HYDRAULICS AND PNEUMATICS

Chapter – 1

UNIT V TROUBLE SHOOTING AND APPLICATIONS

Installation, Selection, Maintenance, Trouble Shooting and Remedies in Hydraulic and Pneumatic systems.

Installation and commissioning of hydraulic systems:

A hydraulic system that operates economically, safely, and trouble-free requires careful planning, as well as proper installation and start-up. Conscientious maintenance has a considerable effect on the service life of the hydraulic elements.

The following methods are to be observed when starting up and performing maintenance. There are helpful tips for fault correction in the trouble-shooting section.

The information given in these instructions are of a general nature and require other professional procedures. The commissioning of the hydraulic equipment must be in accordance with the putting into operation of the entire machine or installation and shall be done by experts who have the special hydraulic knowledge. For a safe and successful start-up, the information for installation and commissioning of each component particularly must be observed.

Technical safety instructions

The hydraulic system is to be planned and executed so that personnel cannot be endangered during possible malfunctions. This requires that the diverse pumps and devices are operated within their specified operating pressure ranges. Possible damage to the system and the electrical control system must be limited to a minimum.

Welding performed afterwards on oil reservoir may only be carried out by specialists at their own risk. Remaining oil and the cleaning cover must be removed.

Preventive steps must be introduced to avoid danger through the welding work.

Further measures must be arranged, depending on where the hydraulic system is set up, such as whether an oil receiver must be provided in water protection areas, etc.

Or whether hardly inflammable liquids must be used withan increased fire hazard.

Hydraulic accumulator

The testing documents of the hydraulic accumulators andsafety valves must be stored separately. If necessary, they must be presented to the safety commissioner. It`snot allowed to remove the lead seal of the safety valves. Observe information signs.

Transport

The power unit or the completely mounted manifold was properly packed and handed over to the transport com- pany. If there are damages, please contact the manufac- turer or your transport company.

For further transportation the hydraulic must be handled with care.

Storage

The power unit, manifolds and components must be protected from contamination, and from mechanical and weather damage.

Suitable measures must be taken to prevent corrosion if they are stored for longer periods of time without final painting.

Mounting

The pipe connection joints of the unit must be connected with the externally mounted devices and manifolds or the machine according to the positions shown in the hydraulic scheme.

Particularly the following points are to be observed:

- Use cold-drawn precision steel pipes, with the exception of nominal widths bigger than or equal NW50.
- Observe pipe cross-sections and permissible working pressure.
- Remove plastic plugs immediately before beginning pipeline work.
- Assemble pipe bends using bending devices.
- The pipe cross-section may not be pinched when bending.
- The pipes, after being cut to their exact lengths, are to be thoroughly debarred and cleaned.
- Fittings corresponding to pressure and environmental conditions are to be used on the system, and the manufacturer’s assembly instructions followed.

- Pipelines are to be lain and tightened without stress.
- Heat-treated pipes must be mechanically cleaned and descaled.
- Drain lines are not to be crimped, and if possible, at a falling angle to the tank, above the oil level.
- If hose lines must be used, they must be selected according to the pressure and the environmental con- ditions of the system. Note their stability, working pres- sure, and nominal width.
- The pipes must be sufficiently mounted with pipe brack- ets to avoid vibrations.
- It is advisable to provide venting connections at the highest position in the pipeline network.
- The power units, the manifolds and the connected parts of the system must be installed and mounted safely for operation.

COMMISSIONING

The hydraulic scheme, the parts list, and the control system flow chart should be present. The planned pres- sure setting must be indicated for all pressure valves in the hydraulic scheme.

Starting-up safety instructions

Before start-up the assembly of the complete hydraulic equipment must be inspected by specialists. Particularly the following points are to be observed:

- Mounting of pipes including clamping
- Accurate connection of pressure and return pipes
- Accurate connection of the pilot pressure pipes
- Accurate assembly of the hydraulic components
- Accurate connection of the power unit
- Accurate connection of the manifolds
- Accurate connection of the cylinder and hydraulic motors
- Accurate connection of the electrics
- Hydraulic equipment must be mounted safely for the operation.

- Parts of the entire system where driven by the hydraulics must be mounted safely for the operation.

Before start-up of the hydraulic system the specialists must prepare all necessary requirements to protect individuals and parts of the system against damage.
The start-up must be done very carefully according to the safety regulation.

Filling

Before the hydraulic fluid is poured into the tank, its interior must be checked again for cleanliness, and be cleaned if necessary.
The tank is to be filled using a fine filter, so that the desired cleanliness class of the fluid is ensured when starting up. Special filling units or equipment provided with the sys- tem are especially suitable for this, e.g. the return line filter.
The oil type is indicated on a separate sign next to the filling opening.

