Oil Hydraulics and Pneumatics

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Part 1: Hydraulic reservoirs-functions, Constructional details, Types, Design aspects of efficient reservoir systems like Sizing, Quality of fluids, Overcoming the adverse effect of entrained air and Cooling the hydraulic fluid

Lecture - 58

Subsystems: Hydraulic Reservoir, Coolers and Filters

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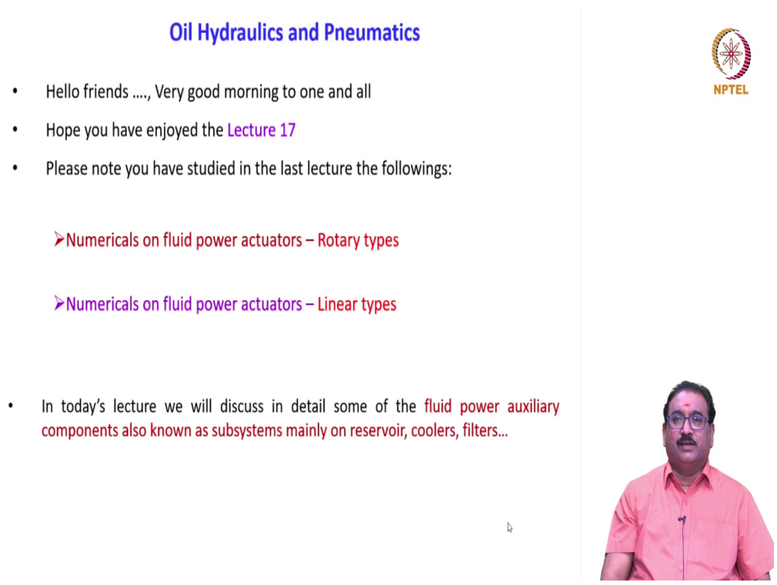

My name is Somashekhar course faculty for this course. Hello friends, very good morning to one and all. Hope you have enjoyed the lecture 17. Please note you have studied in the last lecture the followings: Numerical on fluid power actuator- rotary types, Numerical on fluid power actuator- linear types. In today's lecture we will discuss in detail some of the fluid power auxiliary components also known as a subsystems mainly on reservoir, coolers, filters and many more.

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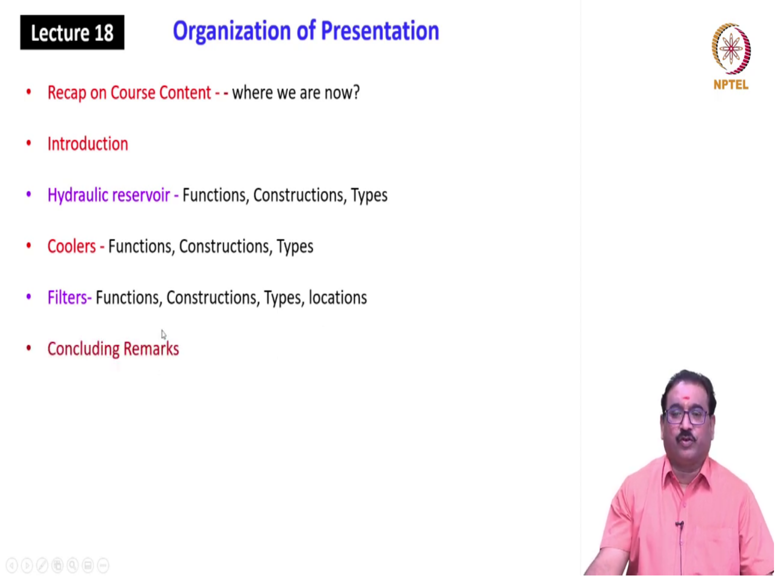

Quickly we will see the Organization of Presentation. It includes the recap on the course content; just to where we are now? And then we will start the introduction to today's lecture. Mainly, hydraulic reservoir- functions, constructions and types. Next, we will move on to coolers. Here we will discuss functions, construction and various types. Next filters functions, construction, types and locations. Then finally, I will conclude today's lecture.

