

Module-4 : Electro-hydraulic Valves

Lecture 10: Hydraulics Servomechanism, Servo and proportional control valves

Infinite Position Valves - Servo valves ;

Most of the directional control valves act as on-off switches. But if the spool of a d.c. valve is held at an intermediate position then it can act also as control valve. As a result it acts both as directional control as well as flow control device. However, such a control valve is made with special care & of different geometric configuration for its performance of specific control task. Coupled with the proper position feedback devices and built in control mechanisms such valves provide very accurate control of position, velocity or acceleration of an actuator. Such a valve is called servo-control valve. The mechanical-hydraulic servo valve also called a follow valve, was introduced in early stage of fluid-power applications. Relatively the electrohydraulic servo valves are modern devices.

Mechanical Servo Valve:

Referring to Fig.-1 mechanical servo valve is essentially a force amplifier which is used for position control.

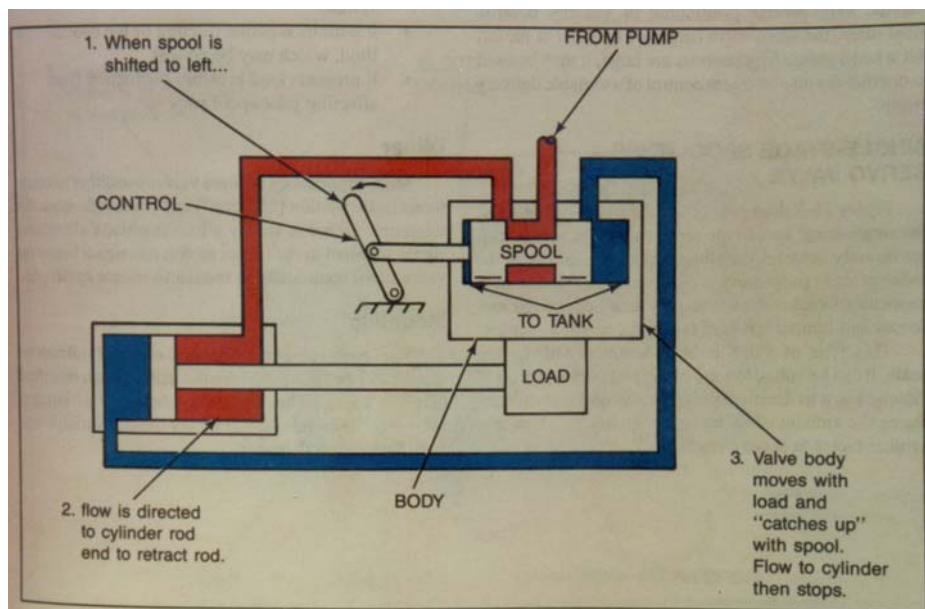
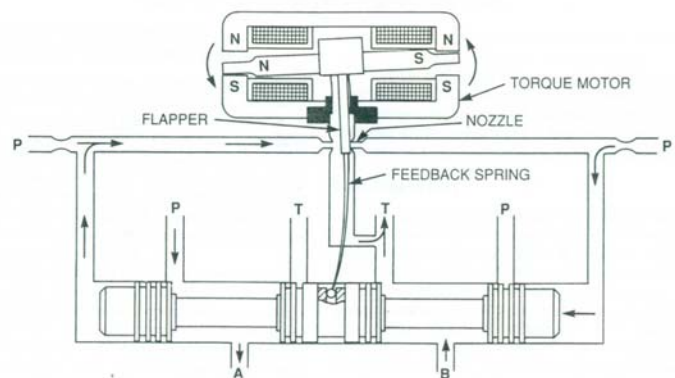


Fig.- 1: Schematic view of Mechanical Servo Valve

For a given stroke to the valve spool the piston with load moves along with the valve body coupled to the load platform, directly or with an amplifier lever arrangement, until the valve comes to neutral. Further movement of load in same direction causes the reverse flow and thus brings back the load in position. Template follower in copying lathe is an example. Hydraulic power steering device is another example.

Electrohydraulic Servo Valve:

An electric torque motor or similar device is employed to drive the spool directly (single stage) or through another pilot device (two stage) in electro hydraulic servo valve. Referring to the Fig. 2 (a) and (b) the signal to the drive torque motor or similar unit is transmitted from a simple potentiometer or a controller unit comprising of electrical and/or electronic devices. Essentially there is a servo amplifier to boost the command power, which ultimately controls the valve spool to maintain the position, velocity or acceleration of the actuator driving the load. A transducer feeds the signal to the servo amplifier about the desired output.