Flushing

After filling the reservoir with fluid we recommend the flushing of the fluid inside the hydraulic system where the fluid flushes around many times in the reservoir.
Before starting the flushing the servo-valves and proportional-valves must be removed and replaced by flushing plates to avoid damages of these valves according contamination. Start-up up of the components and the function of the entire system should only begin once the required minimum cleanliness and the operating temperature are reached.
It is recommended to flush the long pipelines by short circuiting the pressure and return lines, especially for large, central pressure oil stations. This prevents the installation dirt from entering the pilot valves (especially important for servo and proportional valves) or the drives (cylinder, hydro-motors, etc.). The diverse measures should be coordinated during design.

Electrical connections

Are the correct current and voltage types available?

Motor

Check available current with the E-motor type plate.

Solenoids

Are the type of current (~ or =) and the voltage correct? Check the labels of these devices.

Plugs

The electronic connections must be done according to the technical rules by using the appropriate plugs.

Grounding

Power units, parts of the system and single mounted components must be grounded.

Pumps and devices

The pump case must be filled with the clean operating hydraulic fluid before start-up to lubricate the bearing with oil.

Particularly the special start-up instructions for pumps and hydraulic and electric devices must be observed. The following section contains only the most important aspects.

Pumps

It is advantageous to keep the pressure setting low at first when starting the pump for the first time. The pressure compensator for variable displacement pumps and the pressure limiting valve for fixed displacement pumps are set to approx. 15 - 20 bar.

Pressure valves

Depending on the machine function, first begin with a minimum pressure setting. Enter pressure onto the measuring location plate after the final pressure is established.

An exception are the design-tested and preset accumulator safety valves.

Pressure unloading valves

For setting the pressure unloading valves according the pressure information in hydraulic schematic particularly the start-up instructions for this valve must be

observed.

Throttle valves

Set every drive (cylinder etc.) in steps via the throttle or flow control valves at the desired speed or stroke time.

Directional valves

Select the direction using the electric control system for electrically operated valves

Proportional valves

Proportional pressure flow and DC valves must be first started with a low electrical command signal.

Hydraulic accumulators

If hydraulic accumulators are assembled into the system, these must be verified at and/or filled up to the correct gas pre-load level. Suitable testing and filling equipment is necessary.

Switch on

First the motor is quickly switched on and directly switched off to determine the rotation direction. The correct rotation direction is indicated by an arrow on the pump housing. If the rotation direction is incorrect, reverse the polarity of the e-motor. The pump is started by multiple short start- ups (on-off operation)

Air bleeding

Air in the hydraulic system is very disadvantageous and undesirable for the control system. The system must be carefully vented, especially for the first start-up, for oil changes, or when lines and valves were opened. All functions are run through, one after the other, in no-load operation with low pressure and with full cylinder stroke. The pipeline network is vented at its highest point. The fitting can be loosened a little so that the air can escape with only a small amount of oil escaping. When the oil is no longer foaming, the fitting is retightened.

If the air bleeding cylinder is provided with venting screws, these should be used for venting. It must be noted, however, that the full cylinder stroke must be travelled several times. These venting screws must be at the top for horizontally arranged cylinders.

After filling the cylinder, the oil level in the tank must be checked, and refilled as

necessary.

Filter

The function and service life of pumps and hydro-devices are strongly affected by the cleanliness of the fluid. Dirt is the greatest enemy of hydraulic systems. There are three important sources of dirt to watch out for:

- Contamination arising during installation, installation dirt
- Contamination arising during operation, operation dirt
- Impurities from the environment

The correct filtering method is specified during system planning or determined by the necessary cleanliness class. Depending on requirements, pressure or return line filtering as well as additional bypass flow filtration is used. Thus contamination of the tank is prevented, and the pump only sucks in clean oil. Pressure filters are used for systems with higher demands, e.g. smallest oil flows (Q > 200 cm3/min) or high, constant pressure on pressure valves.

Servicing and maintenance of Hydraulic System

Service work may only be carried out by specialists. This requires knowledge of the machine's functions regarding switching on and off, as well as measures of safety engineering.

Regular inspection:

The hydraulic system is subject to a simple inspection at short, regular intervals. An automatic monitoring system is already partly provided. Particularly the following is inspected:

- Oil level in the tank
- Working temperature is not to exceed 60ºC
- Condition of the fluid (visual inspection, colour and smell of the hydraulic oil)
- Working pressures
- Gas pre-load pressure on the accumulator

- Leaks on the pump, valves, and pipelines
- Filter elements, for cleanliness (see 'Filter')
- Hose must be checked according to conditions and age.
- All mechanical and electronic sensors must be checked on function.
- All parts of the entire system must be checked on damage.
- Cleanness must be checked.
- All safety equipment and labelling must be checked
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Oil change

The frequency of oil changes is dependent on:

- Kind of liquid (ageing)
- Filtering
- Operating and environmental conditions (operating temperature)

Trouble Shooting of Hydraulic Systems:

1. Excessive noise in the system

Cause	Reason	Remedy
1.1 Cavitation in the system	Suction filter is blocked.	Clean or recondition.
	Internal width of the suction line is toosmall. Or: Objects in the suction line.	Install pipes with largerinternal width.
	Too many bends in the suction line.	Lay new pipes or use pipes withlarger internal width.
	Local constrictions in the suction line, e.g. partially closed valve, spring is too strong in check valve, damaged pipe or kinked hose.	Make valves accessible or changepipes or hoses are to be repaired or replaced.
	Fluid is too cold.	Use electric heating to warm pressurefluid to the recommended temperature.
	Viscosity of fluid is too high.	Check fluid.