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Recap

Course Outline

Sl. No.	Particulars	Lecture Hours
1.	Introduction to Oil Hydraulics and Pneumatics: Power Transmission Methods, Scopes, Application areas, Components and Subsystems, Merits and Demerits, Research Challenges	2
2.	Basic Laws and Symbols	2
3.	Pumps: Types, Characteristics, Operations, Efficiencies, Torque and Power, Numerical	3
4.	Compressed Air Generation, Preparation and Distribution: Compressors- Types, Characteristics, Operations, Efficiencies, Torque and Power, Pressure Drop and its Calculations	2
5.	Air Driers: Types, Characteristics, and Applications	1
6.	Valves: Constructional Details, Operations and Application Areas of Various Types of Directional Control Valves, Pressure Control Valves, Flow Control Valve, Numerical	4
7.	Actuators: Rotary and Linear Actuators - Types, Characteristics, Operations, Efficiencies, Torque and Power, Numerical	3
8.	Subsystems: Reservoirs, Hydraulic Fluids, Seals, Filters, Accumulators, Maintenance	3
9.	Circuit Design and Analysis: Development of Single Actuator Circuits, Development of Multiple Actuator Circuits, Cascade Method for Sequencing	4
10.	Hydrostatic Transmission and Control: Different Configurations and Analysis, Pump and Motor Characteristics	2
11.	Servo and Proportional Valves: Constructional Details, Operations, and Applications	3
12.	Role of Modeling and Simulation in Hydraulic Components- Case Studies	1

Friends, just see this is the course outline for the entire course. Now, we are here. We have covered in detail all the things introduction to oil hydraulic and pneumatics, basic laws and symbols, pumps, compressed air generation, preparation and distribution, air driers, valves, actuators.

And now, we are here a subsystem, which are very very important like a primary components of the fluid power system. Here we will see here friends I am restricting this study only for 3 lecture hours. Discussing mainly on the reservoirs, hydraulic fluids, filters, accumulators and some glimpse on maintenance.

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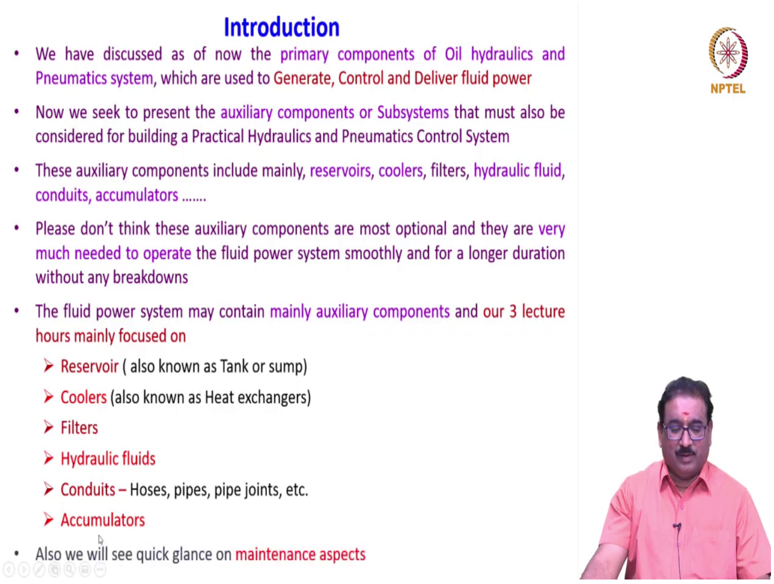

We have discussed as of now the primary components of oil hydraulics and pneumatic system, which are used to generate, control and deliver fluid power. Now, we seek to present the auxiliary components or a subsystems that must also be considered for building a practical hydraulics and pneumatic control system.

These auxiliary components include mainly, reservoirs, coolers, filters, hydraulic fluid, conduits, accumulators and many more. Please do not think these auxiliary components are most optional. They are very much needed to operate the fluid power system smoothly and for a longer duration without any breakdowns.

The fluid power system may contain mainly the auxiliary components and our 3 lecture hours mainly focused on. Reservoirs and some of the design aspects they are also known as the tank or a sump. Coolers also known as heat exchanges, filters, hydraulic fluids, conduits, which includes the hoses, pipes and various joints, accumulators. Also we will see quick glance on maintenance aspects of the fluid power system components.

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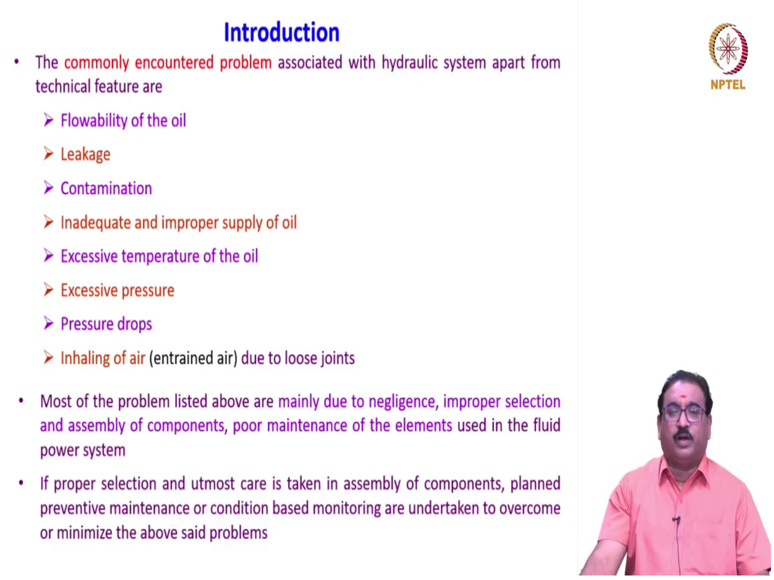

The commonly encountered problem associated with the hydraulic system apart from the technical features are- flowability of the oil, leakage, contamination, inadequate and improper supply of oil, excessive temperature of the oil, excessive pressure, pressure drops, inhaling of air entrained air due to loose joints.

