# Oil Hydraulics and Pneumatics
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## Part 3: Filters, Sources and causes of contamination, Approximate particle size of various contamination and its effect on critical play in hydraulic components, Placement of filters, Filter arrangement in the open loop and closed loop circuits
## Lecture - 60
## Subsystem: Hydraulics Reservoir, Coolers and Filters

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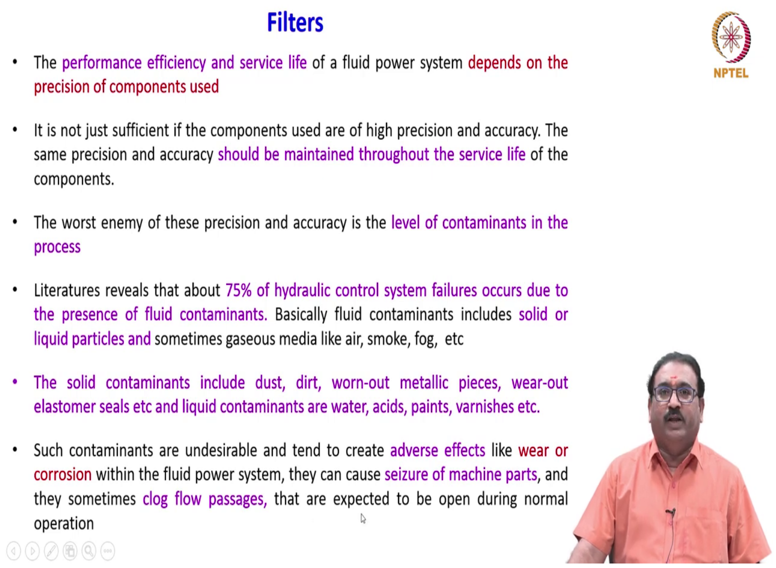


My name is Somashekhar, course faculty for this course. Now, we will move onto filters. The performance efficiency and service life of a fluid power system depends on the precision of components used. It is not just sufficient if the components used are of high precision and accuracy. The same precision and accuracy should be maintained throughout the service life of the component.

The worst enemy of these precision and accuracy is the level of contaminants in the process. Literature reveals that about 75 percent of hydraulic control system failures, occurs due to the presence of fluid contaminants. Basically fluid contaminants includes solid particles, or a liquid particle and sometimes a gaseous media like a air, smoke, fog etcetera.

The solid contaminants includes dust, dirt, worn-out metallic pieces worn-out, elastomer seals and many more. And similarly liquid contaminants are water, acids, paints, varnishes and many more. Such contaminants are undesirable and tend to create a adverse effects like a wear or a corrosion within the fluid power system. They can cause a seizure of machine parts and they sometimes clog flow passages, that are expected to be open during the normal operation.

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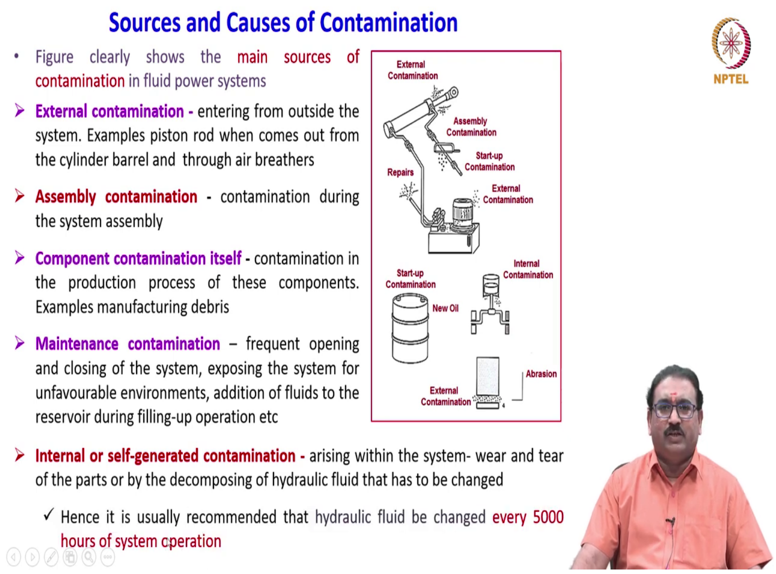

Now, let us we will see friends some sources of contaminations. The figure shows the main sources of contamination in the fluid power system. Just see here friends, here this is a cylinder and this is a power pack, pumped with electric motors, then you will see here. I have marked some sources of contamination proven to occur in the operation, external contamination which occurs, when the piston rod will move in an out of the cylinder.

Assembly contamination during assembly of components, start up contamination external contamination also occurs, because here the air breathers are mounted here. Then, internal contaminations are occurs due to the internal operation of the component, and abrasion of the metallic parts during the operation also takes place.