(a) Single stage Servo Valves (Flapper nozzle type)

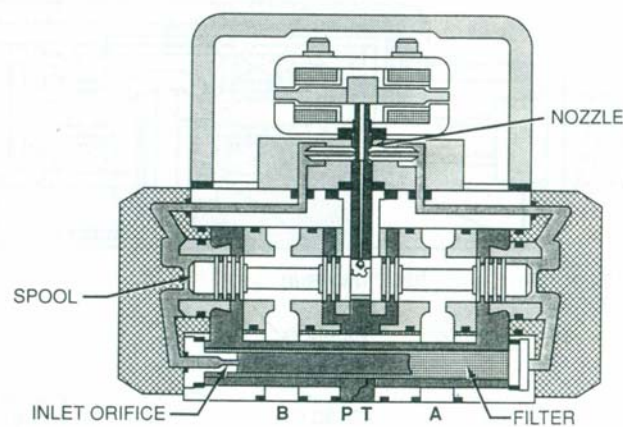


Fig.- 2: Servo Valves

The block diagram of a servo valve system is shown in fig. 3.

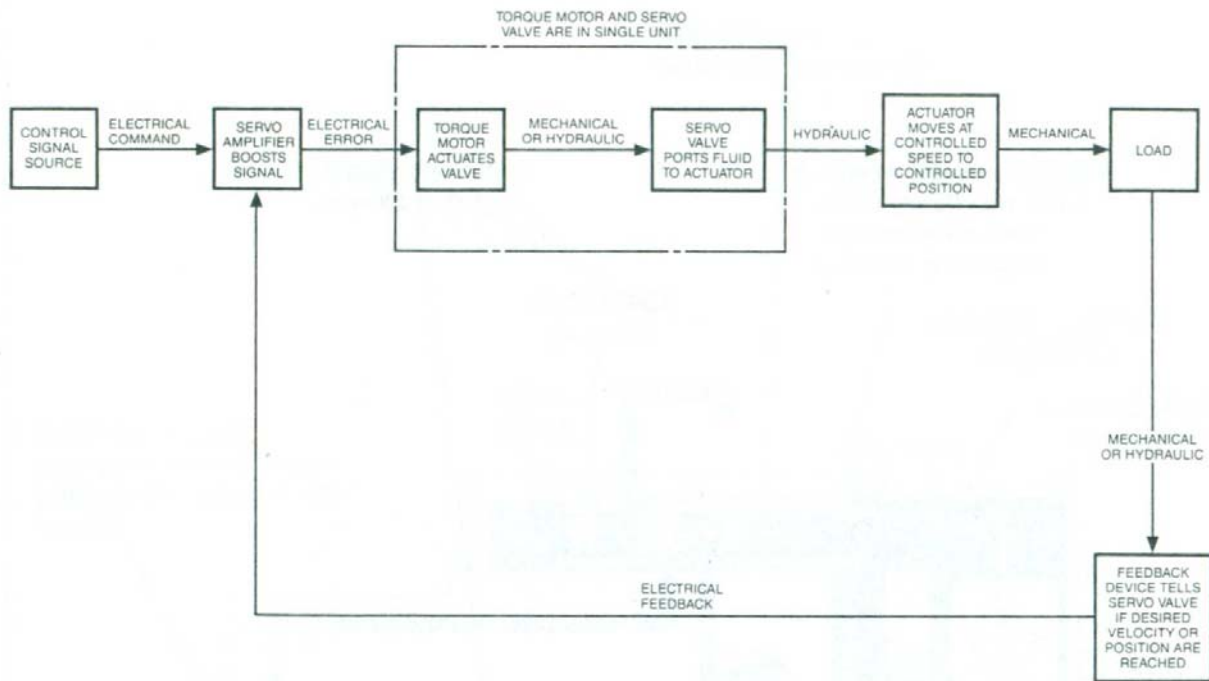


Fig.- 3: Block diagram of a Servo valve system.

Some essential features of Servo Valve:

Control pressure: Separate control pressure source is used. Usually the supply pressure via pressure reducing valve and accumulator is employed for control. Reasons to separate source are:

- i) Provides more flexibility.
- ii) Permits separate filtering of the control fluid.
- iii) Prevents load pressure fluctuation from affecting pilot-spool response.

Dither: Static friction i.e., 'stiction' creates a major problem in spool motion control. For keeping the torque motor active with low amplitude alternating motion dither (low amplitude electrical signals) is used. Such actuation eliminates stiction and thereby hysteresis in spool motion.