	Vapour forms.	Lower working temperature to the correct value: Refill fluid or replace withsuitable fluid.
	Feed pump fails.	Repair feed pump or replace.
	Speed of pump is too high.	Check speed of the motor (see also specifications in the hydraulic plan).
	Completely sealed tank.	Install breather.
	Suction line is too small or too long.	Increase diameter of the suction line.
1.2 Foam or air in the fluid	Fluid level in the tank is too low.	Refill oil. For systems with strongly changing oil level: Only fill between the min. and max. oil level.
	Incorrect tank design.	Improve design.
	Return line ends in tank above the fluid level.	Lay return flow line lower than the fluid level.
	Incorrect fluid.	Replace with the correct fluid, if necessary, contact the system supplier.
	Shaft seal on pump allows air to penetrate.	Replace seal.
	Fitting in the suction line allows air to invade.	Tighten fitting or replace.
	Porous suction hose.	Recondition hose.
	Poor air bleeding.	Vent system.
1.3 Mechanical vibrations	Faulty alignment or loose coupling	Aligning or tightening
	Vibrations in the pipelines	Tighten or improve mounting.
	Pump defective or damaged	Repair or replace.
	Unsuitable pump type	Replace with more suitable pump type.
	Drive defective or damaged	Repair or replace.
	Unsuitable drive type	Replace with more suitable drive type.
	Pressure valve is unstable (oscillates).	Set correctly or replace with more suitable valve.

2. No pressure or insufficient pressure

Cause	Reason	Remedy
2.1 Pump does not deliver correctly.	Penetration of air into the suction lines	See error 1.2
2.2 High pump temperature	Worn out or damaged pump	Repair or replace
	Too little fluid viscosity	See error 1.1
	Insufficient or incorrectly adjusted cooling	Improve cooling line or adjust correctly. Ensure flow of cooling water.
2.3 Pump speed is too low or drive performance too small.	Coupling or belts slip or motor is faulty.	Remove defect parts.
	Motor is too small.	Use the correct driving motor.
2.4 Loss due to leakage from the pressure side in the return line	Incorrect pressure setting	Correct setting.
	Safety valve does not close because of dirt or there are defective parts.	Clean, repair or replace damaged parts.
	Directional valve or another valve is open because dirt or some other defective part is present, or due to electrical failure.	Damaged device is to be determined, adjusted, cleaned, repaired, or replaced.
	Damage to the cylinder hole, piston rod, or seal.	Damaged parts are to be repaired, replaced.
	Failure of piston seal, because the seal material is not suitable for the fluid used.	Use seals made of the correct material.
2.5 Feed pump fails (only for piston pump with feed pump).	Damaged pump, faulty drive, unsuitable fluid viscosity	See error 1.3

3. Pressure pulsations or flow fluctuations

Cause	Reason	Remedy
3.1 Cavitation in the pump	See error 1.1	See error 1.1
3.2 Foam or air in the fluid	See error 1.2	See error 1.2
3.3 Mechanical vibrations	See error 1.3	See error 1.3
3.4 Unstable pressure relief or safety valves	See error 1.3	See error 1.3
	Damaged valve seat.	Repair or replace.

	Valve has insufficient or no damping.	Install a more suitable device or damping equipment.
3.5 Valves stick.	Contamination	Drain fluid, clean system and parts, fill with clean fluid.
	Defective or warped	Replace device, remove warping.
3.6 Unsteady pump delivery	Unsuitable pump type or pump design	Replace with more suitable pump after contacting the pump system manufacturer.
3.7 Air in the system, which causes an irregular or yielding motion.	System is incompletely vented.	see error 1.2
	Electrical system is defective e.g. valves switch constantly.	Find and remove faults.

4. Too little or no pressure flow

Cause	Reason	Remedy
4.1 Cavitation of the pump	See error 1.1	See error 1.1
4.2 Foam formation or air in the fluid	See error 1.2	See error 1.2
4.3 Defective pump	See error 1.2	See error 1.2
4.4 Pump speed is too low or drive performance too small.	See error 2.3	See error 2.3
4.5 Loss due to leakage from the pressure side to the return line	See error 2.4	See error 2.4
4.6 Pump runs in the wrong direction of rotation.	Motor rotation direction is incorrect.	Reverse the e-motor.

5. Liquid temperature is too high

Cause	Reason	Remedy
5.1 Overflow losses	Pressure setting on pump is too high or safety valve is set too low.	Correct setting.