Let us we will see in detail these contaminations. As I have told you external contamination the entering from the outside the system. Examples piston rod when comes out from the cylinder barrel. So, many dust particles, foreign particles will deposit and then it will same it will enter inside the cylinder during the return stroke, which may goes to the fluid and also through the air breathers.

As we have seen in the last class the hydraulic tanks are kept open for the air breathing, due to these passages the dust particle. And so, many foreign particles may chance to enter, these are due to the external contaminations. Then, assembly contamination as we know all the components of the fluid power like a piston and cylinder, and piston rings, control valves and tank everything should be assembled.

During the assembly there are the chances of entering the external contamination, again during the assembly process. The assembly also required sometimes, the welding, riveting, many things correct. These are leads to the contaminations component contamination itself. During the manufacturing process, as I have told you the manufacturing debris are left over the component itself.

Then, they enter during the process. Then, maintenance contamination during the maintenance the maintenance people will kept open all the components, then based on the environmental condition, again the fluid or components will get contaminated through these solid liquid or gaseous components.

The internal or self generated contamination - arising within the system; the wear and tear of the parts or by decomposing of hydraulic fluid that has to be changed frequently. Hence, it is usually recommended that hydraulic fluid be changed every 5000 hours of system operation.

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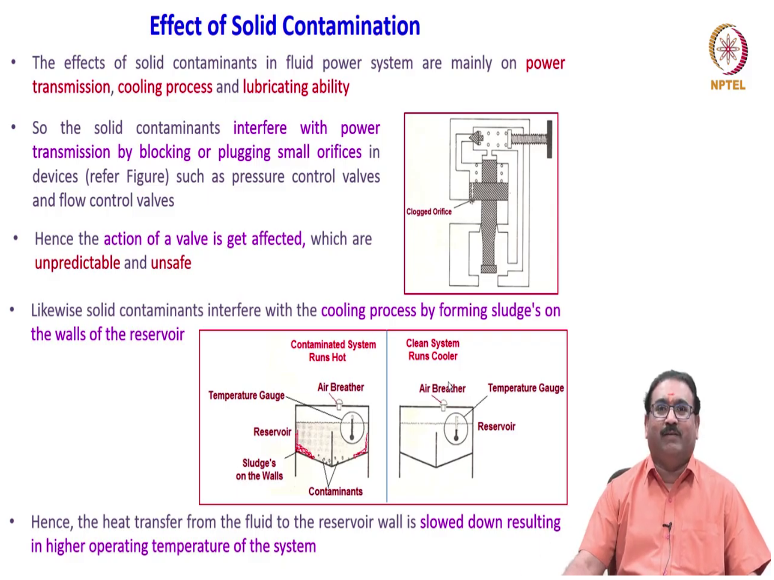


Now, we will see the effect of these contamination, basically we will see the solid contamination. How it effects to the performance of the fluid power components. The effect of solid contaminants, in fluid power systems are mainly on power transmission, cooling process and lubricating ability.

So, the solid contaminants interfere with the power transmission by blocking or plugging small orifices in the devices, I have shown here one device, such as a pressure control valves or a flow control valves. You will see here friends the small orifice is there, due to the contaminants present in the liquid there is a chances of blockage, which will affect to the performance of the these control valves.

Then, they are unpredictable and unsafe during the operation; likewise solid contaminants interfere with the cooling process by forming the sludge’s on the walls of the reservoir or sometimes the return oil will carriers, the many foreign particles, metallic particles, dust particles and many foreign particles, which may enter the tank.

And during the process the there is a chances of formation of sludge’s on the wall. Meaning the wall will be covered with the sludge’s, then what happens the heat transfer from the fluid to the external world is very very difficult. Then, you will see here hence the heat transfer from the fluid to the reservoir wall is slowed down, resulting in higher temperature of the oil and then the system.

You will see here friends, I have shown the two system here, one is contaminated system runs very hot. Due to the particles here contaminants, as well as a sludge’s covering the all the four walls of the tank. Then, here you will see friends the clean system runs cooler, which is a required during the process. Then, our objective is to remove all these contaminants as much as possible or try to reduce this to the minimum level for the higher efficiency.

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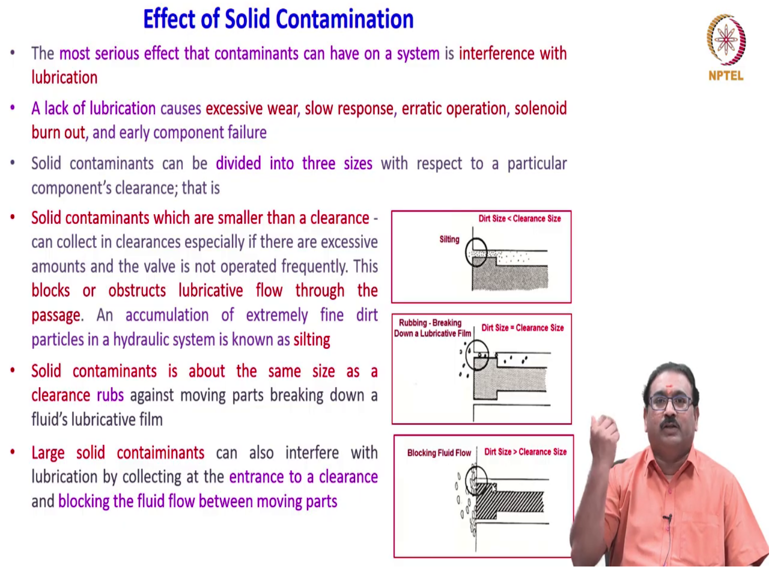