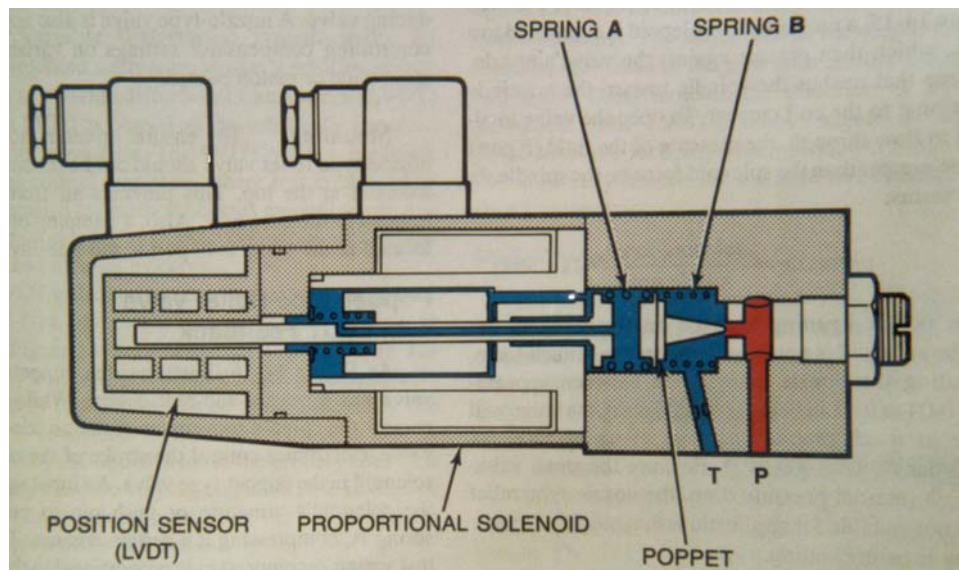
Proportional valves:

In many applications better performances achieved out of systems using ordinary valves, are desired. On the other hand servo valves would be expensive and not cost effective. In many such cases proportion valves could be a good solution. Usually proportion valves are driven by 'Proportional Solenoids'. A proportional solenoid differs from an on-off type solenoid by its capability of assuming infinite number of positions within a design specified working range. Not only that, incorporating a position transducer along with the solenoid push rod solenoid can be operated to have linearly varied output (pressure/flow) against linearly varied current/voltage input. The hydraulic parts in such valves are of the precision of accurately manufactured ordinary valves in contrary to super precision components required for servo valves.

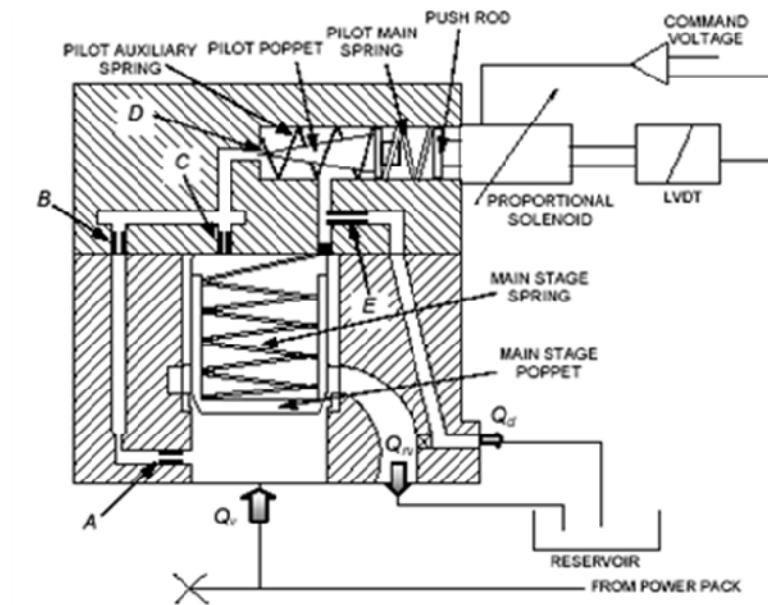
Proportional solenoid valves:

Most common proportional solenoid valves are (i) Proportion Pressure relief valve, (ii) Proportional flow control valve and (iii) proportional direction cum flow control valve.

