Strictly For Writing (Neat &Clean)

Note: 1] Use only <u>one side ruled pages</u> for <u>Writing</u>

2] On LHS Page Draw Circuit Diagram (with pencil & scale) and write Corresponding Description of on RHS Page.

3] Start description of each circuit on fresh page.-[<u>Strictly follow this point</u>]

4] Attach simulation form Fluid-sim after each hand drawn circuit diagram

5] You should mention your Name and Roll number on each simulation circuit diagram

Prof.H.N.Deshpande

<u>Title</u>: Study of Hydraulics Circuits

Introduction

A hydraulic circuit is a group of components such as pumps, actuators, control valves and fluid conductors are arranged such that they will perform a specific useful task. There are three important considerations while analyzing hydraulic circuits

- Safety of operation
- Performance of desired function
- Operation efficiency

Hydraulic circuits are represented using graphic symbol for all components. There are six basic components required in hydraulic system

1. Tank [Reservoir] : To hold hydraulic oil
2. Pump : To force oil through system or maintain fluid flow in the system
3. Electric Motor/Other power source : It work as prime mover to drive the pump
4. Valves: To control oil direction ,pressure, flow rate
5. Actuator : To convert oil pressure into mechanical force or torque to perform work
   (Hydraulic Cylinder: linearMotion, Hydraulic Motor: Rotary Motion)
6. Piping : Carries oil from one location to other

Some of standard hydraulic circuits are considered (explained) in further literature-

1] Regenerative Circuit

Regenerative circuit which used to increase extension speed of double acting cylinder is as shown in Fig 1. It is circuit in which pressurized fluid from rod end side of cylinder is returned to system input in order to reduce power i/p requirements and increase flow rate during extension stroke. One of the ports of 4way DCV is blocked. In this circuit, 4/3 lever operated spring close centered DCV is used to control fluid flow.

When DCV is actuated to position(I), piston extends. Speed of extension is greater than normal double acting cylinder because flow from rod end regenerates with pump flow which is going to piston end. When DCV position is shifted to position (II) the pump flow is diverted to rod end side of actuator and the fluid in piston (blank) end drains to tank, hence retracting piston rod at regular speed.