The most serious effect that contaminants can have on the system is interference with lubrication; the third important adverse effect is on the lubrication. A lack of lubrication causes excessive wear, slow response, erratic operation, solenoid burn out and early component failures.

Solid contaminants can be divided into three sizes with respect to a particular component clearance, based on the clearance the solid particle sizes are divided into three groups. Solid contaminants which are smaller than a clearance, I have shown here the hydraulic component and the clearance between the two matting parts. Here you will see I have marked very very small particles.

They, hence they can collect in clearances especially if there are excessive amounts and the valve is not operated frequently. This blocks or obstruct lubricative flow through the passage.

Also an accumulation of extremely fine dust particles in a hydraulic system is known as a silting. Silting is a collection of small particles in between the clearance.

Second one I am showing here, the solid contaminant is about the same size as the clearance. You will see the particle size is same as the clearance between the two matting parts. Again they may enter the clearance, then what happens rubbing takes place between the matting parts, which will leads to erosion of the some metallic parts. Also why it is due to the it will abstract the lubrication of the fluid.

Then you will see here I have shown the larger particle size. Larger solid contaminants can also interfere with the lubrication by collecting at the entrance to a clearance and blocking the fluid flow between the moving parts, completely they will block the fluid flow between the matting parts. Then, when there is no fluid flow between the matting parts no lubrication, you know the adverse effect of this on the performance of the hydraulic components.

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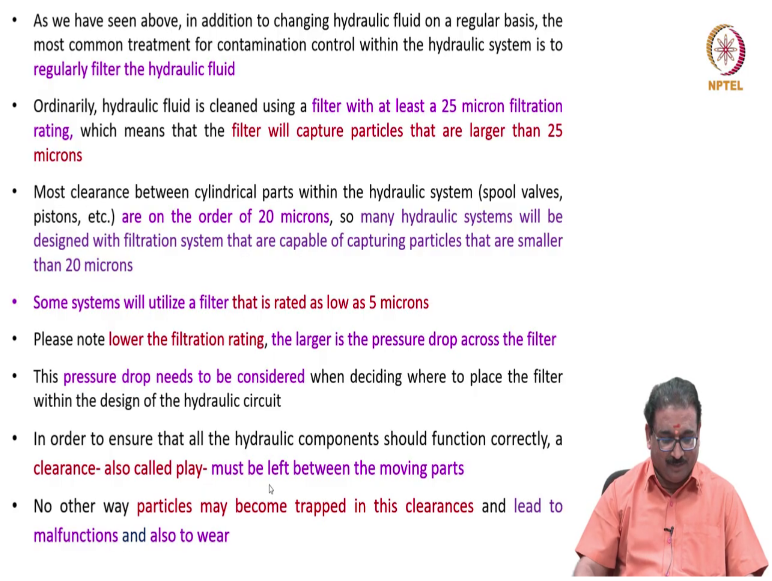


As we have seen above, in addition to changing hydraulic fluid on a regular basis. The most common treatment for contamination control, within the hydraulic system is to regularly filter the hydraulic fluid internally during the process, or externally and then fit to the tank. There are many methods are there we will see how to filter the fluids.

Ordinarily hydraulic fluid is cleaned using a filter with at least a 25 micron filtration rating, which means that the filter will capture particles that are larger than 25 microns there is a 25 micron filter. Most clearance between cylindrical parts within the hydraulic system, like a spool valves pistons and cylinders or on the order of 20 microns, so, many hydraulic systems will be designed, with a filtration system that are capable of capturing particles that are smaller than 20 microns.

Some systems can utilize a filter that is rated as low as 5 micron also, they are very expensive. Please note lower the filtration rating, the larger is the pressure drop across the filter, this pressure drop needs to be considered when deciding, where to place the filters within the design of the hydraulic circuit.

In order to ensure that all the hydraulic components should function correctly, a clearance also called a play-must be left between the moving parts. Wherever there is a moving the play should be there, then wherever the gap is there particles are entering and destroying the dynamic performance. No other way particles may become trapped in these clearance and lead to malfunction and also to wear the parts.

