulent flow (intake and return) also causes air inclusion.
5. If the filter cartridge joint is not perfectly sealed or there is any void in the suction line, the pump sucks air through the same.
6. Leaking pump shaft seal, cylinder rod seals or other leaking unnumbered connections in the intake line cause aeration.

EFFECTS OF AERATION: Aeration causes lack of lubrication, erodes the end plates of pump and vane tips are also worn out earlier. The vanes bounce and cause irregular ripples on the inner side of the cam ring. Wearing of these fast moving parts create excessive clearance between the end plates and rotor as well as between vanes/blades and cam ring and ultimately

s. The pump stops functioning properly and can not build up pressure thus the pump reaches a premature death.

CAVITATION:It is a sort of vacuum created in the hydraulic oil which breaks the fluid into layers or cavities and the fluid does not fill the line perfectly. It can occur equally in pump, motor or cylinder etc.

CAUSES:The following are the probable causes of cavitations in the pump and other hydraulic equipments:-

1. Filter is clogged.
2. Sharp bend in the suction line.
3. Obstruction in suction line.
4. High viscosity hydraulic oil used in machine.
5. Pump inlet is too high above the oil level in the tank.
6. Tank, if not ventilated properly-oil shrinks in volume as it cools.
7. The load is more than the delivery of the pump.

EFFECTS OF CAVITATION:The effects in case of cavitations are similar to those occurring in aeration i.e.

- i. Erosion of end plates.
- ii. Rippled cam ring.
- iii. Worn-out vanes tips and loose in slots.
- iv. Pitting in the cam ring near inlet port.

TROUBLE SHOOTING :

PROBLEM	CAUSES	REMEDIES
1. Pump not delivering oil. ring choked. low in Pump shaft or rotor suction line and replace	1. Pump driven in wrong wrong direction. or not. If not change the direction 2. Intake filter or pipe 3. Fill the tank with hydraulic the tank. oil. 4. Replace the pump shaft or rotor broken. line.	1. We can check the pump rotation by hand priming, pour the oil in intake port and rotate the shaft and see if the oil is coming from outlet by repositioning the cam turned by 90°. 2. Clean or replace the faulty one. 3. Oil level too 4. 5. Air traps in suction 5. Check the
2). Pump making noise.	1). Oil level too low. 2). Restricted or partially clogged intake filter or line. 3).Tank is not vented properly. 4).Viscosity of oil too high. 5).Air leak at pump intake pipe joints.	1). Fill the tank with hydraulic level that more air influence is prevented. 2). Clean or replace the intake filter or line. Suction filter should be changed in time. 3).Air breather screening element should be cleaned regularly, so that atmospheric pressure exert effectively on the oil surface in tank and good suction may take place 4).Use proper grade oil. In winter Season oil becomes thick so no free flow takes place, warm up the oil by starting pump for few minutes. 5).Check for any loose connection or joint and tighten them.

3). Bearing failure.	<ol style="list-style-type: none">1). Chips or other contaminants.2). In adequate lubrication.3). Pump running too fast.4). Excessive or shock loads.	<ol style="list-style-type: none">1). Replace bearing and check source of contaminants.2). Excessive heating of oil should be avoided.3). Adjust the R.P.M of prime mover4). Excessive load due to operating pressure may damage bearing so reduce operating pressure.
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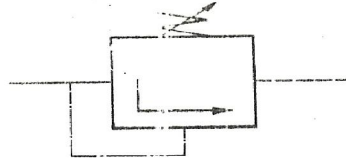
DISCIPLINE: HYDRAULICS (LESSONS: 16 SESSIONS: 21)

Lesson-VII: Pressure Control Valve Session-8: Working and Construction of Relief Valve & Unloader valve, Pressure reducing valve, Trouble shooting.

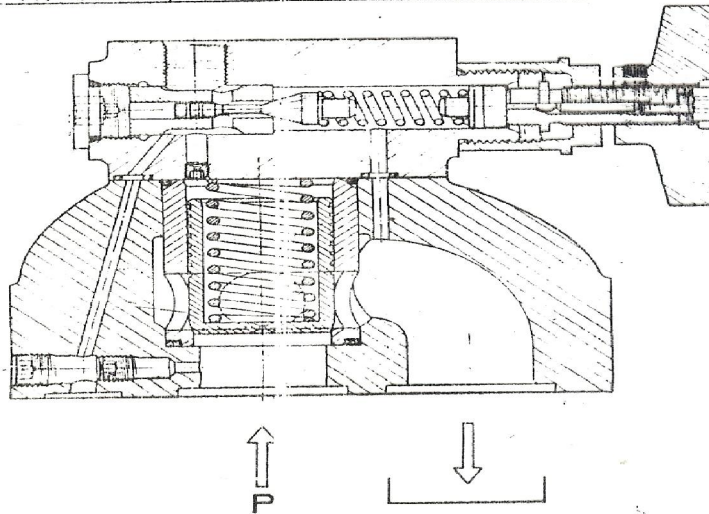
HYDRAULIC VALVES: In hydraulic systems, energy is transferred between the pump and the consuming device along appropriate lines. In order to attain the required values – force or torque, velocity or rpm – and to maintain the prescribed operating conditions for the system, valves are installed in the lines as energy control component. These valves control or regulate the pressure and the flow rate. In addition each valve represents a resistance.

RELIEF VALVE:

RELIEF VALVE VALVE DE SURPRESSION



Type	Druckbereich Pressure range Zone de pression	Durchflußmenge Flow rate Quantité de Débit
HY-502.00	0 – 350 bar	220 l/min
HY-506.00	fix 170 bar	220 l/min
HY-506.01	fix 90 bar	220 l/min



It is found in virtually every hydraulic system. It is a normally closed valve connected between the pressure line and the tank. Its purpose is to limit pressure in the system to a preset maximum by diverting some or all of the pump's output to tank when the pressure setting is reached.

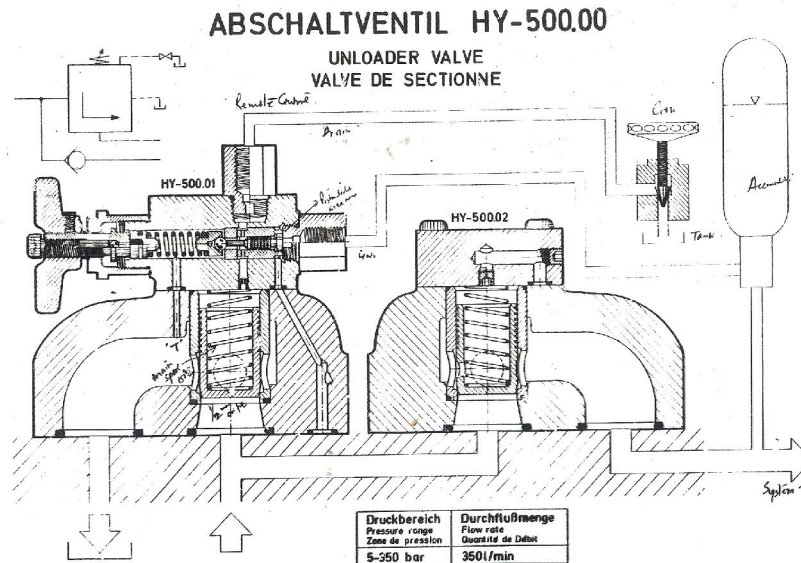
Relief valve consists in two sections (1). Cover section which includes poppet, spring, and adjusting screw & vent connection. (2). Body section which contains the piston, spring & seat. The valve pressure setting is determined by the adjusting screw position which varies the heavy spring compression. The balanced piston is normally held against the seat by the light spring. System pressure is present in lower chamber of piston and also passes to the upper chamber through a pilot line. With system pressure less than the valve setting the pilot poppet is held against its seat by spring force. Pressure in both chambers equalizes and the piston is hydraulically in balance and held against its seat by the light spring.

When system pressure exceeds the heavy spring setting and forces the poppet away from its seat. Fluid then flows through poppet seat to tank port. The pressure in upper chamber is limited by the setting of the heavy spring. When pressure in lower chamber exceeds upper

tly, pressure unbalance overcomes the force of the light spring and lifts the piston. Excess fluid then flows past the bottom of the piston to tank. When system pressure drops below the valve setting, the popper reseats. Control flow through pilot line stops and pressures in both chambers are again effectively equalized. The light spring then forces the piston towards the seat when the balanced piston is closed against its seat, the unloading stops. The pump delivery now goes to the system.

Venting: Relief valves can be vented to unload pump delivery to tank in the manner – connect a shutoff valve to the vent port of the main relief valve. This removes pressure at the top of the balanced piston. Pressure in the lower chamber overcomes the light spring, unseats the balanced piston and diverts all the delivery of pump to tank.