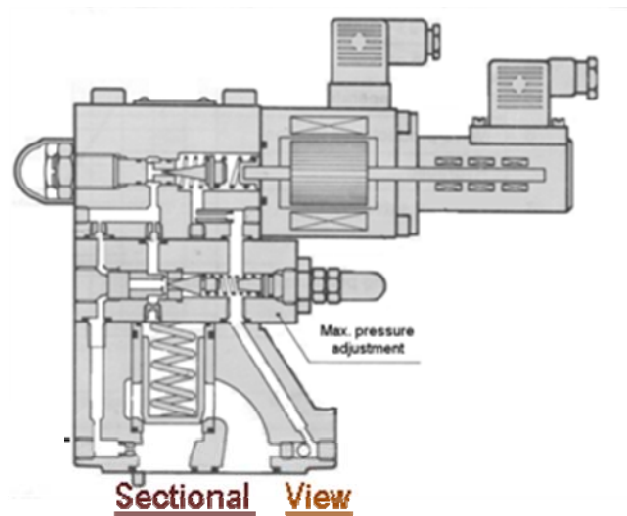
Those are again may be (a) direct drive type or (b) two stage pilot operated type. Fig.- 4 (a) & (b) show direct and two stage proportional control valves respectively.



(a) Single stage Proportional Solenoid Pressure Relief Valve with LVDT feedback.



Schematic Diagram



Sectional View

(b) Two stage Proportional Solenoid Pressure Relief Valve with LVDT feedback And Maximum Relief setting.

Fig. 4: Proportional Solenoid Pressure Relief Valve.

Valve construction:

In construction of such valves following design features are followed:

Valve spools:

Many possible port connections in mid position are possible with d.c. valve. The common three of them are

- 1) In the open centre valve all lines are inter connected in mid position. Hence, in hydraulic systems flow is permitted back to tank at relatively low pressure thus eliminating the heat generation associated with closed centre valves and constant delivery pumps.
- 2) In the closed centre valve all lines are closed off in the mid position. As discussed before this enables a cylinder to be held at an intermediate position. There are other reasons for using this type of valve. For instance, if a hydraulic circuit employs an accumulator, then a closed centre valve will prevent loss of accumulator fluid while the spool move from one extreme to other.
- 3) The tandem centre valve, contains the advantages of closed and open centre valves. In this case, although the pump is connected to tank in mid position, minimizing heat generation, the cylinder ports are blocked holding the load rigidly in position.

When accurate control of position is needed a servo-valve is essential. The two and three position valves discussed above find their application in what are essentially open loop systems. In a closed loop system the valve must respond not only to input changes but also to output changes. This is the principle of feed back. Most automatic control systems are proportional to controller input and experience has shown that such systems can be very accurate. If the controller uses fluid power then the valve must be proportional in its action and infinite position valves are used. Because of their association with servo systems, these valves are called servo valves. Most of these control power by throttling the flow through variable orifices and the data of chapter 2 are relevant when calculating servo valve performance. In what follows the valve supply pressure will be assumed constant, i.e. the constant pressure system. Some systems use constant flow rather than constant pressure.

Construction.

In many cases a special purpose valve is needed to be an integral part of the component where a ready made component can not be used. Moreover, for determining the performance of a

system accurately it is necessary to make a valve of research standard and not of commercial standard. Therefore, it is essential to have some knowledge on the construction namely material selection, surface preparation & treatment, geometries & tolerances & sealing etc.

Choice of material

Fluid property : If petroleum base hydraulic oil then. it is relatively non-corrosive and have fairly good lubricating qualities. In this case steel is the logical material. For valve bodies normally graded C.I. or C.S are used. However, aluminum & manganese alloys are also used to make it light in air borne applications.

For non petroleum based oil - non corrosive coating is used on steel or non-corrosive (to that oil) material like brass etc are used.

Material Composition : For spool, piston, Sleeves or analogous parts, material should be relatively brittle and not ductile. This does not mean that it should be weak material. In reality the material should not be of plastic stage.

Two reasons → Better finishing by abrasive grinding.
Not impingement of dirt on surface.

For high performance valve abrasive machining technique must be used to hold the tolerance & surface finish, such as grinding, honing and lapping. The same advantage of easier machinability of brittle materials applies also to some of the newer methods such as ultrasonic machining, spark machining and precision liquid or vapour blasting.

Now distorting die or gage steel, properly heat treated, is very good. Ball bearing steel,

Hardenable stainless steels → Corrosion

Sintered carbides → High temp application

Ceramics coatings may also be used → C-55/C-60 steel.

Required Dimensional Tolerances :

Axial & Radial dimensions
↓ ↓

Flow-versus-displacement Working clearance

Characteristics



For light oil { Should be minimum of 0.00005 in or say 1.25 Micron

For heavy viscous oil { Clearance may be more upto 10 micron.

Tolerance: ± 0.0001 inch or ± 2.5 Micron

It is difficult to bore a valve body within the tolerance. But the spool is possible.

At the corners, no measurement technique is available.

References

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3. John F. Blackburn, Gerhard Reethof and J. Lowen Shearer, 'Fluid Power Control'. MIT Press and John Wiley & Sons, 1960.