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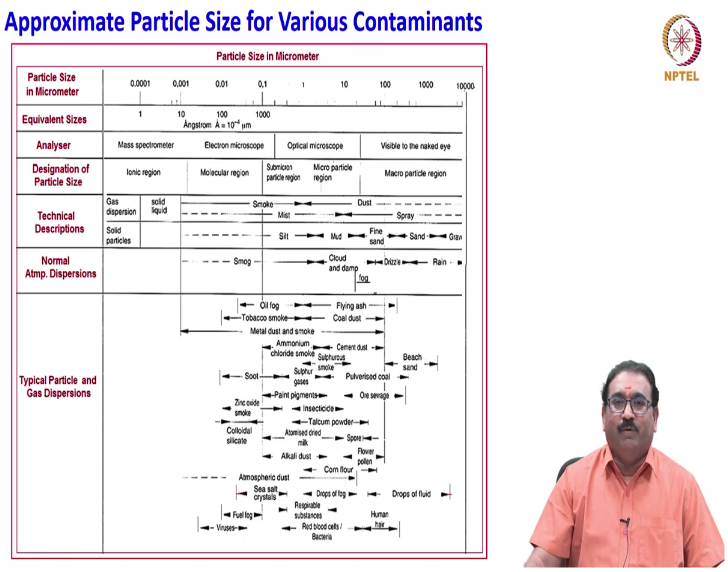


Now, I will show you the approximate particle size for various contaminants, as I have told you there are solid contaminants are there, liquid contaminants are there, and gaseous contaminants are there the size ranges is shown in the table here. Here, you will see friend particle size in micrometer, they are given here particle size in micrometer and then equivalent sizes is given in angstrom.

Then, analyzer of the particles the range is given for mass spectrometer, when we will use electron microscope, when we will use optical microscope, when we will use and sometimes visible in the naked eye. And, also designation of the particle size is given like a ionic region when it is, molecular region when it is. Then, sub micron particle region and a micro particle region which range it will covers. And, macro particle range which it covers.

This table will give the complete information of the particle size and how to categorize with these things during the separations. Also you will see the typical particle and gas dispersion's given in this, which includes the solid particles liquid particles. And, also the gaseous particles like a smoke many flying ash and many things are there here, they should be considered before selecting the filters for your applications.

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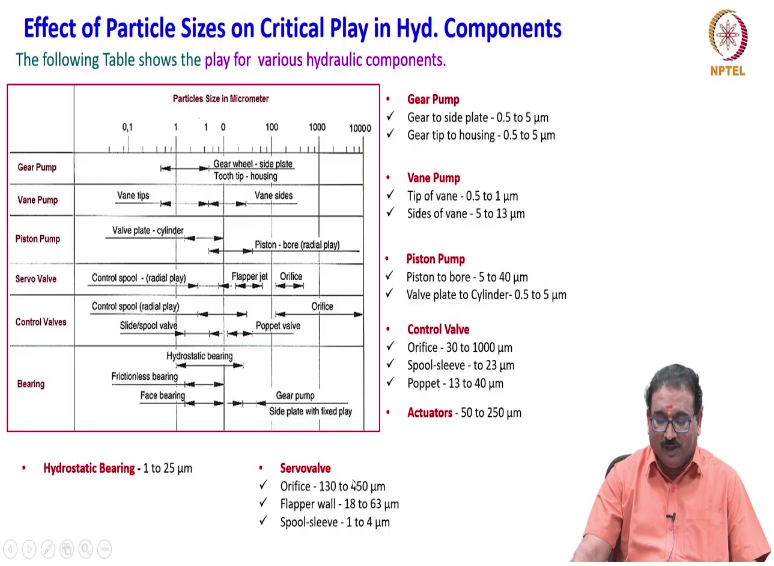


Now, I will show you very quickly the effect of particle sizes on critical play in some of the hydraulic components. You will see here again friends this table will show you the particle size in micron micrometer, then there are particles destroying the play between the matting parts is listed here. For the gear pump, vane pump, piston pump, servo valve control valves and bearing surfaces.

Now, we will see friends here the gear pump meaning here, gear to side plates. The clearance and particle size is 0.5 to 5 micron gear tip two housing is 0.5 to 5 micrometer. Similarly the vane pump the tip of the vane, then sides of the vane, piston pump, piston to bore what is the particle size on the critical play. Valve plate to cylinder, similarly the control valves like a flow control valves, direction control valve are many orifices spool and sleeve poppet and actuators like a piston and cylinders and motors also.

Then you will see the hydrostatic bearings, what is the effect of particle size on the critical play, which is 1 to 25 micrometer. Similarly, the servo valves very precise the orifices 130 to 450 micron the flapper wall 18 to 63 micrometer spool sleeve assembly 1 to 4 micrometer particles may affect the performance.