Most of the problem listed above are mainly due to negligence, improper selection and assembly of components, poor maintenance of the elements used in the fluid power system. Proper selection and utmost care is taken in assembly of components, planned preventive maintenance or a condition based monitoring are undertaken to overcome or minimize the above said problems.

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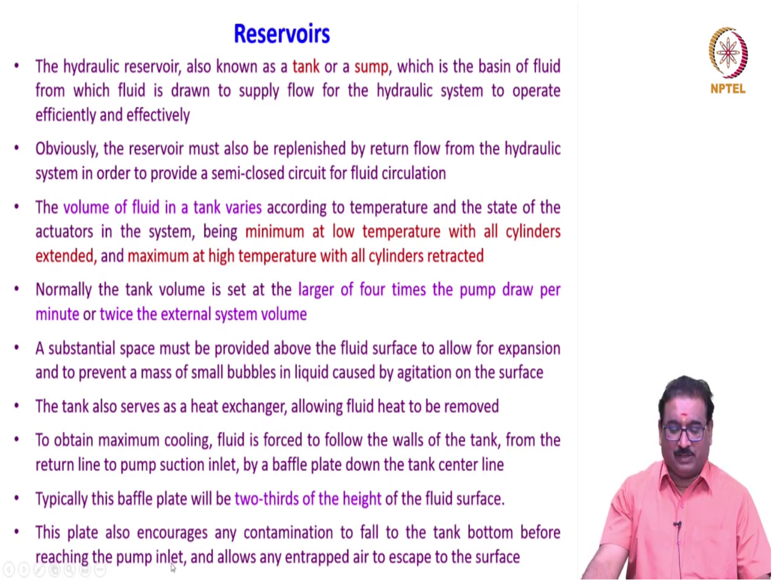

Let us we will begin with the reservoir. The hydraulic reservoir, also known as a tank or a sump, which is the basin of fluid from which fluid is drawn to supply flow to the hydraulic system to operate efficiently and effectively. Obviously, the reservoir must also be replenished by return flow from the hydraulic system in order to provide a semi-closed circuit for fluid circulation.

The volume of fluid in a tank varies according to temperature and the state of the actuator in the system, being minimum at a low temperature with all cylinders extended, and a maximum at high temperature with all cylinders retracted. Normally the tank volume is set at the larger of four times the pump draw per minute or twice the external system volume.

A substantial space must be provided above the fluid surface to allow for the expansion and to present a mass of small bubbles in the liquid caused by agitation on the surface. The tank also serves as a heat exchanger, allowing fluid heat to be removed. To obtain maximum cooling, fluid is forced to follow the walls of the tank, from the return line to pump suction inlet, by a baffle plate down the tank center line.

Typically, this baffle plate will be two-thirds of the height of the fluid surface. This plate also encourages any contamination to fall to the tank bottom before reaching the pump inlet, and allows any entrapped air to escape to the surface.

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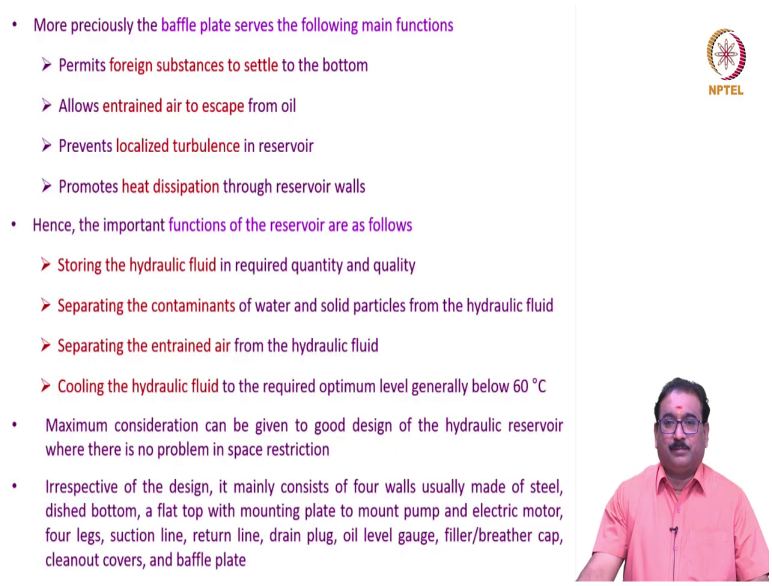

More precisely the baffle plate in the reservoir serves the following main functions. Permits foreign substances to settle to the bottom, allows entrained air to escape from the oil, prevents localized turbulence in reservoir, promotes heat dissipation through the reservoir walls.