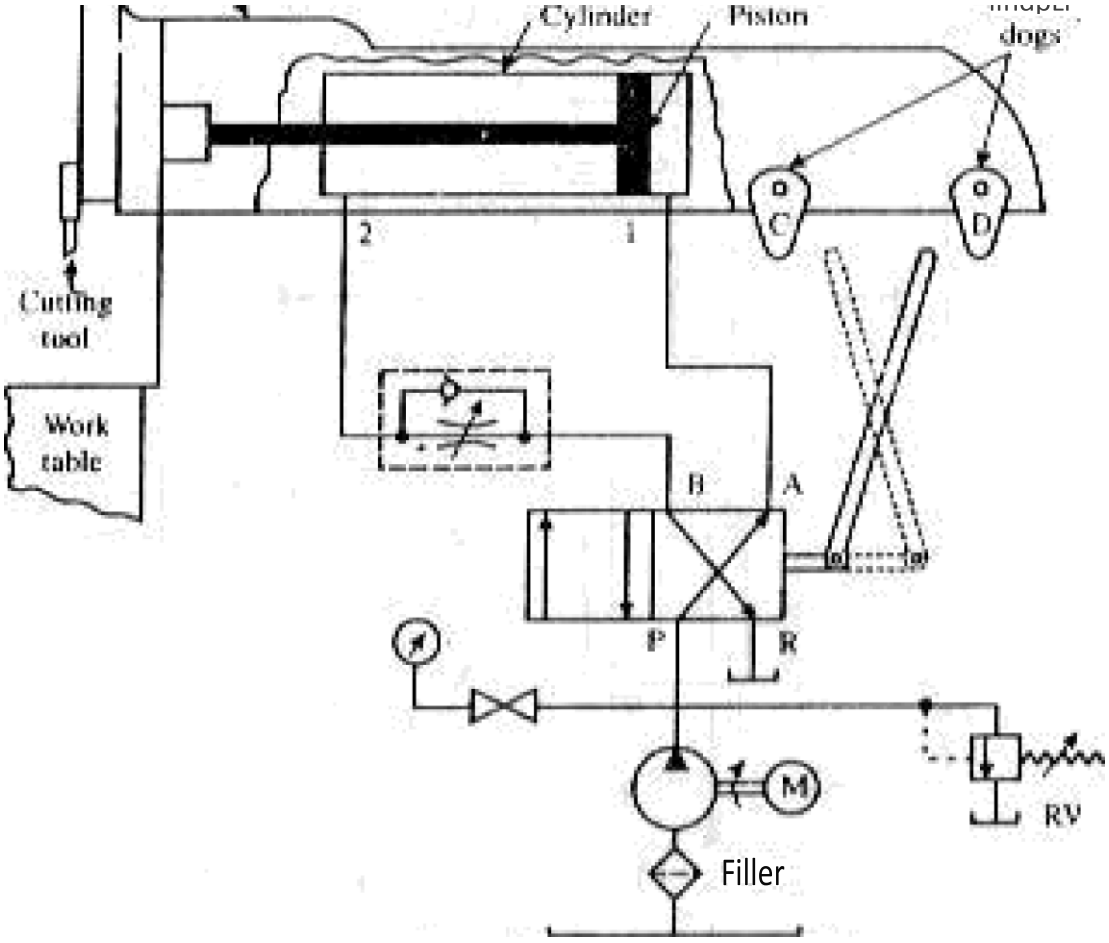
	Oil flows out at accumulator safety block.	Close accumulator drain valve on accumulator safety block.
5.2 Loss due to leakage from the pressure side in the return line	Valves function poorly and seals are faulty.	See error 2.4
	Fluid has incorrect viscosity (viscosity is too low).	Remove fluid and fill up system with fluid that has viscosity recommended by the manufacturer.
5.3 Fluid is delivered under pressure via safety and pressure limiting circulation valve into the tank, although pressure fluid is not needed.	Design of switching for system is not correct.	Provide the correct control system, e.g. switching to de pressurised.
	Faulty function of the air bleeding system as a result of dirt or faulty parts	Clean, or if necessary, repair.
	Safety pressure is set too low.	Correct setting.
5.4 Insufficient cooling	Failure of the cooling water supply	Check cooling water supply, temperature and function of shut-off valve.
	Failure of the ventilating fan	Check function of the oil-air-heat exchanger acc. to manufacturers instruction.
	Deposits in the cooling water line	Clean.
5.5 Insufficient carrying away of heat	System has insufficient cooling surface to carry off delivered heat.	Install cooling system and/or increase tank capacity and surface.
	An increase in machine performance without corresponding increase in the cooling capacity	Improve cooling system and/or tank capacity and surface.
5.6 Overheated pump	Wear in the pump.	Repair or replace.
	Working with fluid whose viscosity is too low	See error 5.2
	Insufficient flushing of the pump	Increase diameter of the drain line and provide a flushing of the pump housing.
5.7 Fluid circulates too	Fluid supply is insufficient.	Increase fluid capacity.

quickly.	Fluid level is too low in the system.	Fill up system to the recommended level.
5.8 Too much viscous friction.	Cross-section is too small in the pipelines and valves.	Install pipes and valves that have the correct size.