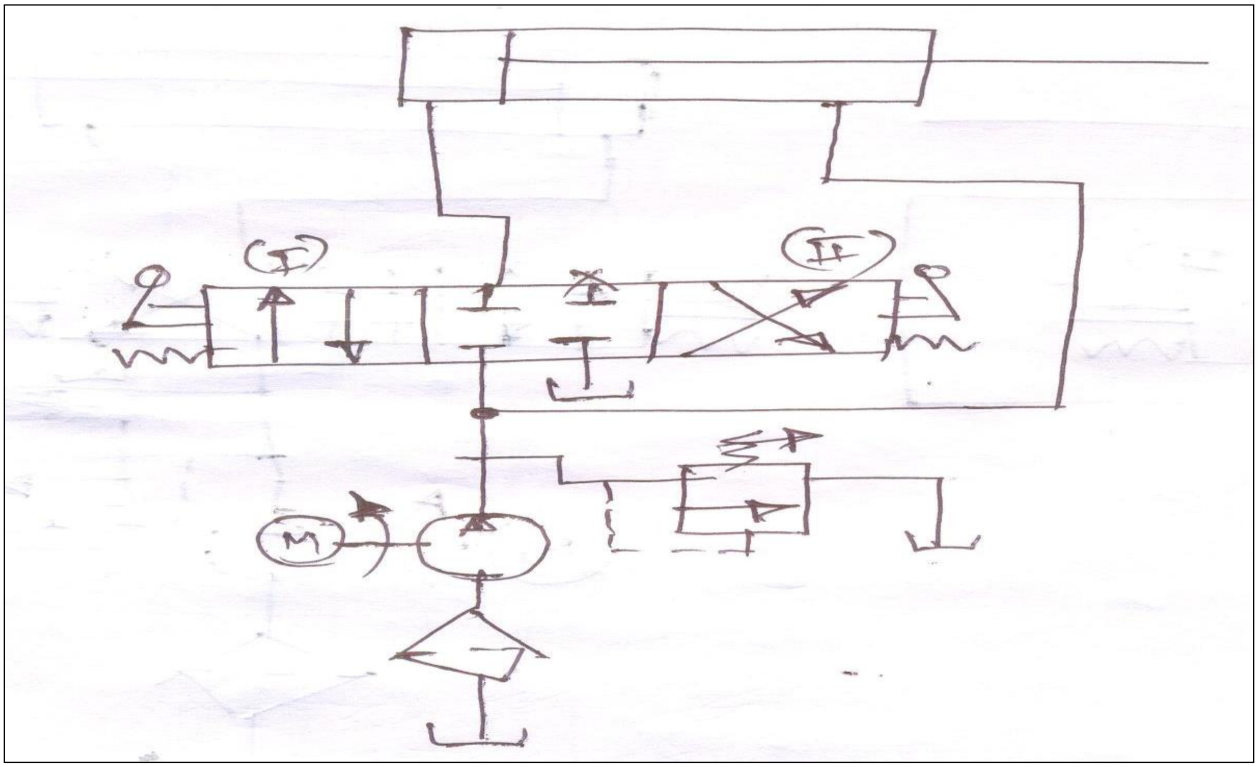


Fig 1: Regenerative circuit

Piston velocity during extension and retraction stroke

Qp = pump flow rate (m^3/s)

Qr = Regenerative flow rate from rod end (m^3/s)

Qt = Total flow rate entering block end (m^3/s)

Ap = Piston area (blank end) (m^2)

Ar = c/s area of piston rod (m^2)

Vext = Extension speed of piston rod (m/s)

Vretra = Retraction speed of piston rod (m/s)

Velocity of piston in extension stroke

Total flow rate entering blank end during extension(speed)

Qt = Qp + Qr

(But Qt = Ap×Vext)

Qr = (Ap-Ar)×Vext

Qp = Ap×Vext – (Ap-Ar)×Vext

Qp = Ar×Vext

Vext = Qp/Ar

This extension speed depends upon Qp& Ar. As piston rod is smaller, hence greater will be the extension speed

Velocity of Piston during retraction stroke

Vretra = Qp/(Ap-Ar)

Vext/Vretra= (Ap-Ar)/Ar

Therefore,

Vext/Vretra=[(Ap/Ar)-1]

2] Speed Control of Double Acting Cylinder (Meter-In Circuit)

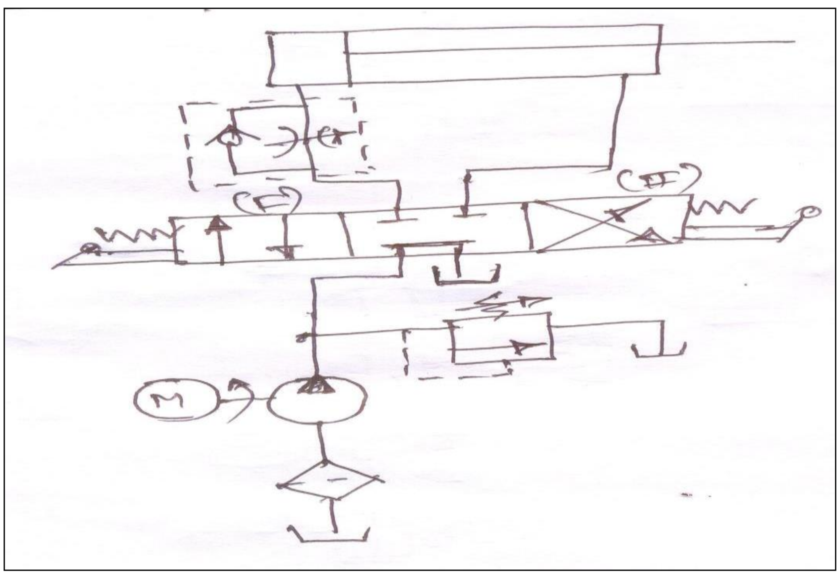


Fig 2: meter in circuit

In meter in circuit Pressure compensated FCV (flow control valve) with check valveand 4/3 spring tandem centered lever operated DCV are placed as shown in Fig 2. It controls quantity of oil entering the cylinder hence called at meter in circuit & thereby controls the speed of actuator.