Hence, the important function of the reservoir are as follows, storing the hydraulic fluid in the required quantity and quality. Separating the contaminants of water and solid particle from the hydraulic fluid. Separating the entrained air from the hydraulic fluid. Cooling the hydraulic fluid to the required optimum level generally below the 60-degree centigrade in most of the industrial applications.

Maximum consideration can be given to good design of the hydraulic reservoir where there is no problem in space restriction. Irrespective of the design, it mainly consists of four valves usually made of steel, dished bottom, a flat top with a mounting plate to mount pump and electric motor, four legs, section line, return line, drain plug, oil level gauge, filler breather cap, clean out covers and baffle plate.

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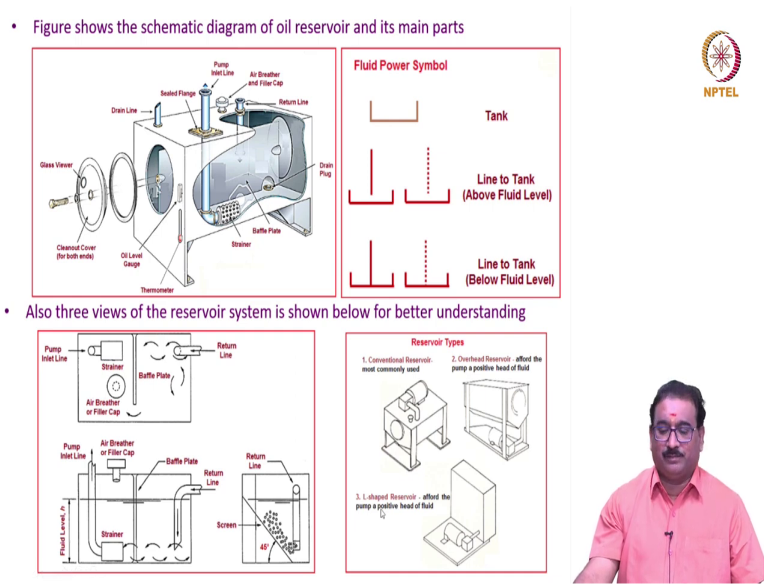

Figure shows, the schematic diagram of the oil reservoir and its main parts. Friends, please see all the parts I have detailed about, which includes this is the whole a tank, which includes we will see here strainer and this is the pump inlet line. And this one is a return line and then you will see here a drain plug and top you will see many parts are their air breather and a filler cap.

Then you will see here a drain line as I have told you the clean out cover for both ends. And some of the monitoring system like a thermometer and oil level gauge. Also, you will see here friends, the baffle plate which is a very very important component in the reservoir system. You will see here the fluid power symbol for the tank is this is small rectangular type.

Then you will see here if it is mentioned like this it is a line to tank above the fluid level. If they will touch here the line to tank it is below the fluid level. Please understand the fluid power symbol, which are most commonly used in the fluid power circuits. Now, we will see here also I am showing you here the 3 views of reservoir system for better understanding.

See all the parts as I have told you are there in the figure. Pump inlet line with a strainer, then return line, then between the return line and the pump inlet line as I have told you baffle plate. Then you will see here top of the tank air breather or a filler cap. Then fluid level is marked here h which sees through the oil level gauge, in oil level gauge they will marked the maximum and minimum oil in the tank.

Then you will see here in the side view I have shown you very important screen, which is kept at the 45 degree for the control the contamination level this is the return line. Now, you will see I will show you here based on the some of the construction future the reservoirs are classified as conventional reservoir this is most commonly used a reservoir tank correct?

What you are seeing here reservoirs tank rectangular reservoirs tank and square rectangular square also they are used in the smaller application. But generally a angular tank and mounted with the pump and a motor it is a all conventional reservoirs. And some of the application you will see here the overhead reservoir afford the pump a positive height fluid because pump is at the down. Then here you will see, the L-shaped reservoir afford the positive head for the pump to suck the fluids.