Design of hydraulic circuits for Drilling, Planning, Shaping, Surface grinding, Press and Forklift applications. Design of Pneumatic circuits for Pick and Place applications and tool handling in CNC Machine tools – Low cost Automation – Hydraulic and Pneumatic power packs.

HYDRAULIC CIRCUIT FOR SHAPER M/C

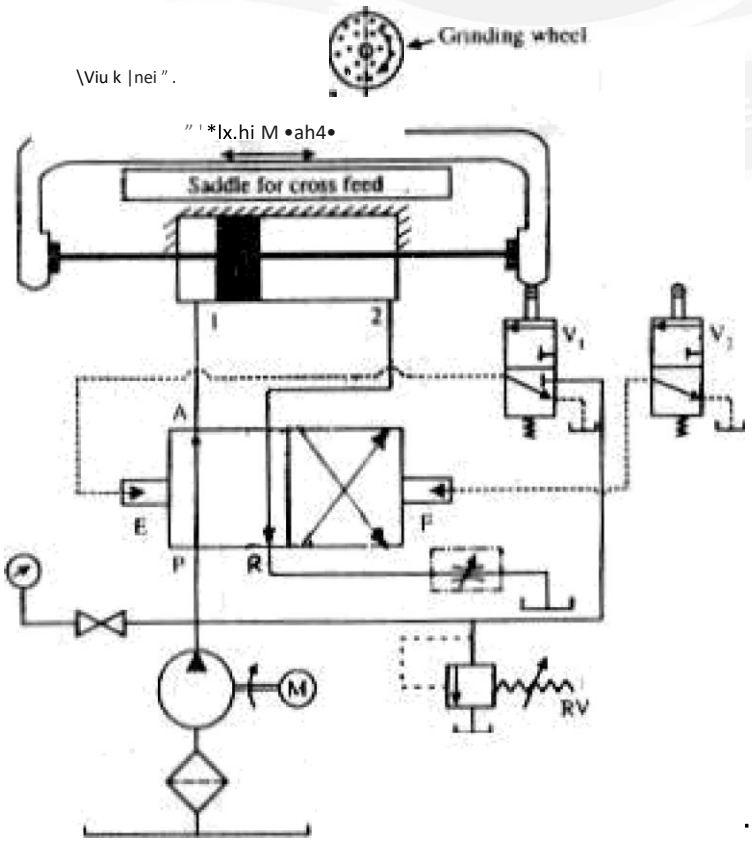
Fig shows the hydraulic circuit for operation of shaper. Here meter- out circuit is used. It consists of hydraulic power unit which delivers the oil at constant pressure. A double acting cylinder is used to reciprocate the ram A pivot actuated D.C. valve is used to alter the direction of stroke of the piston. When spool is in right envelop mode, the oil from port P enters the blind end of cylinder causing the ram to move forward.



The oil from other side of piston is discharged through flow control valve into reservoir. Here quantity of liquid is controlled while going out hence circuit is meter-out. The cutting speed can be changed by controlling the flow control valve. At the end of forward stroke, the ram hits the pivoted lever of D.C. valve shifting the valve into left envelop mode. Thus the oil from pump enters the rod end of the cylinder through check valve causing the ram to perform the return stroke. The oil from blind end returns to reservoir, as there is no restriction the return is quick.

Hydraulic circuit for Surface grinder

Fig. shows the hydraulic circuit for reciprocating the machine table for surface grinder. The circuit consist of a hydraulic power unit, which delivers oil under pressure. It uses pilot operated D.C. valve to alter the direction of stroke of piston in a double acting cylinder. It also consist of two roller actuated three way D.C. valve V1 & V2 to actuate pilot operated four way D.C. valve



The flow control valve is placed in return line to tank which provides smooth and equal speed and feed in both direction of table travel.

When valve V1 is depressed by table, the oil from pump flows through V1 and is supplied to pilot spool E which puts the D.C. valve in left envelop mode

Then the oil from pump enters the cylinder through port 1 causing the table to move forward and oil from other side is delivered to reservoir through flow control valve.

Hydraulic circuit for Hydraulic Press

Fig. shows the hydraulic circuit for the operation of hydraulic press. It consist of manually operated D.C. Valve. A press operation requires an accurate movement rate of piston so that the metal flows smoothly without tearing or cracking.Thus it is necessary to meter the fluid into the blank end of the cylinder. Here meter-in circuit is used. Therefore flow control valve is located in the feed line B- 1 on the actuator so that one stroke is to be speed controlled and check valve permits the rapid retraction. When spool of D.C. valve is in left envelop mode, the metered quantity of oil from pump enters the blank end of cylinder via flow control valve causing forward stroke. The oil from rod end is discharged out into the reservoir via line 2-A-R. during this stroke operation is done on workpiece.