UNLOADER VALVE:



An unloader valve is used in accumulator charging circuit to (i) limit max. pressure and. (ii) unload the pump when the desired accumulator pressure is reached. In construction, it contains a compound, balance piston relief valve, a check valve to prevent reserve flow from the accumulator & a pressure operated plunger which vents the valve at the selected pressure.

Normally, the relief valve piston is in balance and is held seated by its light spring. Flow is through the check valve to the accumulator/system. When preset pressure has been reached, the relief valve poppet has unseated limiting pressure above piston and on the poppet side of the plunger. Further increase in system pressure acting on the opposite end of the plunger has caused it to force the poppet completely off its seat, in effect, venting the relief valve and unloading the pump. The check valve has closed permitting the accumulator to maintain pressure in the system.

Because of the difference in area between the plunger & poppet seat (approx. 15%), when pressure drops to about 85% of the valve setting, the poppet & piston reseal & the cycle is repeated.

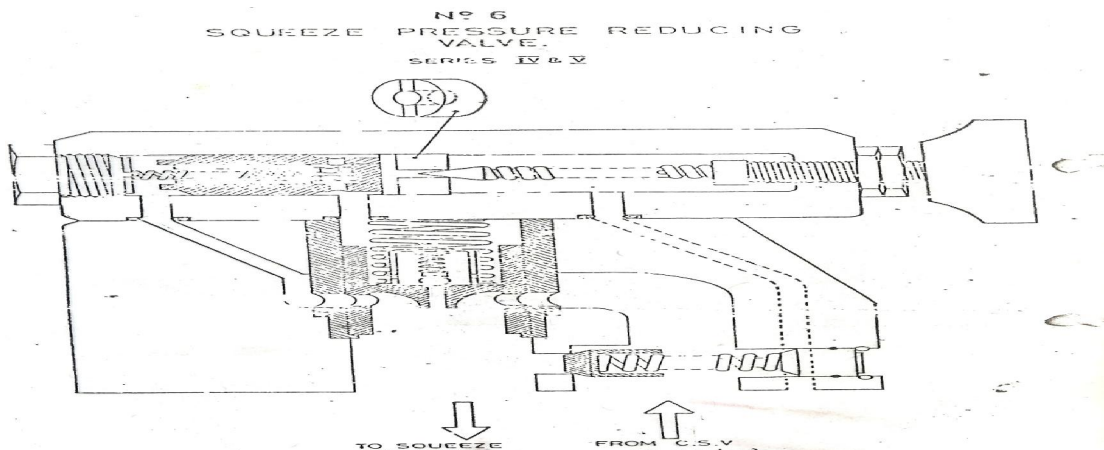
NOTING IN UNLOADER VALVE:

Sl.No.	FAULT	REASON	REMEDIES
1	No pressure in the circuit	1. Defective pump	Check the pump and replace if required
		2. Leakage in the system	Check the leakage and rectify the fault
2	Pump O.K. no leakage in the system, still no pressure	1. Choked up orifice of main spool	Clean the orifice.
		2. Secondary stage vent open to tank	Close the vent
		3. Safety valve at Zero setting	Set safety valve as per value written in the circuit.
3	Pressure does not rise to required value even after complete tightening the control knob	1. Worn out pump is not able to push the fluid against set resistance.	Replace the pump.
		2. Leakage in the system	Check the leakage and rectify the fault.
		3. Leakage at seat of ball in control head	Check the seat and ball. If defective replace it.
		4. Safety valve setting lower than unloader valve setting	Set safety valve 10-15 % higher than unloader setting.
4	Unloader does not unload	1. Nil or low nitrogen pressure in the accumulator	Check pressure recharge the accumulator
		2. Punctured bladder	Change the bladder.
		3. Leakage in the system	Locate fault and rectify the leakage.
		4. Less delivery from pump than demand of the circuit.	Replace the pump
		5. Partial leakage at ball seat in control head	Replace the ball and seat.
		6. Wrong connection of control head spool from the system.	Correct the connection.
		7. Vent line of unloader connected to return line. drain line.	Connect line to

NOTING IN RELIEF VALVE

Sl. No.	FAULT	REASON	REMEDIES
1	No pressure in the circuit	1. Defective pump flow 2. Leakage in the system	Check flow with the Meter and replace pump if Required. Arrest the leakage.
2.	Pump OK & no leakage in sys. still no pressure.	1. Choked up orifice of main spool 2. Secondary stage vent open to tank	Take out the spool and clear the orifice. Close the vent
3.	Pressure does not rise to required value even after complete tightening the control knob.	1. Excessive clearance in pump matching parts due to wear 2. Leakage in the system 3. Leakage at poppet seat 4. Under size valve in relation to flow of pump.	Replace the pump. Check the leakage & rectify the fault. Check the seat and poppet, if defective Replace it. Provide proper size valve.
4.	Valve sticks	1. Valve stressed. 2. Oil temperature too low. 3. Piping stressed. 4. Drain line under pressure.	Loosen bolts and tighten uniformly. Warm up system by starting hydraulic system. Providing proper bends in piping. Install line or separate from return line.

PRESSURE REDUCING VALVE:



Pressure reducing valves are normally open pressure controls used to maintain reduced pressure in certain portions of the system. They are actuated by pressure sensed in the branch circuit & tend to close as it reaches the valve setting thus preventing further build-up. The pilot op. pressure reducing valve has a wider range of adjustment & generally provides more accurate control. The op. pressure is set by an adjustable spring in the pilot stage in the upper body. The spool is hydraulically balanced through an orifice in its centre and the light spring holds it in the wide open position. When pressure has reached the valve setting and the pilot valve is diverting flow to the drain passage limiting pressure above the spool. Flow through the orifice in the spool creates a pressure difference that moves the spool up against the spring force. The spool partially closes the outlet port to create a pressure drop from the supply to the branch system.

TROUBLE SHOOTING:

Sl. No.	Problems	Causes	Remedies
1.	Valve flutters	1. Valve seat defective	Exchange parts
		2. Pilot control defective	Repair pilot control
		3. Oil speed too high	Install valve of greater nominal size
		4. Wrong oil grade	Respect oil recommendations
		5. Dirt in system	Flush system if needed pickle and flush out
		6. Damping defective	Repair valve or change spring
2.	Valve sticks	1. Valve stressed	Loosen bolts and tighten uniformly
		2. Oil temperature too low	Warm up system through pump or install heating
		3. Piping stressed	Incorporate balancing bends
		4. Drain line lacking or under pressure	Install line or separate form return
		5. Dirt in system	Flush system or if needed pickle and flush
		6. Wrong oil grade	Respect oil recommendations
		7. Water condensation in system	Check cooler and check system for condenser effect
		8. Oil gumming	Clean spool and if needed change oil
		9. Body parts wrongly fitted	Observe assembly sequence in service instructions
		10. Wrong seals	Replace seals prescribed
3.	Valve does not function	1. Valve spring broken	Change spring
		2. Valve sticks	Establish cause and repair defect
4.	Valve overheats	1. System temperature too high	Observe maximum pressure
		2. Oil speed too high	Install valve of greater nominal size

DISCIPLINE: HYDRAULICS (LESSONS: 16 SESSIONS: 21)

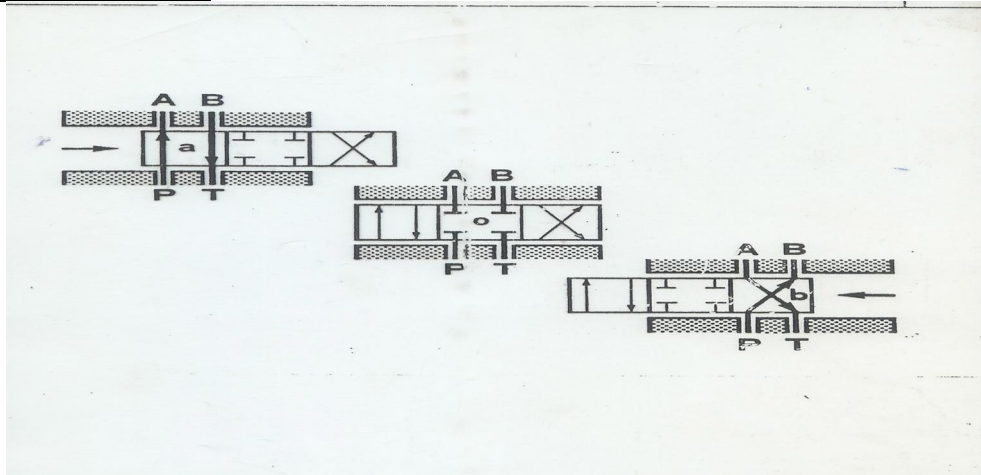
LESSON-VIII: Direction Control Valve Session-9: Function and Types such as Spring centered valves; Spring offset valves, Check valve, POC valve, Trouble shooting.