When DCV is at position (I) fluid from pump cannot pass through check valve & is forced to go through metering orifice hence metered flow given to actuator so extension speed of actuator can be controlled.When FCV is fully open actuator can be run at regular speed. When DCV is at position (II) FCV (metering orifice) being bypassed through check valve hence uncontrolled (regular) retraction speed.Net result is controlling extension speed [Working stroke] and uncontrolled (regular) retraction (return stroke at full speed)

Supply pressure is higher than circuit pressure to accommodate pressure drop at FCV. The pressure required to start piston moving is usually greater than pressure needed to maintain movement due to load inertia & beak off friction. Meter In circuit is good for load opposed actuator movement and constant, positive loads. If load direction reverses (i.e. negative load), meter in circuit looses the control. This can be avoided by using counter balance in tank line with increase in cylinder pressure.

If fixed displacement pump is used over wide piston speed with restrictor type FCV, a large percentage of oil flow through pressure relief valve at high pressure leads large heat generation. Bypass FCV can accurately regulate speed of actuator which operates in wide range of loads and reduced heat generation.

Typical application of this circuit is milling machine, surface grinders, welders etc.

3] Speed Control of Double Acting Cylinder (Meter Out Circuit)

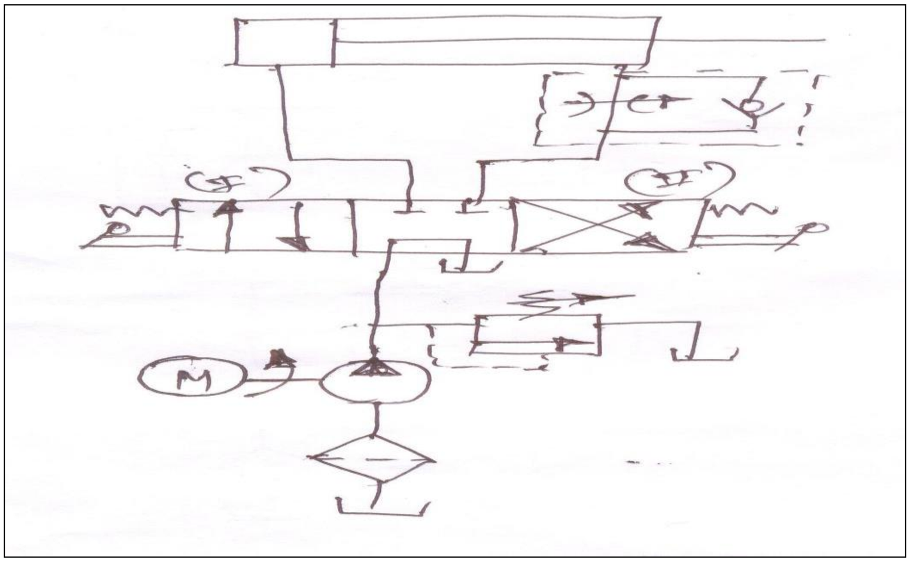


Fig 3: meter Out circuit

This circuit also controls extension speed of actuator but only the way of controlling is different. In this circuit Pressure compensated FCV (flow control valve) with check valve and 4/3 spring tandem centered lever operated DCV is placed as shown in Fig 3. It controls quantity of oil being discharged by the actuator hence named as meter out circuit.

When DCV is at position (I) piston starts extending, the fluid flow coming out from the cylinder cannot pass through check valve & is forced to go through metering orifice. Hence there is speed control during extension. When DCV is at position (II) the metering orifice is being bypassed through check valve hence speed is not in control. The net result is same as meter in i.e. extension speed is controlled but retraction speed is uncontrolled or regular.