When the spool is shifted to right envelop mode the pump supplies the fluid to rod end of cylinder and the fluid from blank end returns back to reservoir through check valve causing quick retraction of cylinder. When spool is in neutral position the operator unloads the object and load another object. In this position pump delivery is directed to reservoir. The hydraulic presses are slower and more powerful and adapted for pressing, forming and bending operations. These are also employed for fabrication of heavy forgings.

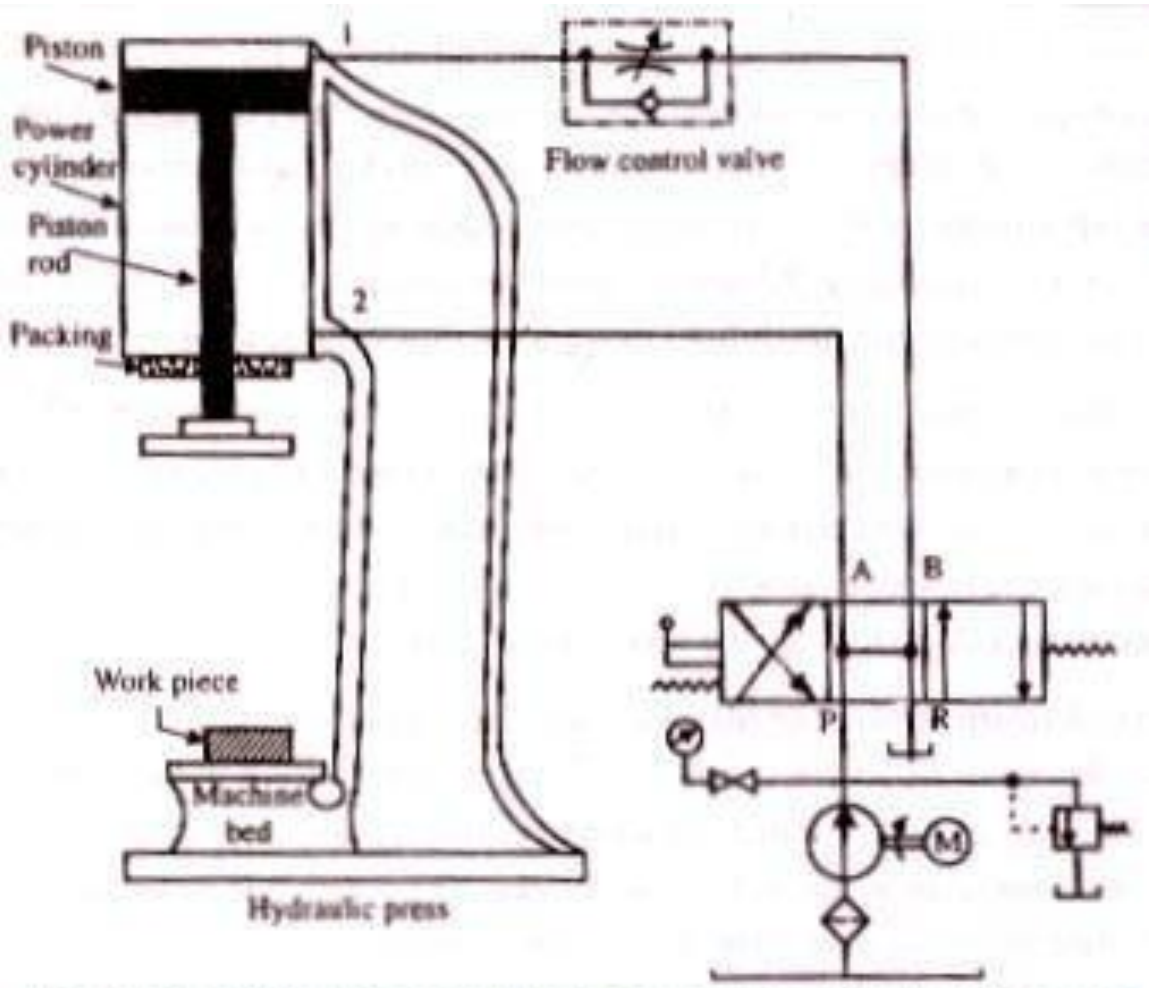


Fig. 7.16 : Hydraulic circuit for the operation of hydraulic press

HYDRAULIC FORKLIFT CIRCUIT

For designing any component, the design considerations are very important. The following are the steps and design considerations for building the hydraulic forklift circuit:

Power source: The main source of the hydraulic circuit is the hydraulic pump which converts the mechanical energy into hydraulic energy. The main pump is of the Axial Piston Pump.

The system has two distinct sections-steering section and operating section.