FUNCTION: There are several types of valves in hydraulic system. Some are used to limit and regulate the pressure, while other controls the direction of fluid flow. The direction of pressurized fluid is controlled by D.C. valve and thus the direction of movement. They can be simple check valve, more complicated pilot and solenoid operated valves. It can be manually or automatically operated. Valve body has a precision machined bore in which a very close tolerance spool is suspended on a film of hydraulic fluid. Spool lands and body cavities are designed to divide the bore openings into separate chambers. Ports in the body lead into this chambers so that spool positions determine which ports are opened or closed.

TYPES: There are three types of D.C. valves:-

1. Spring centered valve.
2. Spring offset valve.
3. Pilot operated valve.

Spring centered valve:



This valve is provided with spring and centering washer at each end of spool. The spring and washer centre the spool with in the valve body when solenoids are de-energized where it is necessary to stop or hold an actuator at some mid point in its travel, a 3 position valve is used. The third position is achieved by centering springs. Flow conditions in this centre or neutral position are determined by the work requirement of the system.

Spring offset valve:

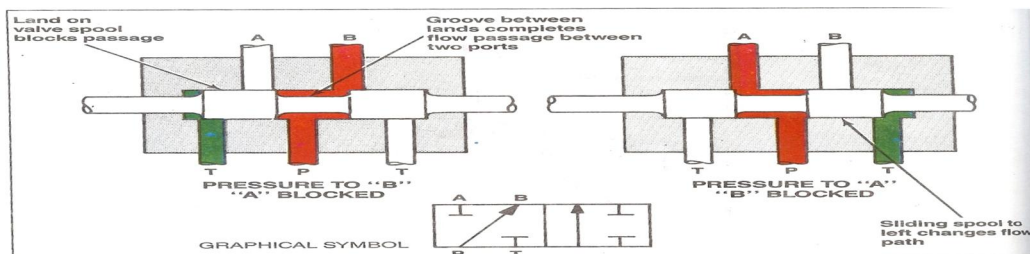


Figure 8-11. Two-way spool valve slides in machined bore.

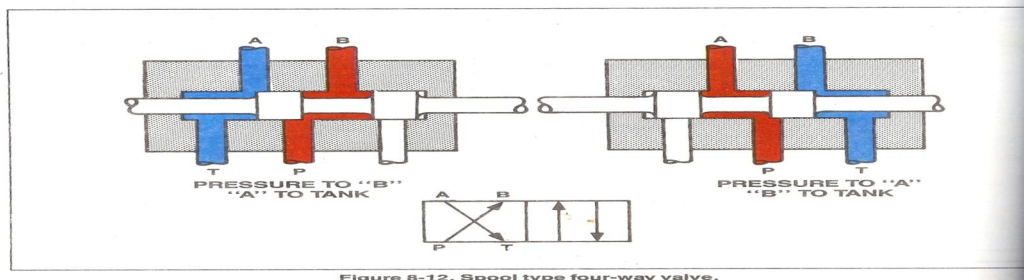
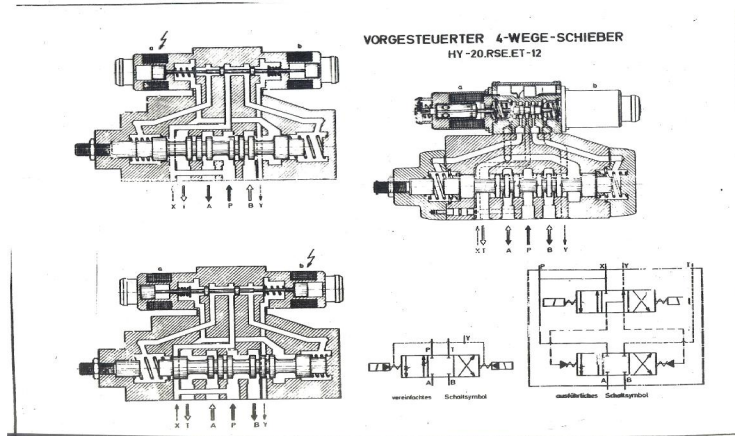


Figure 8-12. Spool type four-way valve.

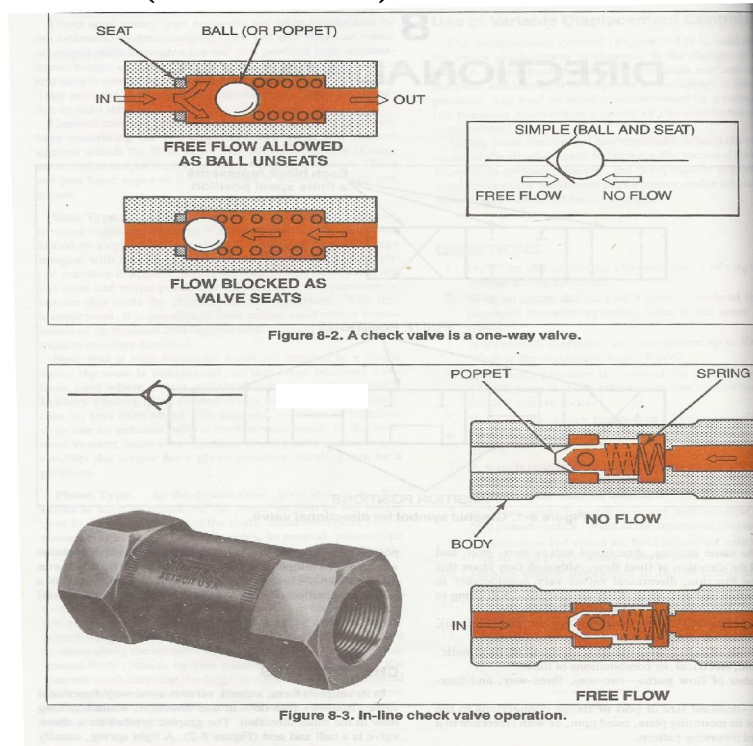
one solenoid only. Spring returns the spool to offset position when the solenoid is de-energized.

Pilot operated valve:



In larger valves much force is required to shift the spool which can not be shifted by 24 V D.C. Therefore pilot operated D.C valve is used. This valve is operated by pilot pressure against either spool end. The pilot oil furnished from a small 4 way valve i.e. is pilot valve which is actuated by solenoids. Thus we may control high flow rates with low solenoid power. Pilot valve or master valve is mounted on top of the larger “slave valve”. The normal position of pilot valve is A – B to T.

NON RETURN VALVE (CHECK VALVE):



Non-return valves block the flow in one direction and permit free flow in the other. As there must be leaks in the closed direction, valves are always of poppet design and are constructed according to the following basic principle.

The sealing element (generally a ball or cone) is pressed against an appropriately shaped seat. The valve is opened by volumetric flow in the flow direction, the sealing element being lifted from the seat.

PISTON OPERATED CHECK VALVE:

Pilot operated check valve designed to permit free flow in one direction and to block return flow until opened by a pressure signal. This valve is used to support vertical cylinders which come downwards due to leakage in D.C valve. Normal position of D.C valve is always A – B to tank. It is a variation of directional poppet valve and commonly used in hydraulic system. It works on the principle that in order to allow and additional flow over the valve seat in opposite direction a small cylinder with a piston and piston rod acts on the closing part and lifts it from the seat when pressured the area ratio between control piston and valve seat is the deciding factor for the operation of valve.

LOGIC VALVE (CARTRIDGE VALVE):

Refinements in hydraulic system development have led to greater use of manifold blocks. A manifold block greatly reduces the number of fittings required for the interconnecting lines between components in a system. This eliminates many potential leakage points and reduces fluid waste from leakage. A cartridge valve is inserted into a standardized cavity in a manifold block and held in place with either self-contained screw threads or a cover secured with bolts to complete the cartridge valve design concept.

Cartridge valves are two types: (1) Slip-in cartridge valves and (2) Screw-in cartridge valves.

Advantages of Cartridge valve:

Cartridge valves provide several advantages over conventional line-or subplate-mounted spool-type directional, pressure, and flow control valves. In many applications, the advantages include:-

1. Greater system design flexibility.
2. Lower installed cost.
3. Smaller package size.
4. Better performance and control.
5. Improved reliability.
6. Higher pressure capability.
7. More efficient operation.
8. Elimination of external leakage and reduction of internal leakage.
9. Greater contamination tolerance.
10. Faster cycle times.
11. Lower noise levels.