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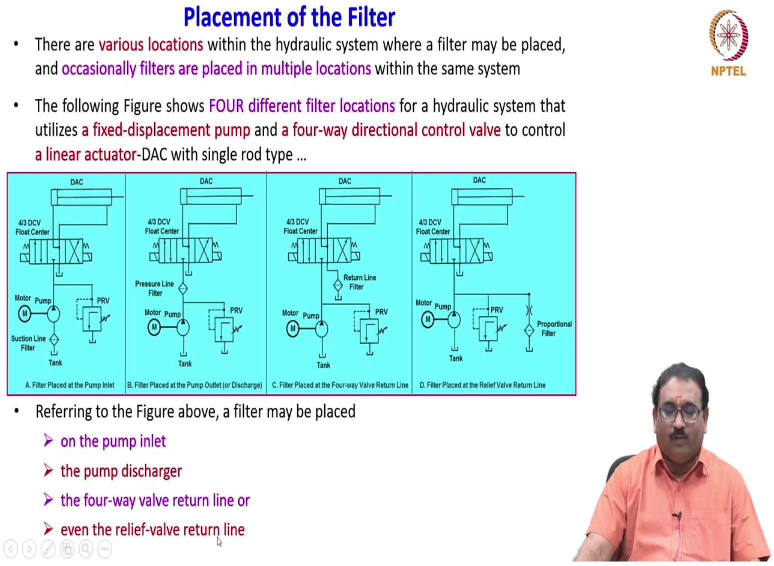


Now, quickly we will see to overcome these contaminants for the better performance of the all the hydraulics circuit should equipped with the filters in various location. Placing these filters for various location, is a trick to overcome the burdens to the maintenance people. And, also enhancing the service life of the components, let us we will see the placement of filter.

There are various locations within the hydraulic system, where a filter may be placed, and occasionally filters are placed in multiple location within the same system. The following four shows the following figure shows four different filter locations for a hydraulic system. That utilizes a fixed displacement pump and a four-way directional control valve to control a linear actuator which is a double acting cylinder with a single rod type.

You will see here I have shown the four different locations of the filters here, you will see the location the filter symbol you are seen already it a rhombus and dotted line you will see. Wherever rhombus and dotted lines are there all are the filters. I have shown here in the first, where I have placed a first before that you identify the components here. The pump hydraulic pump drives through the electric motor or IC engine.

Here, it is the pressure relief valve this is a 4 by 3 DCV, which type it is center is a float center, because A and B are connected to the tank. This is a double acting cylinder, the single rod type correct same. Now, we will see the location of the filters friends a filter is placed at the pump at the pump inlet.

Here, the filter is placed at the pump outlet or a discharged site. Here you will see friends, filter placed at the four way valve return line, here you will see friends where it is PRV is there here the filter placed at the relief valve return line. Now, so referring to the above figure a filter may be placed on the pump inlet, the pump discharge or the outlet the four way valve return line or even the relief valve return line.

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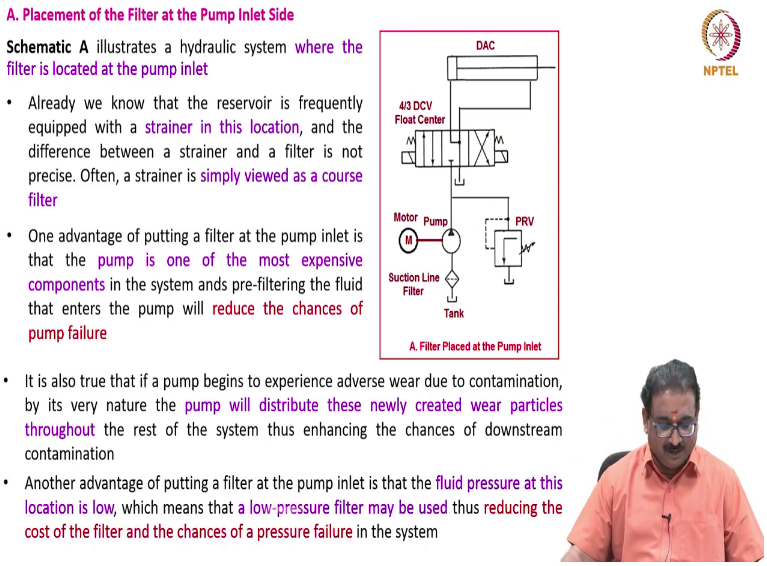


Let us we will see one by one what is the effect and what is the use of placing, the filter in the different location. First one as we have seen the placement of filter at the pump inlet. We will see here figure A illustrates a hydraulic system, where the filter is located at the pump inlet. Pump inlet is a suction that is why it is also known as suction line filter.

Already we know that the reservoir is frequently equipped with the strainer in this location, and the difference between the strainer and a filter is not precise, often a strainer is simply viewed as a course filter. One advantages of putting a filter at the pump inlet is that, the pump is one of the most expensive components in the system and pre-filtering the fluid that enters the pump will reduce the chances of pump failures.