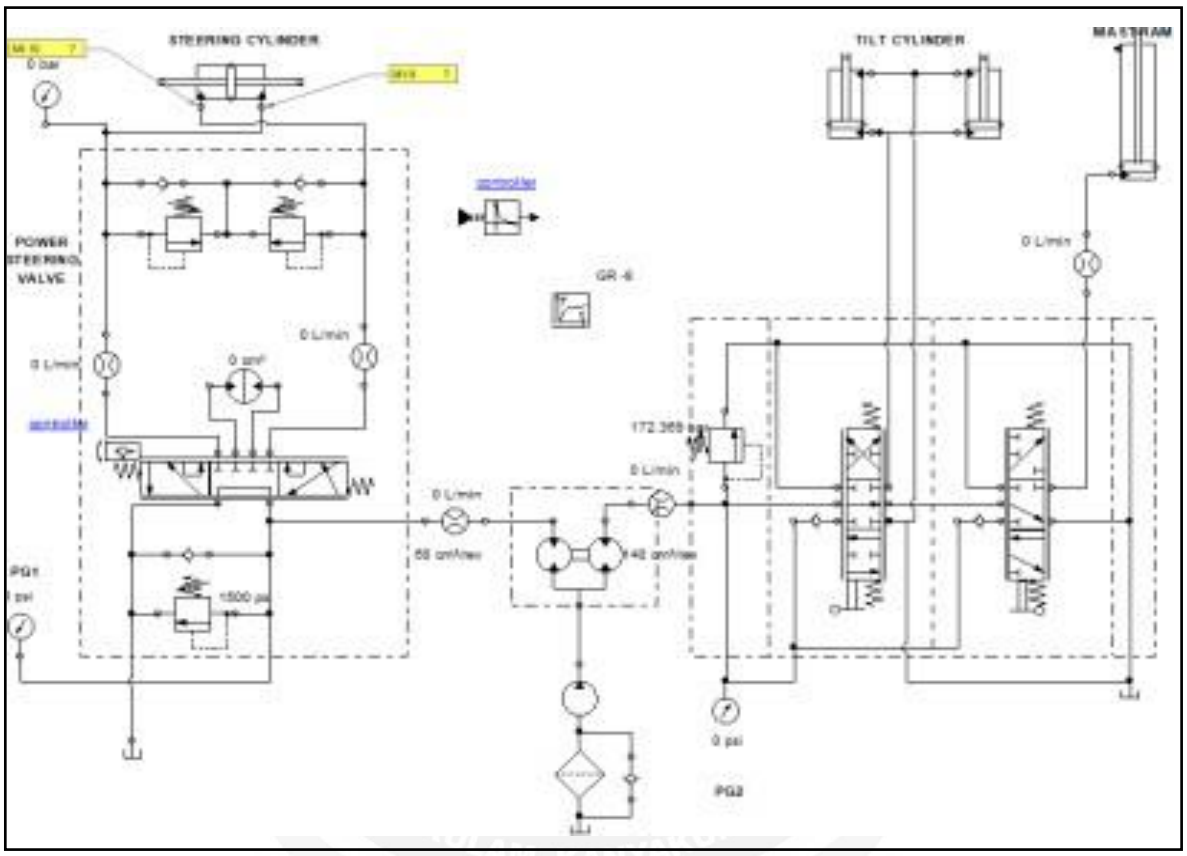
The pump would be directly being connected to the steering section and operating section. Due to the direct connection of the pump, it causes imbalance of high amount of pressure and flow to both the sections. Therefore, the flow divider is used to get the rid of this situation and to keep the two sections isolated. The total displacement of the pump is divided 60 cm3/rev and 140 cm3/rev to the steering unit and operating unit respectively.

The steering unit: The flow divider divides the flow 1/3rd to the power steering unit. Steering unit block is of the Char-Lynn® steering control unit of series 5 of the Eaton Company. This means there is no mechanical connection between the steering unit, the pump and the steering cylinders. The unit consists of a manually operated directional control servo valve and feedback meter element in a single body. It is used principally for fluid linked power steering systems but it can be used for some servo-type applications or any application where visual positioning is required. The steering control response from 0 to 100% for 1 sec For obtaining accurate control on the steering, the metering unit is used as a feedback to the system.

The steering unit of series 5 is selected such that the maximum pressure of this system is not more than 140 bar and the maximum flow is 19 L/min. The main feature of this valve is the load sensing, open centre, manual steering check valve and anti- cavitation valve.

Operating section: The operating section receives the flow rate of 210 L/min. It consists of the PVG block, flow divider, tilt cylinders and mast cylinder. The VO40 is an open centre directional control valve with the flexibility of sectional construction. Consistent with this technology, it is simple in its application, reliable, easy to troubleshoot, and cost effective. It can handle for maximum system, the pressure is 300 bar and maximum flow rate is 40 L/min. The main features of the valve are load independent, load sensing and pressure compensated valve.