Operation of Slip-in Cartridge Valves:

These valves are used in hook lifting-lowering circuit of Unimat machine. Most Slip-in cartridge valves are poppet type elements that are normally controlled by another valve to provide a complete hydraulic function. These valves are similar to poppet check valves and consist of an insert assembly that slips into a cavity machined into a manifold block. A control cover bolted to the manifold secures the insert within the cavity. The insert includes a sleeve, a poppet, a spring and seals.

The cartridge valve insert can be viewed as the main stage of a two-stage valve. It has two main flow ports, “A” and “B”. Drilled passages in the manifold connect the “A” and “B” ports to other cartridge or to the operating hydraulic system. Similarly, a drilled pilot passage in the manifold connects the control port “X” as desire.

Notice the orifice in the drilled passage between the “X” port and the spring chamber “AP”. The purpose of this orifice is to reduce the speed at which the valve poppet opens and closes. Various orifice sizes are available to optimize or tune cartridge response in relation to that of the entire hydraulic system. The hydraulic system designer can select the orifice size that provides maximum operating speeds with minimum hydraulic shock.

DURING MOUNTING D.C. VALVE:

1. On solenoid operated D.C. valve make sure that the electrical ground is connected to the valve that prevents the possibility of shock hazards developing if a coil were to short out to the frame
2. The number of bends in tubing should be kept to a minimum to prevent excessive turbulence and friction of oil flow. Tubing must not be bent too sharply the recommended radius for bents is three times more than the pipe inside diameter.
3. The selection of valve should be according to the circuit.
4. The normal configuration of valve should be checked. Pour hydraulic oil in P port and check the position of A, B and T port.
5. O – Ring should be checked on the grooves provided between valve and base plate.

TROUBLE SHOOTING

PROBLEM	CAUSE	REMEDIES
1.Valve spool stick.	1). Dirt in the system. 2).Body parts wrongly fitted. 3).Rusting due to water	1). Disassemble, clean and re- assemble 2). Fit properly. Clean 3). Clean or replace if required.
	Condensation	
	4). Solenoids not operated 5). Spool is stressed.	4). Check electrical supply and source 5).Check surface, clean, tighten the bolts. Oil film should be available between valve body and spool.
2.Solenoid not function-1).Faulty electrical circuit.	ing	1). Check and rectify.
	2).No current.	2). Check the electrical wires and supply.
	3).Coil burnt out.	3). Replace
3.Leakage in valves	1).Connections not sealed	1).Check and rectify.
	2).Wrong seals	2).Replace by proper size.
	3).Defective valves, cracks	3).Repair or replace.
4. Valve overheats	1) System pressure too high 2) Wrong oil grade 3) Dirt in the system 4) Faulty electric circuit 5) Spool defective	Reduce pressure setting Use proper grade oil Flush system and clean the valve Check electric circuit Repair spool

Lesson-IX: Proportional Valve, Servo Valve and Flow Control Valve .

Session-10: Function and Troubleshooting.

FUNCTIONS OF PROPORTIONAL VALVE:

- Ø Proportional valves control and vary pressure, flow, direction, acceleration and deceleration.
- Ø They are adjusted electrically are actuated by proportional solenoids.
- Ø Output flow is proportional to the input signal.
- Ø By varying the input signal solenoid adjusts the spool movement to vary the flow through the valve.
- Ø To control the speed of the spool a gradually increasing or decreasing signal (a ramp function) is fed to the control amplifier and thus we get a smooth, shock free movement.
- Ø Used for Tamping unit lifting-lowering and satellite drive.
- Ø Maximum voltage 24V DC, current range-250mA to 750mA
- Ø For Tamping Unit Lowering current-650mA
- Ø For Tamping Unit Lifting current-600mA

Working of Proportional Valve:

D.C conventional valves are ‘Yes’ or ‘No’ type valve. These valves are completely ‘OFF’ or ‘ON’ type that means either the ports will be completely closed or completely opened and these types of valves are known as finite positioning valves. During operation the movement of actuator is not controllable.

To get a controlled and measured amount of actuation, other types of valves known as proportional valves has been introduced and such valves are known as infinite positioning valves. These valves are also known as direction cum flow control valve. To get measured amount of correction or actuation and accordingly the movement of spool of the valve is proportionate to the current. It means what ever amount of correction or actuation we need. That only will be done. Neither this will be less nor will be more.

In this valve how much amount of current flow through coil, proportional amount of fluid will pass through it. It means its operation is proportional to signal it receives i.e. as movement will be such that it corresponds to the controlling signal. Higher the amounts of signal, higher the actuation. Lower the amount of signal, lower the actuation will be. So we need a proportional movement and proportion actuation.

The amount of movement of the spool in either direction is electrical from an electrical i/p signal. This signal is converted via an electrical amplifier to a current signal to the relevant solenoid the force generated moves the main spool against the main spring. The positional transducer then ascertains the actual position of spool and feeds this back as a voltage signal to the amplifier. The input signal and actual values are then compared electrically. From these two values a signal is generated and fed to the solenoid in order to give a defined position to the main spool. The main spool has metering slots cut into it which give a progressive flow characteristic.

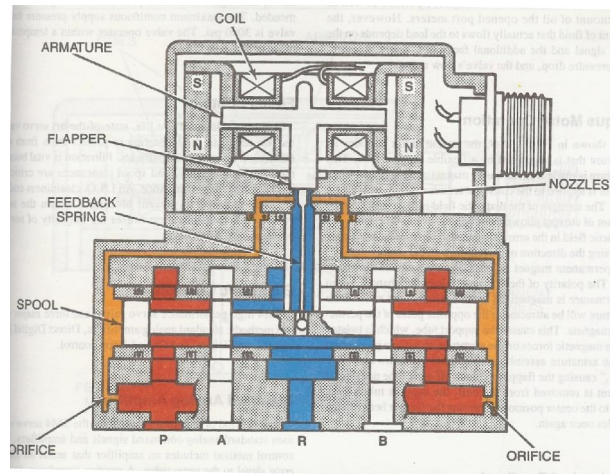
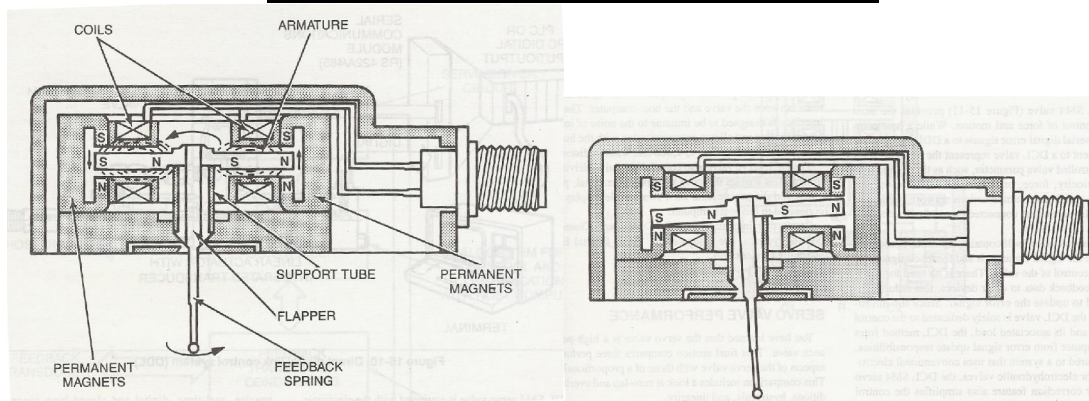
NOTING OF PROPORTIONAL VALVE:

Sr.No.	Trouble	Causes	Rectification
1.	Spool sticks	a) Spool stressed b) Dirt in the system c) Body parts wrongly fitted d) Wrong seals e) Oil temperature too high f) Spool defective g) Return pipe under high pressure	Loosen union and tighten uniformly. Clean the valve and flush the system. Dismantle valve, observe assembly sequence and reassemble. Replace seals prescribed. Check cooling circuit. Repair or replace. Dismantle the connection and clean. If required lead pipe separately to tank.
2.	Proportional valve does not function.	a) Proportional solenoid defective b) Electric circuit faulty c) Proportional filter clogged d) No current	Replace. Check circuit & PCB. Replace. Check electrical installation.
3.	Proportional valves overheat.	a) Oil temperature too high b) Wrong oil grade c) Dirt in the system d) Faulty electrical circuit e) Spool defective	Check cooling circuit, reduce pressure setting. Use recommended oil. Flush system. Check and rectify. Repair or replace.