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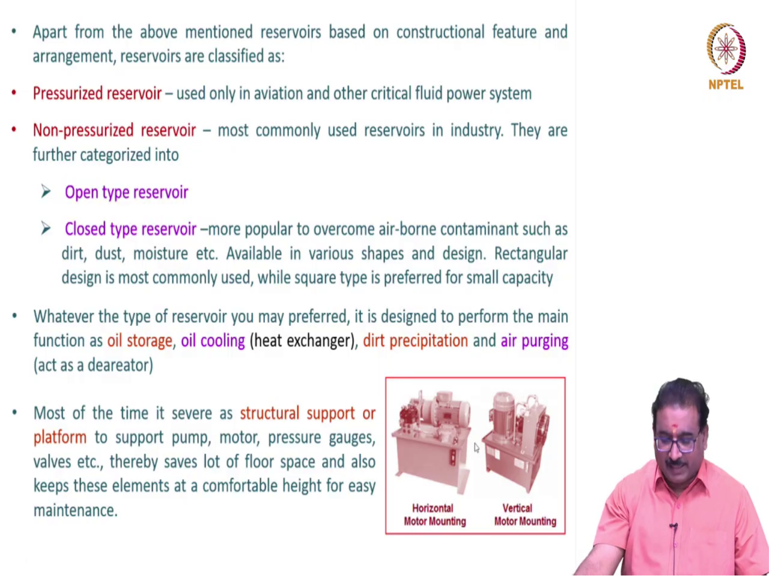

Apart from the above mentioned reservoirs based on the constructional future and arrangement the tank and the pump and motor system as you have seen in the previous slide. Apart from this they are classified as the pressurized reservoir - used only in aviation and other critical fluid power system.

Non-pressurized reservoir most commonly used reservoirs in industry. They are further categorized into open type reservoir and closed type reservoir. This is a more popular to overcome airborne contaminants such as a dirt, dust, moisture etcetera. They are available in various shapes and design. As I have told you rectangular design is most commonly used while the square type is preferred for a small capacity.

Whatever the type of reservoir you may preferred it is designed to perform the main function as oil storage, oil cooling, dirt precipitation and air purging meaning act as a deareator. These are the four important function each reservoir should follow. Most of the time it serves as a structural support or a platform to support a pump, motor, pressure gauges, valves and many more.

Thereby saves a lot of floor space and also keeps these elements at a comfortable height for easy in maintenance work. You will see here I am shown here the horizontal motor mounting. Here you will see the vertical motor mounting the various designs are there in the power pacts.

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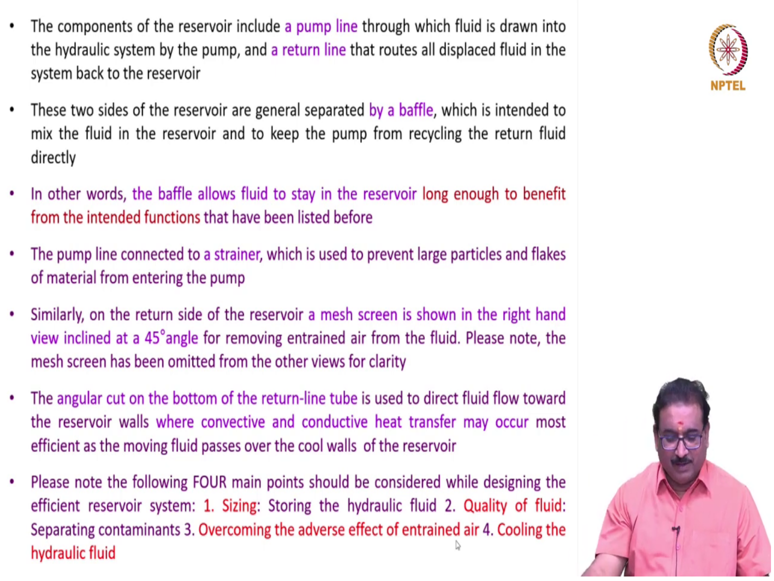

The components of the reservoir include a pump line through, which a fluid is drawn into the hydraulic system by the pump, and a return line that routes all displaced fluid in the system back to the reservoir. These two sides of the reservoir are generally separated by a baffle, which is intended to mix the fluid in the reservoir and to keep the pump from recycling the return fluid directly.

In other words, a baffle allows a fluid to stay in the reservoir long enough to benefit from the intended function that have been listed above. The pump line connected to a strainer, which is used to prevent a large particles and a flakes of material from entering the pump.

Similarly, on the return line side of the reservoir a mesh screen is shown in the right-hand view inclined at 45 degree for removing the entrained air from the fluid. Please note, the mesh screen has been omitted from the other views as I have shown in the previous slide for the clarity.