It is also true that if the pump begins to experience a adverse wear due to contamination, by its very nature of the pump will distribute these newly created wear particles throughout the rest of the system thus enhancing the chances of breakdown, and downstream contamination.

Another advantages of putting a filter at the pump inlet is that the fluid pressure at this location is low, because always the pump inlet is atmospheric pressure one bar, which means that a low pressure filter may be used, thus reducing the cost of the filter and the chances of pressure failure in the system.

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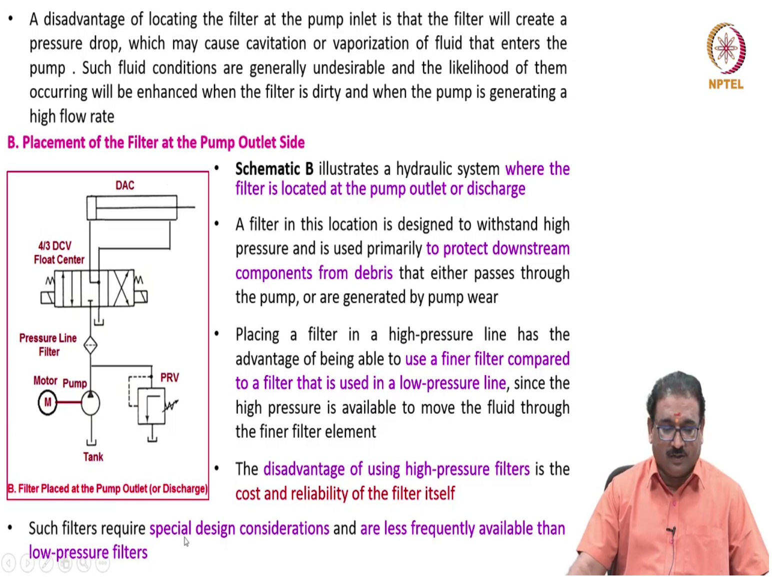


A disadvantages of locating the filter at the pump inlet is that, filter will create a pressure drop, which may cause a cavitation or vaporization of the fluid that enters the pump. Such fluid conditions are generally undesirable, and the likelihood of them occurring will be enhanced when the filter is dirty and when the pump is generating a high flow rate.

Then, placement of filter at the pump outlet side: The schematic B illustrates a hydraulic system, where the filter is located at the pump outlet or the discharge side. A filter in this location is designed to withstand a high pressure always the pump outlet is high pressure, which is generated through the resistance to the flow from the actuator.

So, the filter should withstand a high pressure and used primarily to protect a downstream components from debris, that either pass through the pump, or generated by pump wear. Placing a filter in a high-pressure line has the advantages of being able to use a finer filter compared to filter that is used in a low-pressure line.

Since the high pressure is available to move the fluid through the filter element. The disadvantages of using high-pressure filter is the cost and reliability of the filter itself. Such filters require a special design consideration and are less frequently available than low-pressure filters.

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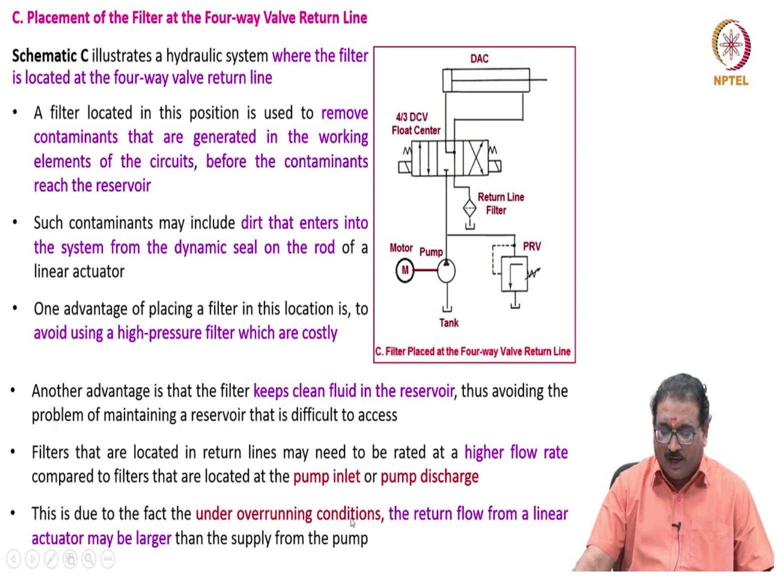


Next one is placement of filter at the four-way valve return line. The schematic C illustrates the hydraulic system, where a filter is located at the four-way valve return line. You will see, this is a return line. A filter located in this position is used to remove contaminants, that are generated in the working elements of the circuits, before the contaminants reach the reservoir. After doing all the work the contaminants, they may enter which should be filtered out before it is going to the tank.