Tilt Cylinders: Assume that the tilt cylinders are at 600 inclinations, extension and retraction time = 3 sec, piston stroke = 200 mm and the external load = 4000 Kg including the self-weight = 100 Kg independent such that both the cylinders are synchronized in static and dynamic conditions. The logical solution behind the



synchronization, the flow divider divides the flow at 50-50%. Both the piston extracts and retracts from 0 to 100%.

Mast Cylinder: Assume that the mast cylinder is at the inclination of 900, piston stroke = 1500 mm, extension and retraction time = 5sec, static load = 4100 Kg (including external load = 4000 Kg and self-weight =100 Kg). For dynamic condition, consider 100 Kg constant load.

HYDRAULIC CIRCUIT FOR DRILLING

The circuit depicted in Figure contains a hydraulic system in which two sequence valves are used to control the sequence of operation of two double-acting cylinders.

When the DCV is shifted into its left envelope mode, the left cylinder extends completely and then the right cylinder extends. If the DCV is shifted into its right envelope mode, the right cylinder retracts fully followed by the left cylinder. This sequence of the cylinder operation is controlled by the sequence valves. The spring centered position of the DCV locks both the cylinders in place.

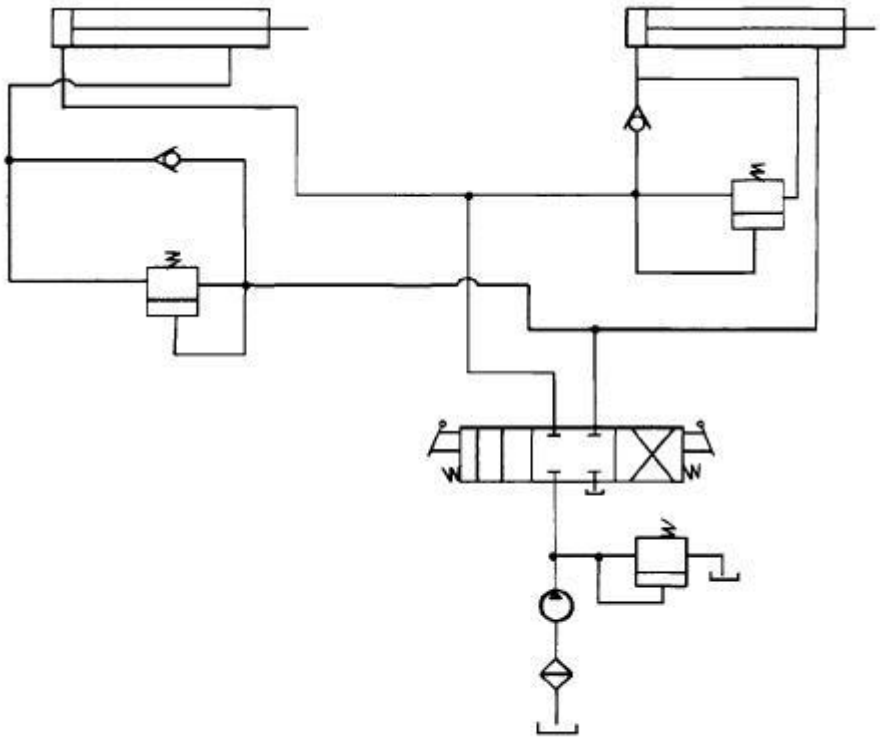


Figure 10.6
Hydraulic cylinder sequence circuit

The best example of this circuit is the case of a drilling operation. The left cylinder should extend in order to accomplish the job of clamping a work piece with the help of a power vice jaw. The right cylinder extends to drive a spindle to drill a hole in the work piece. After the hole has been drilled, the right cylinder retracts first and then the left one. The sequence valve installed in the circuit ensures that these operations occur in a predefined fashion.

HYDRAULIC CIRCUIT FOR MILLING

The hydraulic circuit for a milling machine is comparatively different from the hydraulic circuit of the surface grinding machine and hydraulic circuit of the shaper machine This is because the table movement in milling operation is comparatively slower. Also, the different feeds or you can say adjustable feeds are required for milling different types of work.

Hence, in the hydraulic circuit for the milling machines in addition to other elements a flow control valve is incorporated in the circuit.

The hydraulic circuit of the milling machine consist of the following components

Oil reservoir or tank

Hydraulic pump

Booster pump

Pressure Relief Valve

Spool type of direction control valve

Double-acting cylinder

Flow control valve

It has a main pump which is low pressure and a high discharge pump, and one booster pump, which is a low discharge high-pressure pump. The function of the booster pump is to boost the hydraulic pressure to a level above that provided by the main pump.

There are two sets of flow control valve and check valve, fitted in both the supply and return line to the cylinder, to achieve speed control in both the directions.

A manually operated spool valve decides the direction of the flow of the cylinder. The stroke length of the cylinder is adjustable through limit switches.

The limit switch disconnects the supply of oil to the cylinder when the table reaches the set position.