SERVO VALVE:

- Ø Servo valve is a directional valve that may be infinitely positioned to control of both the amount and the direction of the flow. A servo valve coupled with the proper feedback sensing devices provides very accurate control of the position, velocity, or acceleration of an actuator.
- Ø Small input signal causes a large output of hyd. Power.
- Ø A low power control signal can produce output of several hundreds horse-power.
- Ø In airplanes, jet planes servo valves are used for fast response.
- Ø Used in lifting and lining circuit in 09 CSM, 09-3X, Unimat-3X, new Duomatic.
- Ø For track lifting – 2nos and for alignment- 1no servo valve is provided.
- Ø Voltage-3V DC, Current-15mA.
- Ø Contaminated oil is not desirable.
- Ø Maintain the oil cleanliness to NAS-5 class.
- Ø Before installing the servo valves flush the system.
- Ø Filter should be replaced in non-contaminated atmosphere.
- Ø Null should be adjusted properly, if null gets disturbed.

Working of servo valve:



Servo valve consist of an electrical torque motor, nozzle flexure tube, flapper and sliding spool. In the torque motor there are upper and lower pole plates, permanent magnet and an armature. The armature is supported for limited movement by a flexure tube. The flexure tube acts as a seal between the electromagnetic and hydraulic portion of the valve. The coils surround the armature one on each side. The flapper is rigidly attached to centre of armature. The flapper extends down inside and passes between two nozzle tips and flapper. Flapper motion varies the nozzle openings. The pressurized oil is supplied to each nozzle through a filter and inlet orifices. Differential pressures caused by flapper movement between the nozzles are applied to the ends of the valve spool. Due to nozzle area difference force develops accordingly more on one side and spool is shifted and 'P' may connect 'A or B'

your requirement. A feed back wire is deflected by spool movement so that feed-back torque is applied to the armature.

Input signal in the torque motor coils causes clockwise or anticlockwise torque on the armature. This torque displaces the flopper between the two nozzles. Thus pressure difference is created due to area difference in nozzle and moves the spool either left or right. The spool displacement causes a force in feed back wire, which opposes the input signal torque. Spool movement continues until the feed-back wire force equals the input signal force. So the spool stops and remains displaced until electrical input changes to a new level. The actual flow from the valve to the load will depend upon the load pressure. In neutral position leakage rate is 0.005 cc/sec.

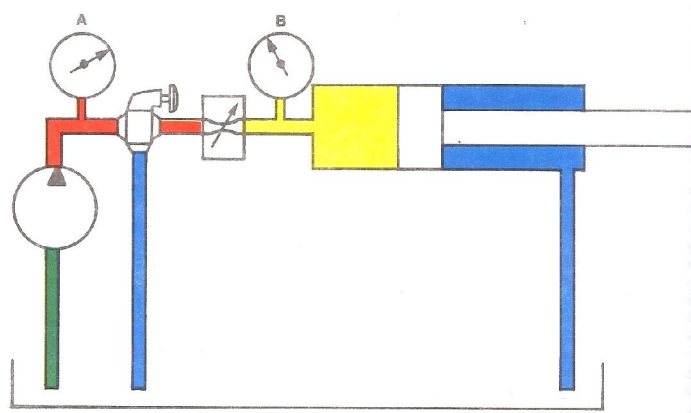
TROUBLESHOOTING OF SERVO VALVE:

Sr. No.	Fault	Causes	Rectification
1.	Servo valve spool sticks.	a) Feed tube dirty b) Fine filter dirty c) Mechanical return sticks d) Valve stressed	Check system for dirt and clean filter. Check system for dirt and clean filter Valve should be dismantled. Loosen unions and tighten uniformly
2.	Servo valve does not function.	a) Electric circuit defective b) Rotary magnet system defective c) No differential current d) No pressure e) Oil gummy f) Oil temperature too high g) Servo filter clogged	Check electric circuit. Repair system or replace torque motor. Check electrical installation. Check pump and relief valve. Clean valve, flush system and change oil if needed. Check cooling circuit, check for any line restrictions and reduce pressure setting. Replace filter.
3.	High null basis (High input current required to maintain the hydraulic cylinder stationary)	a) Incorrect Null adjustment b) Partially plugged inlet orifice assembly c) Partially plugged filter element. d) Partially plugged Nozzle	Readjust the null. Clean the inlet. Replace the filters element. Servicing required.
4.	Out flow obtain from one part only	Plugged inlet orifice	Clean inlet orifice.
5.	Low flow gain (Problem in getting high speed)	Plugged button filter	Replace the filter element.
6.	High threshold (jerky, hunting motion)	Sticky spool	Servicing.
7.	Servo valve overheats.	a) Wrong current b) Mechanical return sticks c) System pressure too high d) Wrong oil grade e) Dirt in system	Check current use servo valve tester. Needs opening valve. Reduce pressure settings. Respect oil recommendations. Flush the system.

FLOW CONTROL VALVE : By controlling the rate of flow in a hydraulic circuit, it's possible to control the speed of hydraulic cylinder or motors. A more typical method is to use a flow control valve. By varying the size of opening, one can vary the amount of oil entering the cylinder and thus control its speed. Three factors affect flow rate: pressure, fluid temperature, and orifice size. If any one of these factors is increased, the flow rate increases.

TYPES: Control of flow in hydraulic circuits can be accomplished with a meter-in circuit, a meter-out circuit or a bleed-off circuit.

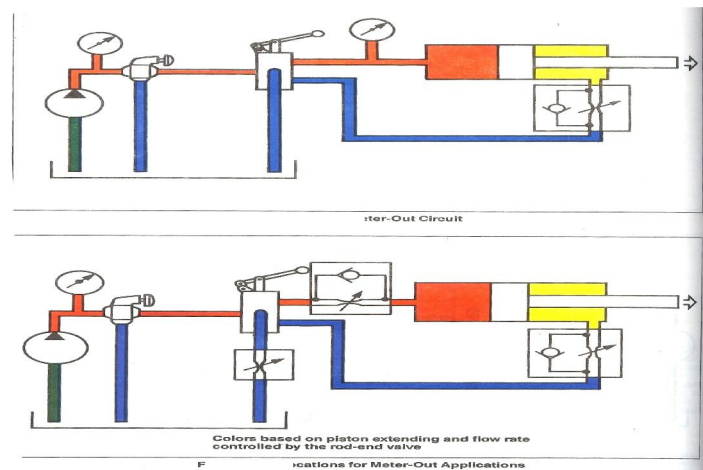
Meter-In circuit:



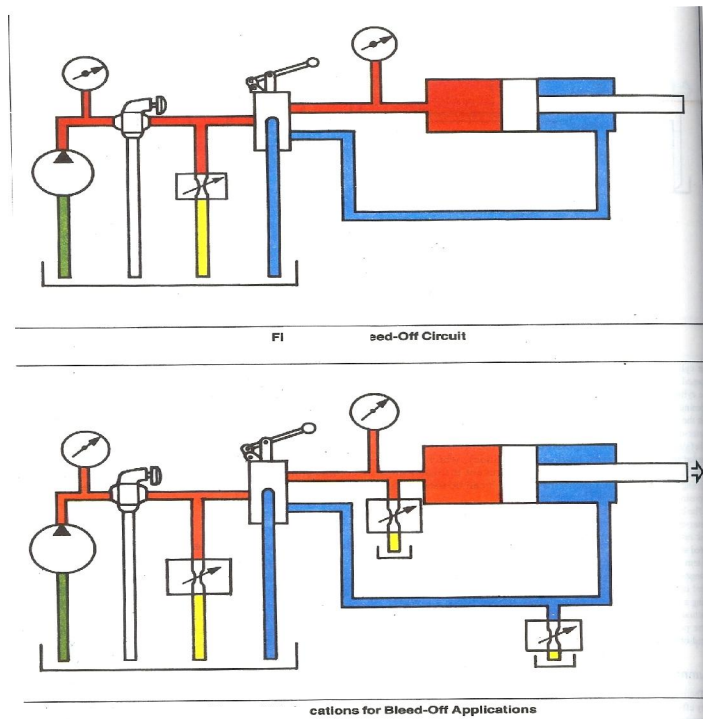
In meter-in operation, the flow control valve is placed between the pump and actuator. In this way, it controls the amount of fluid going into the actuator. Pump delivery in excess of the metered amount is diverted to tank over the relief valve.

Meter-in circuit can only be used with opposing loads. If the load tends to run away, it would pull the cylinder piston ahead of the oil supply; and since the exhaust flow has a free path back to tank, the meter-in circuit could not prevent the load from running away.

Meter-Out circuit:



The flow control is on the outlet side of the cylinder to control the flow coming out. This is known as a meter-out circuit. If the flow control were closed completely, the oil could not exhaust from the cylinder and it could not move. Regulating the size of the opening controls the flow rate and thus the speed of the cylinder. Although metering into the cylinder is fine with an opposing load, but if the load tends to run away, a better way is to meter out. In fact, a meter-out circuit works if the load pushes or pulls.