Such contaminants include dirt that enters into the system from the dynamic seal on the rod of a linear actuator. One advantages of placing a filter, in this location is to avoid using a high pressure filter which are costly affairs. Another advantages is that the filter keeps clean fluid in the reservoir, thus avoiding the problem of maintaining a reservoir that is difficult to access.

Filter that are located in the return lines may need to be rated at a higher flow rate compared to filter that are located at the pump inlet or a pump discharge. This is due to the fact that the under overrunning conditions, the return flow from a linear actuator maybe larger than the supply from the pump.

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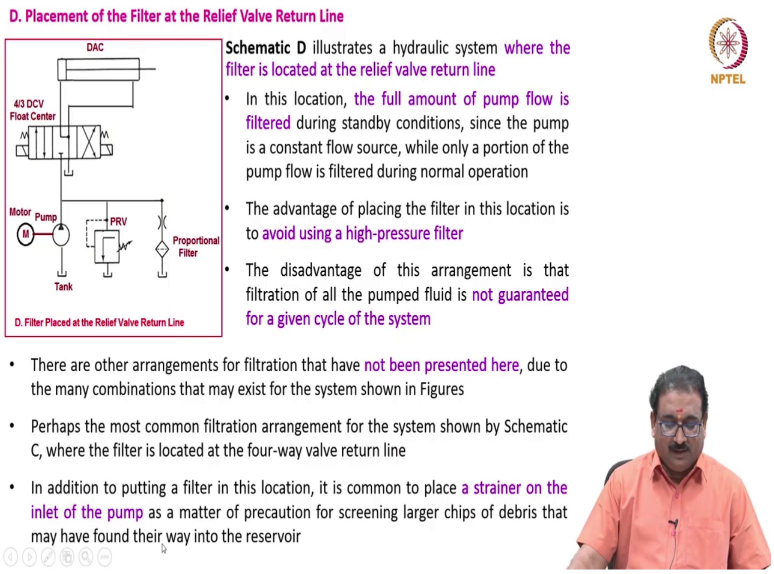


The fourth one, placement of the filter at the relief valve return line: The schematic D illustrates a hydraulic system, where a filter is located at the relief valve return line. In this location the full amount of pump flow is filtered, during a standby conditions. Since the pump is constant flow source while only a portion of the pump flow is filtered during normal operation.

The advantage of placing the filter in this location is to avoid using a high-pressure filter. The disadvantages of this arrangement is that filtration of all pumped fluid is not guaranteed, for a given cycle of the system. There are other arrangements for filtration that have not been presented here, because it is the ocean friends, due to the many combination that may exist for the system shown in above figures.

Perhaps the most common filtration arrangement, for the system shown by the schematic C, where the filter is located at the four-way valve return line. In addition to putting a filter in this location, it is a common to place a strainer on the inlet of the pump as a matter of precaution for screening a larger chips, or debris that may found their way into the reservoir.

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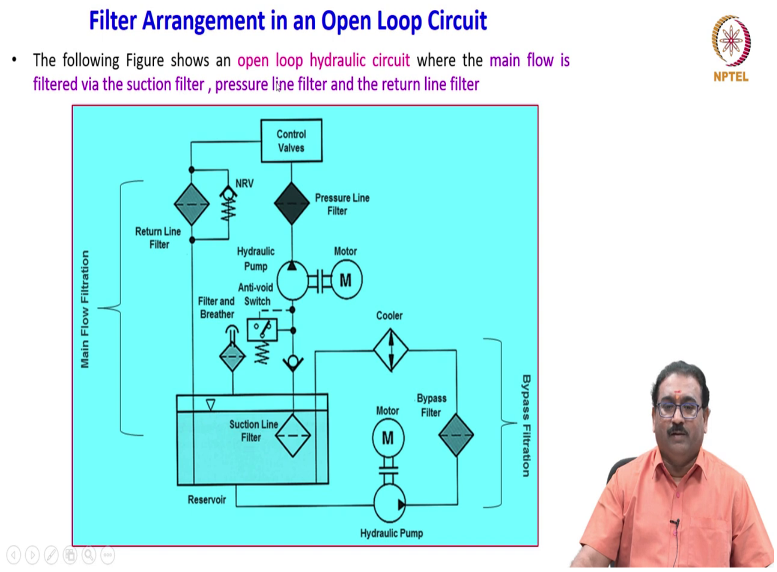


Now, we will quickly see the filter arrangement in an open loop control circuit. This is a figure shows the an open loop control circuit, where the main flow filtration via the suction filter, pressure line filter, and the return line filter. You will see friends here, this is a reservoir at the pump inlet the suction line filters are there, or sometimes a strainer is also there and at the outlet the pressure line filter.

Then, it goes to the control valves, during the return the return line filters equipped with the non-return valve, to bypass the fluid sometimes to the tank during maintenance. Then, you will see here the filter and breather arrangement is also there, this is a main filtration system.