Only in the side way I have shown the screen mesh which kept at 45 degree angle. The angular cut of the bottom of the return-line tube is used to direct fluid flow towards the reservoir walls where the convective and a conductive heat transfer may occur most efficient as the moving fluid passes over the cool walls of the reservoir.

Please note the following four main points should be considered while designing the efficient reservoir system: what are those? Based on the application the sizing of the reservoir is very important. Because, which will stores the hydraulic fluid and then quality of fluid meaning the mechanism you have to provide for separating the contaminants.

And also overcome the adverse effect of entrained air, which is a very dangerous in the hydraulic reservoirs. And last, but not the least cooling the hydraulic fluid is also essential these are the four important points you have to considered while designing the reservoir system.

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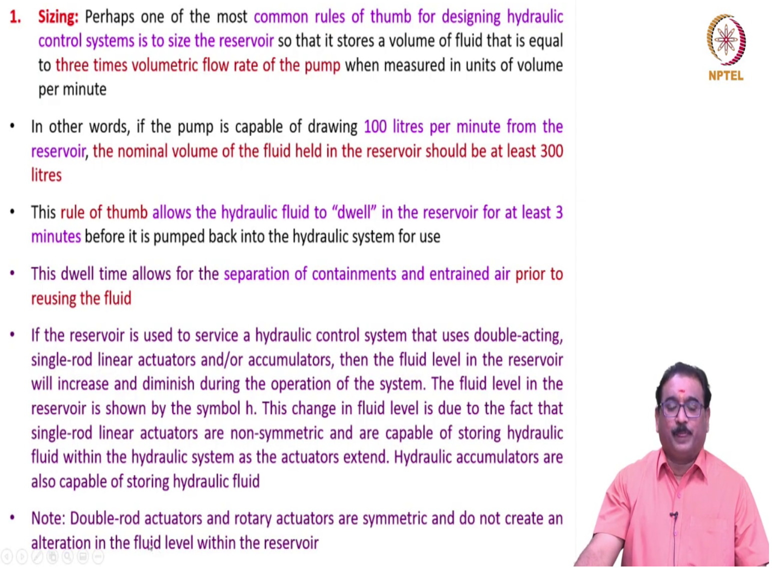

Let us we will see one by one now. Sizing: perhaps one of the most common rules of thumb for designing the hydraulic control system is to size the reservoir. So that it stores a volume of fluid that is equal to three times volumetric flow rate of the pump when measured in units of volume per minute.

In other words, if the pump is capable of drawing 100 litres per minute from the reservoir, the nominal volume of the fluid held in the reservoir should be at least 300 liters. This rule of thumb allows to the hydraulic fluid to "dwell" in the reservoir for at least 3 minutes before it is pumped back into the hydraulic system for use.

This dwell time allows for the separation of contaminants and entrained air prior to reusing the fluids. If the reservoir is used to service a hydraulic control system that uses a double-acting, single acting, linear actuators and accumulators, then the fluid level in the reservoir will increase and diminish during the operation of the system. The fluid level in the reservoir is shown by the symbol h in the previous slide.

This change in fluid level is due to the fact that a single linear actuators are non-symmetric and are capable of storing hydraulic fluid within the hydraulic system as the actuators extend. Hydraulic accumulators are also capable of storing the hydraulic fluids. Note: double-rod actuators and rotary actuators are symmetric and do not create an alteration in the fluid level within the reservoir.

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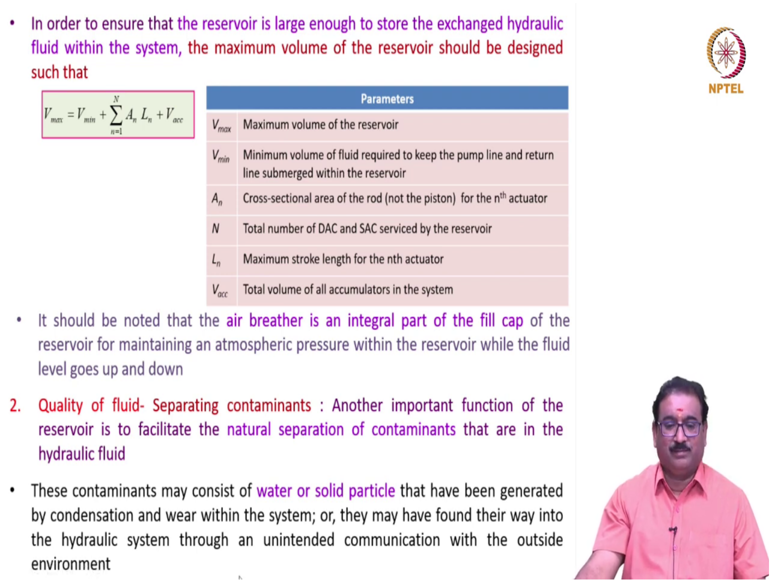

In order to ensure that the reservoir is large enough to store the exchanged hydraulic fluid within the system, the maximum volume of the reservoirs should be designed such that V max equal to V min plus summation of n equal to 1 to capital N A n L n plus V c V acc. What is this? V max is the maximum volume of the reservoir is equal to the minimum volume of fluid required to keep the pump line and return line submerged within the reservoir.