The flow control is simply bleed off the main line to control cylinder speed. For instance, with the flow control completely closed, the full flow from the pump would go into the cylinder. However, the moment the flow control is opened up, some bleed off of that pump delivery occurs and the cylinder starts to slow down. Adjusting the size of the opening will bleed off any amount necessary to control how fast the cylinder moves. In the case, unlike the meter-in or meter-out circuits, there is no excess flow going over the relief valve and the pump operates at only the pressure that is needed to move the work load on the cylinder, which saves energy. The bleed-off circuit will not prevent a load from running away. As with meter-in circuit, it can be used with opposing loads only.

TROUBLESHOOTING IN FLOW CONTROL VALVE:

Sr.No.	Fault	Causes	Rectification
1.	Device does not function	a) Device stressed b) Seat defective c) Throttle valve defective d) Non-return valve sticks e) Fine throttle-valve sticks f) Compensator mechanism defective g) Piston sticks h) Spring broken i) Corrosion on setting mechanism j) Wrong choice of device	Loosen bolt and tighten uniformly. Exchange seat. Exchange cone. Check cone and seat, if needed exchange it. Exchange restrictor Disassemble controller and exchange defective parts. Check system for dirt, exchange piston. Exchange spring. Clean if needed change. Install controller of correct nominal size.

INTRODUCTION:

Unlike gases, which are compressible and can be stored for a period of time, hydraulic fluids are usually incompressible. Accumulators provide a way to store these fluids under pressure. Hydraulic fluid enters the accumulator chamber and acts on a piston or bladder area to either rise the weight or compress a spring or a gas. Any tendency for pressure to drop at the accumulator inlet forces fluid back out into the system.

In many hydraulic circuits, the demand of pressurized oil is not constant. The demand of pressurized oil may be temporarily so great that pump cannot supply it alone and one or several motions will be starved of oil and machine will slow down or the system pressure will drop or both. One way is the large pump may be provided to supply the maximum demand need by the system. But it is expensive in both, the initial and running cost. The better way is to use a pump which can supply the average demand of oil and put one or more accumulators in the system. The pump can recharge the accumulator during the idle period.

FUNCTIONS:

1. It acts as an emergency unit. In case of sudden power loss e.g. pipe or joint failure, pump breakdown etc. the accumulator can provide sufficient energy to complete an operational cycle.
2. As a leakage compensator. Oil reserve for maintaining pressure to compensate leakage losses and to maintain pressure for longer period.
3. As an anti vibration device. It prevents pressure knocks and unpleasant operating noise resulting from system. Rapid valve closer can produce shock waves resulting in over pressurization of pipes, joints, valves, etc. The accumulator can neutralize or reduce the shock.

TYPES:

1. Weight type
2. Spring type
3. Piston type
4. Bladder type
5. Diaphragm type

WORKING OF BLADDER OR DIAPHRAGM TYPE ACCUMULATOR:

Operation of an accumulator is automatic. A combination of oil (which is non-compressible) and nitrogen gas (which can both expand and compress) make the accumulator work. When the oil pressure rises, incoming oil compresses the gas. When oil pressure drops, the gas expands forcing out oil. The gas is separated from the oil by bladder. This prevents mixing of the gas and oil and keeps gas out of the hydraulic system. Oil forces the bladder to compress until the resistance of gas is equal to oil pressure. When the hydraulic system needs oil, the compressed gas inside the bladder forces oil to maintain the system flow. The bladder is precharged through the valve core with nitrogen gas. The other end of accumulator contains the oil valve which connects the hydraulic circuit. A rubber sealing ring is provided near at the oil valve to protect the bladder during operation.

FOR NITROGEN PRESSURE:

1. Start the engine so that hydraulic pump supplies pressurized oil to the accumulator.
2. Close the pressurized oil supply to the system.
3. Connect the pressure gauge provided in the circuit (driving cabin) to indicate the hydraulic pressure.
4. Stop the engine immediately and keep on watching the pressure gauge. The gauge needle starts coming down slowly.
5. The pressure gauge needle stops momentarily at a place (pressure) and then immediately comes down to zero.
6. The pressure shown by the gauge needle at this momentary stoop over accumulator which should not be less than 80 atmospheres.

CHECKING AND FILLING WITH CHARGING UNIT:

Make sure that Hydraulic pressure is released from the system before attempting to fill or check the Accumulator for Nitrogen.

PROCEDURE:

1. Remove the protecting cap from top of accumulator.
2. Remove the closing nipple from the Accumulator gas valve.
3. Close the venting screw on the charging unit. Turn the handle fully clockwise.
4. Turn the spindle on filler head fully anticlockwise.
5. Connect the filler head to the gas valve and by turning knur clockwise.
6. Connect the charging unit to nitrogen bottle and tighten nut.
7. For checking only nitrogen bottle is not necessary. On new types of charging units a check valve prevents a gas return flow from the accumulator.
8. Turn the spindle on filler head gently clock wise.
9. Read the existing nitrogen pressure in the accumulator on pressure gauge.
10. If a recharging is necessary, open the bottle valve gently until a filling pressure of 90 atm is reading. Shut the bottle valve properly again.
11. Open gently the venting screw on the charging until the required pressure 80 atm is reading on the pressure gauge. Shut the venting screw properly again.
12. Remove the charging unit from the nitrogen bottle.
13. Turn the spindle on filler head fully anticlockwise.
14. Release nitrogen pressure left in the charging unit by opening the venting screw.
15. Disconnect the charging unit from the gas valve on the accumulator.
16. Check the sealing of the gas valve.
17. Fit the closing nipple on to the gas valve and also the protecting cap.

FUNCTIONS: Cylinders are drive components which convert hydraulic power into mechanical power. They generate linear movement through the pressure on the surface of the movable piston. Cylinders are linear actuators.

Construction: A hydraulic actuator constructed of piston or plunger operating in a cylinder housing or tube by energy laden liquid is known as cylinder. The piston of a cylinder is provided either with seals or piston ring to impart sealing effect with inner surface of the cylinder tube and stands for the efficiency of the cylinder. The efficiency of a cylinder is reduced as soon as the seals/rings start wearing resulting in internal leakage of the fluid. The rod of the piston is also provided with seal and scraper arrangement to stop out flow of liquid from cylinder and wiping out dust etc., from the piston rod.

The cylinder barrel/tube is generally seamless steel tube which has been cold worked and steel piston rod is highly polished usually hard chrome plated to resist puffing and scoring. This piston is generally made out of brass or cast iron.

The seals provided are made out of oil and heat resistant synthetic rubbers like Nitrile, Neoprene and Buna-N. For high temperature working Viton is much suitable. These days polyurethane finds good use in manufacture of seals which are not only heat and oil resistant but wear very slowly which reduces maintenance problem to the minimum.

TYPES:

1. **Ram type:** It is perhaps simplest actuator. It has only one fluid chamber and exerts force in only one direction, most are mounted vertically and retract by the force of gravity on the load. Ram type cylinders are used in elevators jacks and automobile hoists.
2. **Single acting cylinders:** A single acting cylinder has only one port allowing pressurized oil for its actuation. The return stroke of the piston or plunger is achieved either by gravitational action or spring force releasing the oil back to the tank. The oil flow in single acting cylinder is controlled by reversing directional control valve.
3. **Double acting cylinders:** A double acting cylinder has got two ports through which oil flow is controlled by directional control valve (generally solenoid valve) in such a way that if one of the two ports is connected to the in flow of liquid from pump the other is connected for back flow to tank and vice-versa. Such cylinders are called differential cylinders.
4. **Telescopic cylinders:** A telescopic cylinder is used where collapsed length must be shorter than could be obtained with a standard cylinder upto 4 to 5 sleeves can be used.
5. **Double rod cylinders:** Cylinder has two equal power stroke. Such cylinders are called non-differential cylinder as they have equal areas on either side.

CYLINDER CUSHION:

Cylinder cushion are often provided either or both ends of a cylinder to slow it down near the end of stroke to prevent the piston from hammering. Deceleration begins when the tapered cushion ring or plunger enters the cap and begin to restrict exhaust flow from the barrel to port. During the final fraction of the stroke the exhaust oil must discharge through an adjustable orifice. The cushion feature also includes a check valve to bypass the orifice during its return stroke.

ESSENTIAL PARTS OF A CYLINDER:

1. BARRELS: Barrels are usually seamless tubings, honed to a fine on the inside, bore to be parallel and without longitudinal scratches. Other wise oil will leak from one side to other during working due to high working pressure and frequent bursting of seals will occur.