Now, we will see again I have shown you here from the reservoir, as and when required during the maintenance time, that time what I will do the hydraulic pump will sucks the fluid and sends to the bypass filter to clean it out. This is a bypass filtration.

Then, again you will see here hydraulic pump is drive through the motor here, additional one it is compared to this. Then, you will see after you have to cool using the cooler before sending to the tank, this is a bypass filtration, this is a main flow filtration during the process. It is a open loop circuit the location of the various filters.

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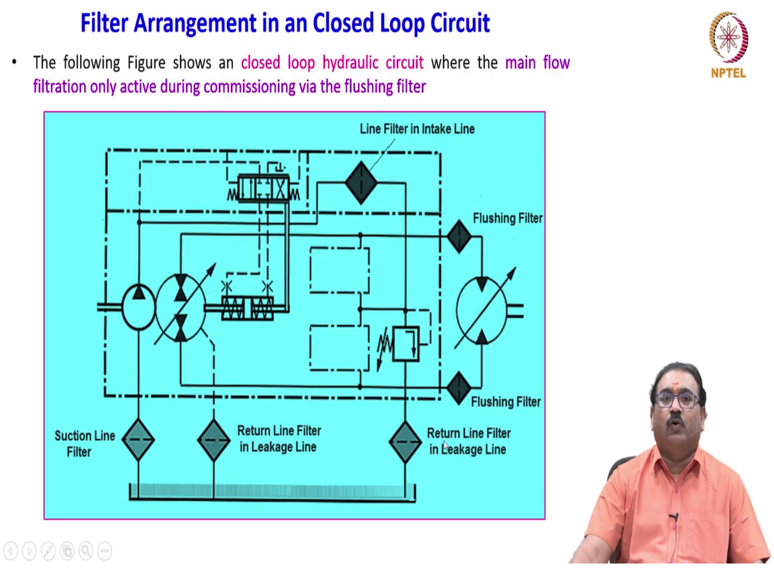


Now, we will see the filter arrangement in an closed loop circuit. The following figure shows an closed loop hydraulic circuit, where the main flow filtration only active during commissioning via the flushing filter, this is a flushing filter.

You will see here friends, many things are there, this is a tank, suction line filters, return line filter, in a leakage line, return line filter, again it is a leakage line. And, then you will see here friends the flushing filters are there correct. And one more filter I have shown line filter intake line, this is the various filters used in the closed loop circuit, concluding remarks.

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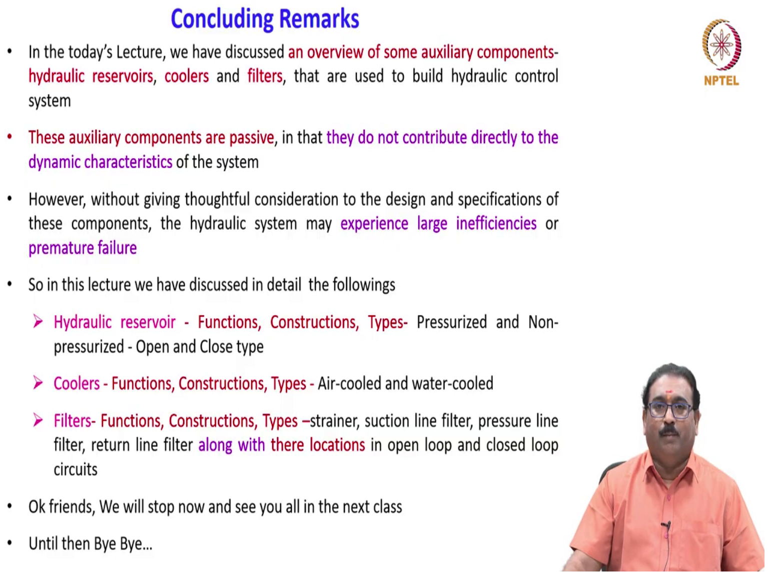


In today's lecture, we have discussed an overview of some auxiliary components, hydraulic reservoirs, coolers, filters that are used to build hydraulic control system. These auxiliary components are passive, in that they do not contribute directly to the dynamic characteristics of the system.

However, without giving a thoughtful consideration in the design and specification of these components, the hydraulic system may experience a large inefficiencies or a premature failure. So, in this lecture we have discussed in detail the followings hydraulic reservoirs we have seen, the functions, construction, types we have seen pressurized and non-pressurized.

In non pressurized again a open and closed type and what are the elements involved in the reservoir we have seen. Then, coolers the functions constructions, types, again air cooled and water-cooled we have studied.

Filters the functions construction types like a strainer, suction line filter, pressure line filter, return line filter, along with their location in open loop and a closed loop circuits. Ok friends, we, will stop now and see you all in the next class, again we will discuss some of the auxiliary components. Until then bye bye.

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Thank you one and all for your kind attention. [FL]