A n is cross-sectional area of the rod not the piston for the n-th actuator. Capital N is total number of double acting, single acting serviced by the reservoir. L n is maximum stroke length of the n-th actuator. V acc equal to total volume of all accumulators in the system.

Please understand friends here while sizing the reservoir you have to take into account the available actuator whether it is a single acting, double acting and the rod area as well as the number of accumulators used to support this reservoir. It should be noted that the air breather is an integral part of the fill cap of the reservoir for maintaining an atmospheric pressure within the reservoir while the fluid level goes up and down.

Then we will see the quality of fluids 2nd important parameter in designing this is based on the mechanism incorporated in separating the contaminants. Another important function of the reservoir is to facilitate the natural separation of the contaminants that are in the hydraulic fluid. These contaminants they consist of water or solid particle that have been generated by condensation and wear within the system; or, they may have found their way into the hydraulic system through an unintended communication with the outside environment.

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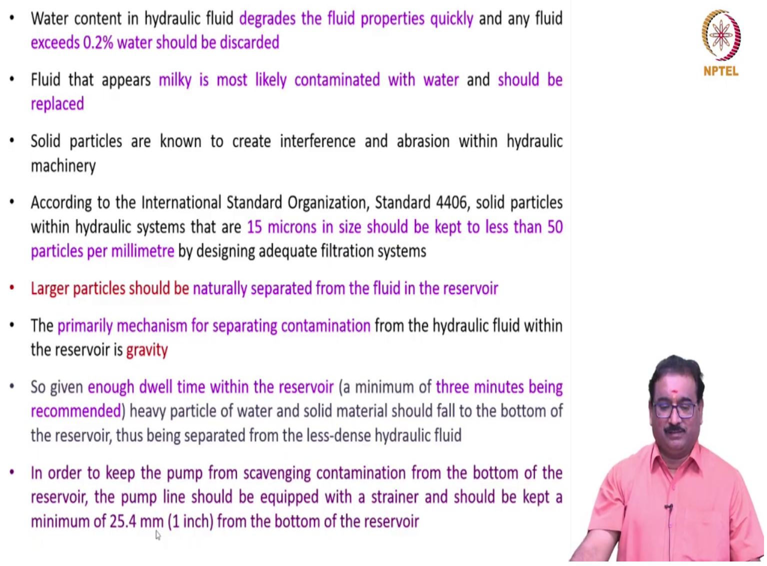

Water content in hydraulic fluid degrades the fluid properties quickly and any fluid exceeds 0.2 percent of water should be discarded. You will see how much oil is safe from the moisture. Fluid that appears a milky is most likely contaminated with water and should be replaced as early as possible.

Solid particles are known to create interferences and abrasion within the hydraulic machinery. According to the International Standard Organization, Standard 4406, solid particles within the hydraulic system that are 15 microns in size should be kept to less than a 50 particles per millimeter by designing the adequate filtration system to overcome these particles.

Larger particles should be naturally separated from the fluid in the reservoir. The primary mechanism for separating the contamination from the hydraulic fluid within the reservoir is by gravity. They will settle by themselves that is why leave the fluid at least 3 minutes before you are reusing.

So, given enough dwell time within the reservoir heavy particles of water and solid material should fall to the bottom surface of the reservoir, thus being separated from the less dense hydraulic fluids. In order to keep the pump from scavenging contamination from the bottom of the reservoir, the pump line should be equipped with a strainer and should be kept a minimum of 25.4 mm from the bottom of the reservoir.

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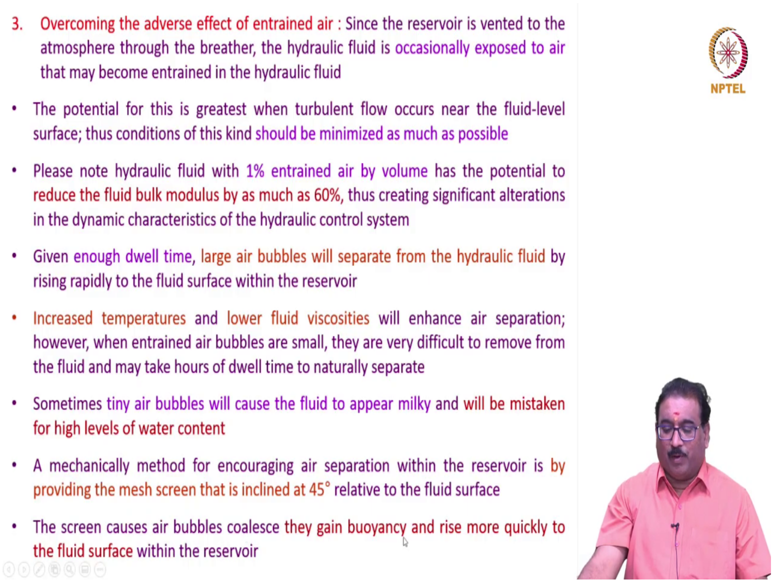