2. PISTON: Piston usually made of cast iron or steel, incorporate seals to reduce leakage between it and cylinder barrel. Step cut automotive type piston rings are used where some leakage can be tolerated.

3. END CAPS: The end caps plug the barrel ends and provide cylinder ports. These are secured with the help of tie bolts.

4. SEALS: Various types of seals are used in the cylinder to prevent leakage and contaminants.

CYLINDER MOUNTINGS:

The main function of a cylinder mount is to provide a means of anchoring the cylinder. There are variety of ways to mount the cylinder including the tie rod, bolt mount, flange, trunnion, side lug and side tapped, and clevis. Rod ends are generally, threaded for attachment directly to the load or to accept a clevis, yoke or similar coupling device.

CYLINDER RATINGS:

The ratings of a cylinder include its size and pressure capability. Main features are-

- i. Piston diameter
- ii. Piston rod diameter
- iii. Stroke length

Cylinder speed, the output force available, and the pressure required for a given load all depend on the piston area, when extending the rod. When retracting the rod, the area of the rod must be subtracted from the piston area.

To find the speed of a cylinder when size and gpm delivery are known, use the following formula:

Speed (Inches Per Minute) =

$$\text{GPM} \times \frac{231}{\text{Effective Piston Area in Sq. In.}}$$

DISCIPLINE: HYDRAULICS (LESSONS: 16 SESSIONS: 21)

Lesson-XII: Hydraulic Motor **Session-13:** Definition, Working of Vane motor, Gear motor and. Axial Piston motor, Troubleshooting.

DEFINITION: Hydraulic motor converts the movement (Kinetic energy and pressure – potential energy) of a stream of hydraulic fluid in the continuous rotating force or movement. More specifically the kinetic energy of a fluid is converted into the kinetic energy of a fluid is converted into the kinetic energy of a rotating shaft in a hydraulic motor. The output of the shaft is the point where the motor is connected to the machine or device to be operated. The pressure of the fluid admitted to the motor determines its force or output. Motor's rating is represented in torque, GPM, cubic inches/rev A hydraulic motor converts hydraulic energy into mechanical energy. It is a rotary actuator. In construction it is almost some as hydraulic pump. The gear's, rotor are pushed by pressurized fluid and torque is developed i.e. continuous rotating motion is developed hydraulic motor's are externally drained Hydraulic motors are rated according to displacement (size), torque capacity, speed and maximum pressure limitations.

CLASSIFICATION OF HYDRAULIC MOTORS:

Hydraulic motors can be classified by application into three categories:

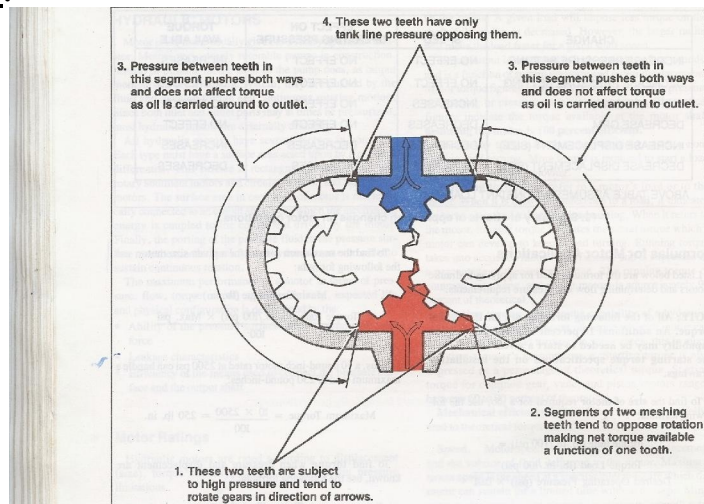
- (1) High Speed, Low Torque Motors (HSLT)-in line piston motor , bent-axis motor vane motor and gear motor.
- (2) Low speed, High Torque Motors (LSHT)-internal gear motor, vane rolling motor radial piston motor and axial ball piston motor.
- (3) Limited Rotation Motors (Torque Actuators)

TYPES OF MOTORS:

1. Gear motors—including external and internal (gerotor and rolator or orbital) motors
2. vane motors—including unbalanced, balanced, fixed, variable and cartridge (high performance) types
3. piston motors-including in-line, bent-axis, and radial motors (fixed, variable and cam type)
4. screw motors-
5. Torque Generators – including

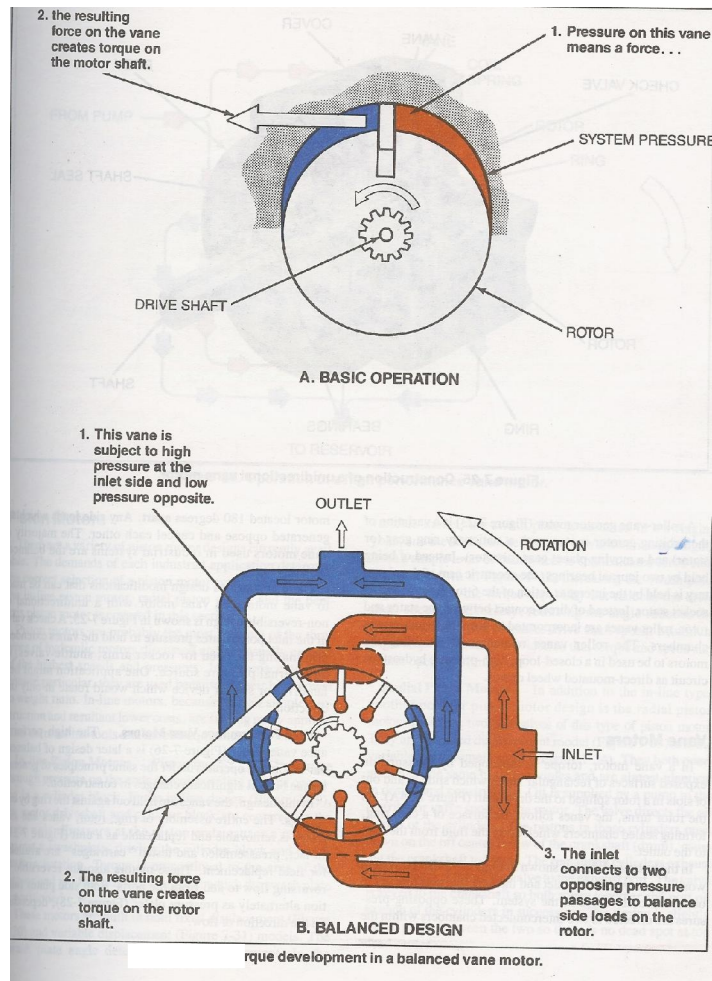
WORKING:

1. Gear motor:



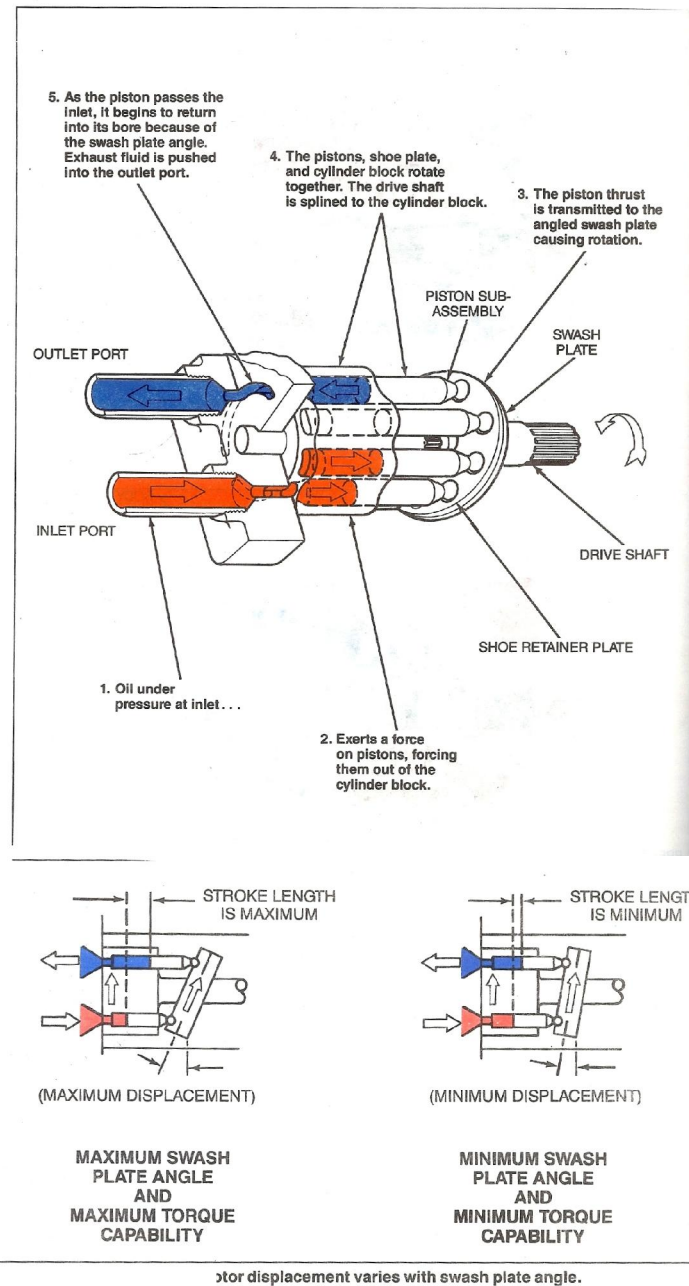
tor develops torque through pressure on the surfaces of gear teeth. The two gears mesh and rotate together, one gear coupled to drive shaft. The displacement of a gear motor is fixed and is equal to volume between two teeth multiplied by number of teeth. Generally gear's are not in balance with respect to pressure at the outlet result in high side loads on the shaft and gears as well as the bearings. Gear motor's are simple and more dirt tolerant.