In this circuit FCV is placed on rod end side so less pressure is required at full bore end .This is because as FCV is on rod end side, differential area will cause rise in pressure. This increased pressure helps to overcome pressure drop a/c FCV. Hence system pressure required will be relatively low. It makes this circuit more efficient on extension stroke.Meter Out circuit provides accurate speed control even in reversing load at in case of negative load application this circuit can be used as back pressure is maintained on exhaust side which prevents erratic motion.

But same as meter in circuit, fixed displacement pump is used over wide piston speed with restrictor type FCV, a large percentage of oil flow through pressure relief valve at high pressure leads large heat generation.

Meter out circuit typically used in applications such as drilling, boring, reaming, taping etc

4] Fast Approach and Slow Transverse Circuit

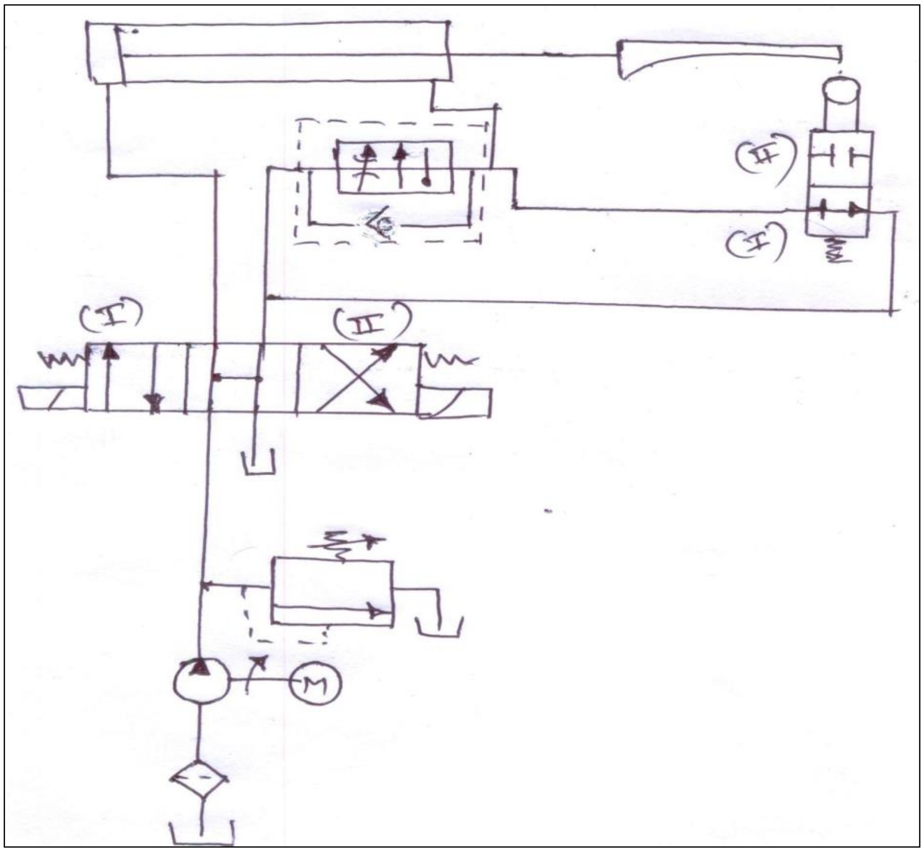


Fig.4 Fast Approach and Slow Transverse Circuit

The name for this circuit is Transverse and Feed Circuit which commonly used in machine tool. In meter in or out circuit constant speed during forward or extension stroke is controlled but in case of machine tool applications where two different speeds are required in single stroke. This circuit is used when the cylinder must move fast initially with lesser load and then with more load lesser speed.