3rd consideration overcoming the adverse effect of entrained air: Since the reservoir is vented to the atmosphere through the breather, the hydraulic fluid is occasionally exposed to air that may become entrained in the hydraulic fluid. The potential for this is greatest when turbulent flow occurs near the fluid-level surface. Thus condition of this kind should be minimized as much as possible.

Please note the hydraulic fluid with 1 percent entrained air by volume as the potential to reduce the fluid bulk modulus by as much as 60 percent, thus creating a significant alteration in the dynamic characteristics of the hydraulic system. You will see the effect of entrained air even 1 percent reduces the performance drastically.

Given enough dwell time, larger air particles will separate from the hydraulic fluid by rising rapidly to the fluid surface within the reservoir. Increased temperature and lower fluid viscosity will enhance a air separation; however, when the entrained air bubbles are small, they are very difficult to remove from the fluid and may take hours of dwell time to naturally separate.

Sometimes a tiny bubbles will cause the fluid to appear milky and will be mistaken for high levels of water contaminant. Please take care here, the milky appearance of the hydraulic fluid is not only due to the water content they sometimes it is misleading to the maintenance people this is due to the air entrapment in the fluid.

A mechanical method for encouraging the air separation within the reservoir is by providing the mesh screen that is inclined at 45 degrees relative to the fluid surface. The screen causes air bubble coalesces they gain buoyancy and rise more quickly to the fluid surface within the reservoir.

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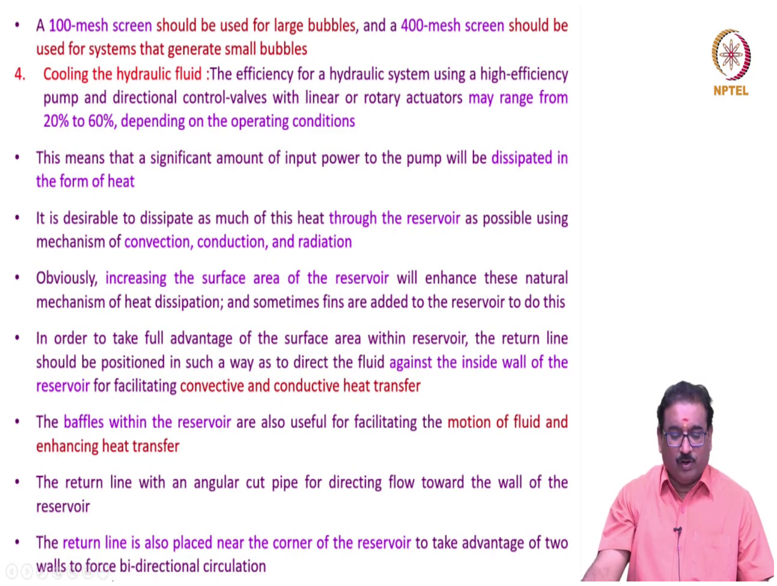

A 100-mesh screen should be used for larger bubbles, and a 400-mesh screen should be used for a system that generate a small bubbles. 4-th important factor in the reservoir is cooling the hydraulic fluid: The efficiency of the hydraulic system using a high-efficiency pump and directional control-valves with a linear or a rotary actuator may range from 20 percent to 60 percent, depending on the operating conditions.

This means that a significant amount of input power to the pump will be dissipated in the form of heat. It is desirable to dissipate as much as this heat through the reservoir as possible using a mechanism of convection, conduction, and radiation. Obviously, increasing the surface area of the reservoir will enhance these natural mechanism of heat dissipation; and sometimes fins are added to the reservoir to do this function.

In order to take advantages of the surface area within the reservoir, the return line should be positioned in such a way as to direct the fluid against the inside walls of the reservoir for facilitating convective and conductive heat transfer. The baffles within the reservoir are also useful for facilitating the motion of fluid and enhancing heat transfer.

The return line within an angular cut pipe for directing a fluid flow towards the wall of the reservoir. The return line is also placed near the corner of the reservoir to take the advantages of two walls to force bi-directional circulation.