2. Vane motor:



In vane motor torque is developed by pressure on exposed surface of rectangular vanes, which slides in and out of slots in a rotor to drive shaft. As the rotor turns the vanes follow the surface of cam ring, carrying the fluid from inlet to outlet. In operation pressure under the vanes also holds them in contact with cam ring some devices are used to hold the vanes, may be spring clips or small springs beneath each vane pushing it out.

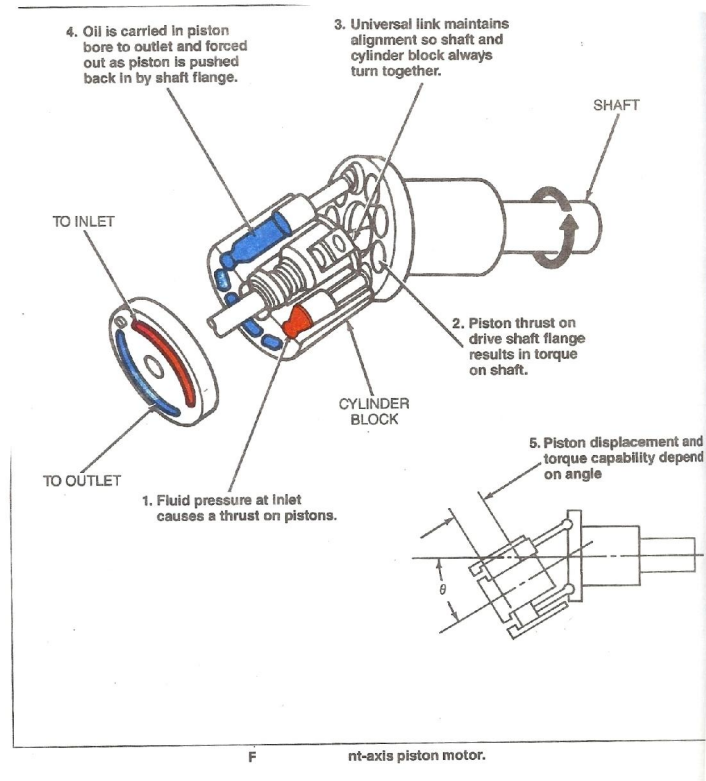
MOTOR:



The axial piston motor is an energy converter with an axial piston arrangement in a barrel shaped body in swash plate-design motor circular arrangement of 9 pistons is located parallel to the drive shaft in a fixed housing. The pistons run in a cylinderal barrel which his firmly fixed to the drive shaft by means of a key. The piston ends or of burn and surface design and run on slipper pads. These are held on a swiveling but not rotating swash plate by means of holding discs. On the fixed displacement model the swash plate forms a part of the housing and therefore has a fixed swash angle which determines the pump displacement. The function of hydraulic motor is the reverse of that of the pump. Energy laden fluid is directed to the hydraulic motor while fluid is being directed at atmospheric pressure from a tank to the pump which then receives a specific amount of energy via the drive motor and the fluid is supplied to the system as pressure fluid. By charging the direction of the active components of this pressure fluid, hydraulic energy is converted into mechanical energy (as a torque) via the driven shaft (31). The energy- free fluid is now returned from the hydraulic motor to the tank. On this particular design too, 4 pistons are pressurized 4 are connected to the tank, and 1 is in

position. The bores in the pistons leading to the ball and socket serve to reduce the high surface pressure in the ball and socket and on the sliding disc that is to say – they serve to provide a hydro-static bearing. For special applications these hydraulics motors can also be equipped with any of the control and regulating devices

BENT AXIS DESIGN MOTOR:



The axial piston motor of bent axis design is an energy converter which converts the energy of the input fluid via a rotary movement into a torque on the driven shaft. The output speed is proportional to the displacement on the so called swept volume, and the torque is proportional to the operating pressure for to be more to the pressure drop between the inlet and outlet. As a rule motors with fixed displacement that is with a fixed swivel angle are used. Variable displacement units are, however, used in some applications.

The rotary group takes from of a complete interchangeable unit and consists of the angled barrel body with output shaft, supported in the housing by robust bearings.

Pressure oil is supplied via the spherical port plate and those pistons not connected, the hydraulic energy being transmitted to the driven shaft by means of the stroke and output force of 3 pistons are converted into a torque. The now energyless fluid is returned to the tank by means of the return stroke of the 3 pressure unloaded pistons. The seventh piston remains in the crossover position. Due to the spherical design of the port plate torque free bearing of the barrel body is always given, even with maximum loading, the resulting forces in the motor housing being fully absorbed.

CAUTION:

1. Motor's rating should be according to the work load.
2. All hydraulic connections must be tight. Loose connections will permit air to be drawn into the system causing noisy and erratic operation or will permit the hydraulic fluid to leak out.
3. Incoming and outgoing ports should be kept in desired direction.
4. All mounting screws should be properly tightened to prevent misalignment of shaft connections.
5. Shaft connecting devices such as keys, collars, etc. must be properly seated to avoid slippage and possible shearing of the shaft.
6. Tubing must not be bent too sharply. The minimum radius for bends is three times the inside diameter of the tube.
7. Sometimes motor is mounted indirectly to work load using pulleys and V-belts or chain or spur gear arrangements. Because of slippage possibilities flat belts must not be used. It is important to check for correct alignment and excessive belt tension. This is necessary to prevent excessive side loads imposed on the drive shaft bearings.

TROUBLE SHOOTING:

PROBLEMS	CAUSES	REMEDIES
1. Motor not running	1. No incoming pressure	1. Check pump and relief valve.
	2. Shaft seizure due to misalignment.	2. Align correctly the shaft with work load.
	3. Shaft seizure due to excessive load.	3. Check load and load capacity of motor.
	4. Too much play in the shaft.	4. Replace bearing.
	5. Oil spill at motor.	5. Check if port plate is in contact.
	6. O-ring on port plate effective.	6. Replace O-ring.
	7. Motor type too small.	7. Replace for larger type.
2. Slow motor operation.	1. Inlet pressure too low.	1. Increase pressure by setting relief valve.
	2. Motor parts defective	2. Replace defective parts.
	3. Oil temperature too high.	3. Check for line restrictions, wrong fluid viscosity and also check cooling circuit.
	4. Outlet pressure too high	4. Check outlet line
	5. Port plate does not make contact.	5. Disassemble motor and repair.

Demonstration of Hydraulic Transparent Models

Session-14: Hydraulic motor, D.C. Valves, Cylinder, Accumulator, Pressure Gauge, Pressure control valves, Flow control valve, Check Valve, Pilot Operated Check Valve etc.

Demonstration of internal detail of working of above said components is done and explained

Lesson-XIV: Practical Disassembly & Assembly of Hydraulic Components in Model Room

Session-15: Vane pump and Vane motor.

Session-16: Axial Piston pump.

Session-17: D.C. valve, Proportional valve, Servo valve.

Session-18: Relief valve and Unloader valve.

Lesson-XV: Hydraulic Circuits.

Session-19: Constant pressure circuit, Closed loop circuit, Regenerating circuit of 3X, CSM, DUO, Unimat.

Lesson-XVI: Demonstration of Hydraulic Equipment Sets.

Session-20: Demonstration of Hydraulic circuits using FluidsimH Software & Work exercises.

Session-21: Demonstration of Hydraulic circuits using FluidsimH Software & Work exercises.