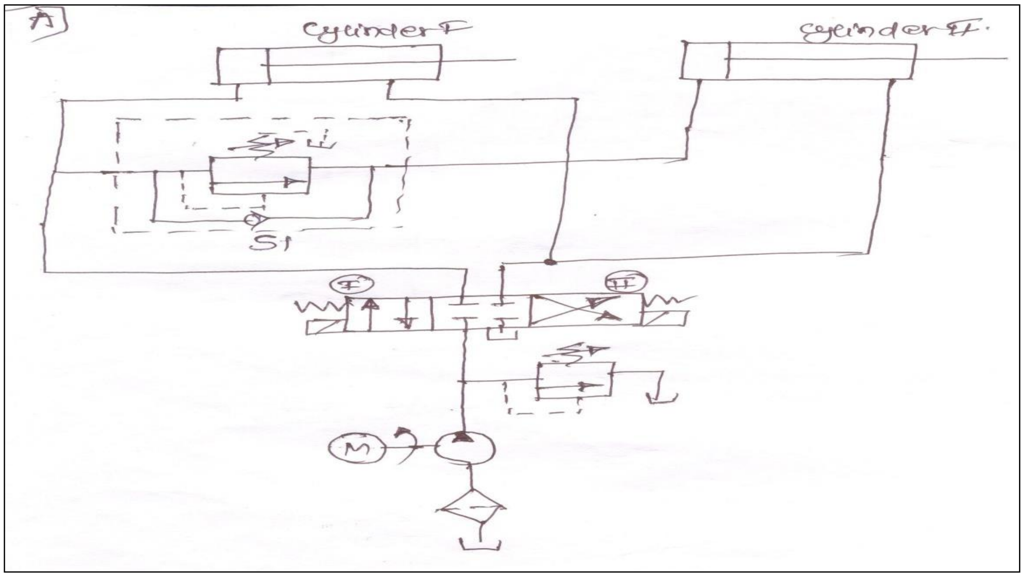
This circuit (Fig 4) consists of 4/3 solenoid operated DCV. Linear actuator with cam connected as shown to operate roller operated 2/2 DCV. Meter out circuit is constructed by connecting pressure temperature compensated FCV at cylinder rod end side for speed control in extension stroke.

When 4/3 DCV is at position I pump flow is diverted to blank end side and oil from rod end side is drained to tank through 2/2 DCV at it is in open condition (position I) hence no oil flow through FCV hence fast extension speed with fewer loads. When cam passes over roller 2/2 DCV gets position II and hence entire oil flow is through FCV (meter out circuit) hence slow extension.

When 4/3 DCV is at position II pump flow is diverted to rod end side through check valve of FCV and oil from piston side is drained to tank hence rapid return.At the end of this return stroke cam releases roller hence again 2/2 DCV gets position I (original position) this completes one cycle.

In this way in one stroke of cylinder two speeds can be achieved.

5] <u>Sequencing Circuit (I) (with one Sequence valve)</u>

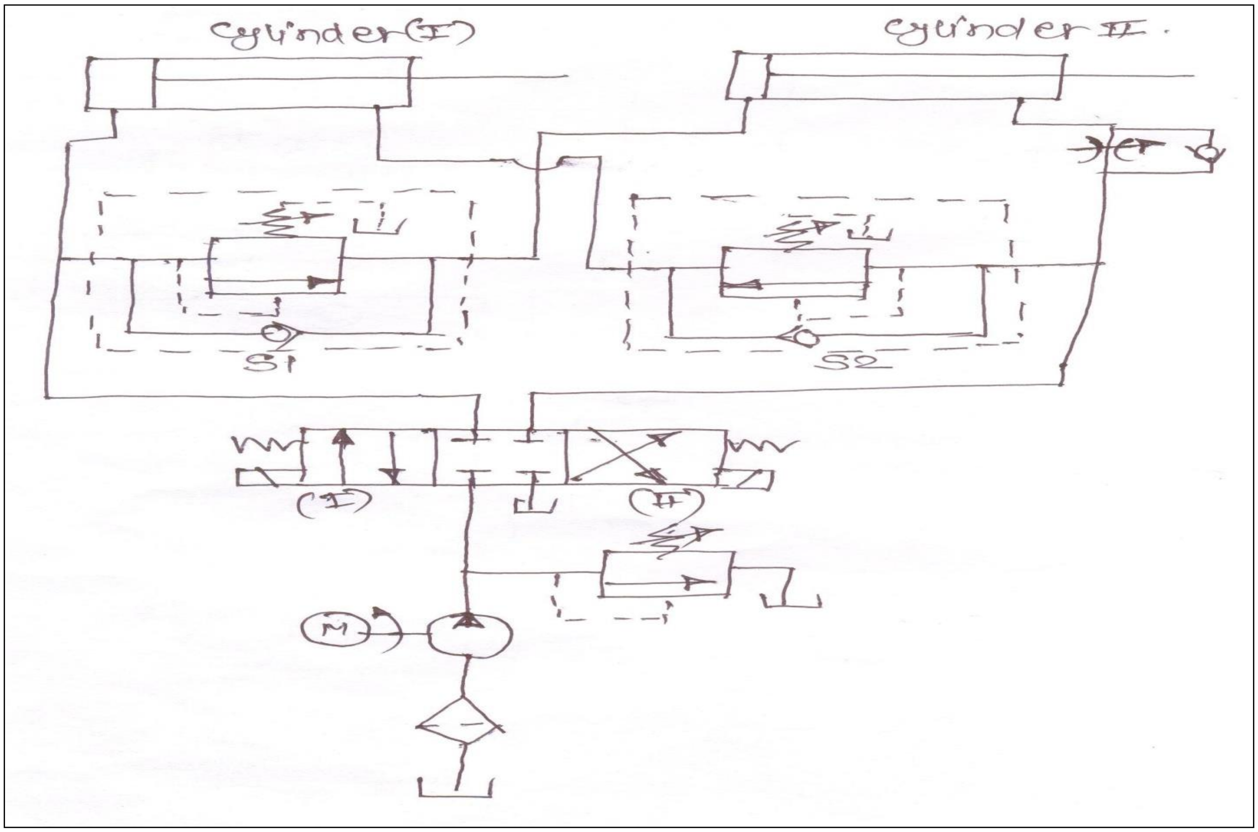


In pressure sequence circuit important component used is sequence valve. This valve senses/reads (set) fluid pressure in the system and generates hydraulic signal when set pressure is reached. It is used to assign priority hydraulic pressure in one system before other system operates. Hence, allow two actuators to be operated in sequence.

Consider circuit (Fig 5) in which two linear actuators (double acting cylinder) are used. In this circuit one sequence valve is used and 4/3 solenoid operated spring close centered DCV are used to change fluid flow in circuit. WhenDCV is shifted to position I, cylinder Iextendfully which rises the pressure in the actuator up to set point of valve S1, then sequence valve S1 open and pump flow is diverted to the cylinder IIfor its extension. When DCV is shifted to position II, the sequence valve has no effect on the circuit at it is bypassed because of check valve therefore retraction of both cylinder is together.

In this circuit two double acting cylinders are controlled by single sequence valve, cylinder Iextends completely then cylinder II extends completely. But for retraction both cylinders retract simultaneously there is no effect of sequence valve.

6] <u>Sequencing Circuit (II) (with Two Sequence valves)</u>



This circuit is modified from previous circuit. It consists of two linear actuators and two sequence valves S1, S2 connected as shown Fig 6. The 4/3 solenoid operated spring close center DCV is used to control fluid flow.

When DCV is shifted to position I, the fluid from pump flows to piston side of cylinder I and it extends completely. When piston in the cylinder reaches extreme position the pressure rises and it opens sequence valve S1. Then fluid flows to piston side of cylinder II. In short, due to sequence valve S1 cylinder I extends completely then cylinder II extends.For retraction: DCV is actuated to its position changes to II. Then cylinder II retracts completely then due to pressure rise in it sequence valve S2 opens then cylinder I retracts completely and completes one cycle. Meter out circuit in rod end of cylinder II helps to slow down feed as it uses in drilling operation

Typical application of this circuit is clamping and drilling operations. In this it is required that drilling cylinder should extend only after the clamp cylinder is fully extended and clamp cylinder should retract only after the drilling cylinder is fully retracted.

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