Oil Hydraulics and Pneumatics
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Subsystems: Hydraulic Fluids, Conduits and Simple Numericals
Lecture - 63
Part-3: Hydraulic conduits, Main functions, Seal Failures and simple numerical

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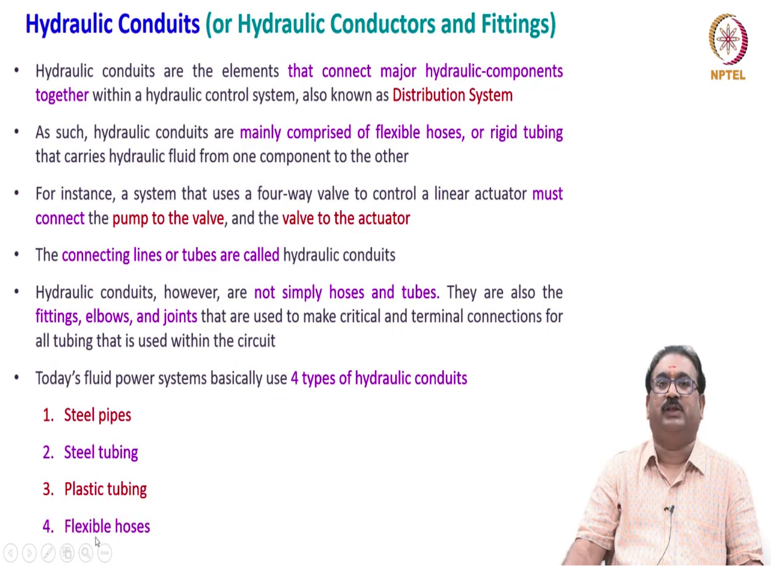

My name is Somashekhar, course faculty for this course. After knowing this, now we will concentrate on Hydraulic Conduits. It is also known as hydraulic conductors and a fittings, which is a very very important in hydraulic system to transmit the pressurized fluid from the tank to the various stages; meaning, it will go from the pump to the valves, the valves to the actuator; then, after doing the work, again it will come back to the tank. Who will do this? Using the hydraulic conduits.

Now, we will see hydraulic conduits are the elements that connect a major hydraulic-components together within the control system also known as a Distribution system. As such, hydraulic conduits are mainly comprised of flexible hoses or a rigid tubing that carries hydraulic fluid from one component to the other.

For instance, a system that uses a four-way valve to control a linear actuator must connect the pump to the valve and the valve to the actuator and then, return that is very important. The connecting lines or a tubes are called hydraulic conduits. Hydraulic conduits, however, are not simply hoses and a tubes.

They are also includes the fittings, elbows, joints that are used to make critical and terminal connections for all tubing that is used within the circuit. Today's fluid power system basically use 4 types of hydraulic conduits; steel pipes, steel tubing, plastic tubing, flexible hoses.

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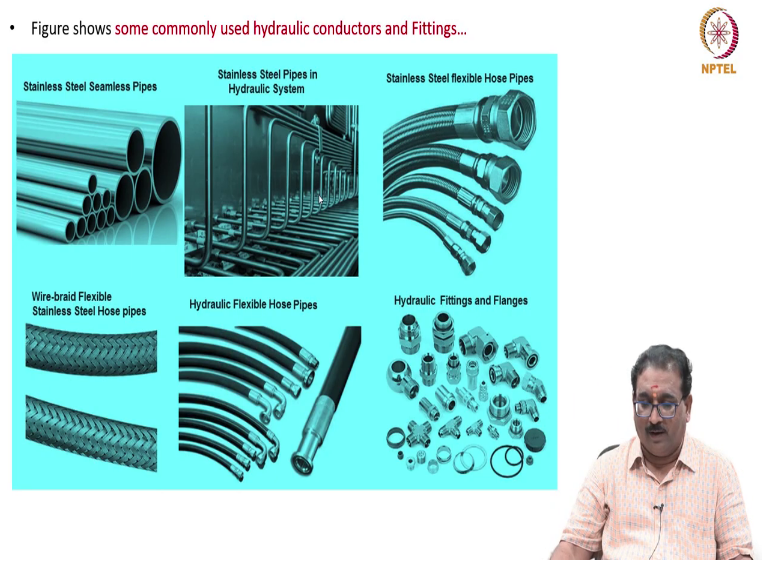

Now, we will see here, the figure shows the photographic view of the stainless steel seamless round pipes. Here it will show in the hydraulic industry, how the stainless steel tubes are used for connecting the one part to another to transmit the fluid flow. Then, you will see here a stainless steel flexible hoses.

Then, wire braid flexible stainless steel hose pipes. Here, you will see hydraulic flexible hose pipes for high pressure applications. As I have told you, the hydraulic conduits also includes the various fittings connectors and a flanges.

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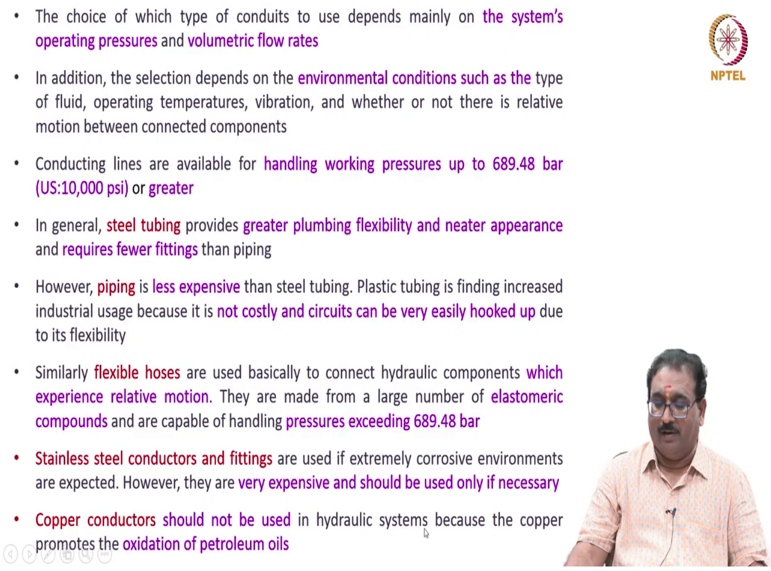

The choice of which type of conduits to use depends mainly on the system's operating pressure and volumetric flow rates. In addition, the selection depends on the environmental conditions such as the type of fluid, operating temperatures, vibration, and whether or not there is a relative motion between the connected components.

Conducting lines are available for handling working pressures up to 689.48 bar or a greater. In general, steel tubing provides a greater plumbing flexibility and a neater appearance and requires fewer fittings than a piping. However, piping is less expensive than the steel tubing.

Plastic tubing is finding increased industrial usage because it is not costly and a circuits can be very easily hooked up due to its flexibility. Similarly, flexible hoses are used basically to connect hydraulic components which experience relative motion. They are made from a large number of elastomeric compounds and are capable of handling pressures exceeding 689.48 bar.

Stainless steel conductors and fittings are used if extremely corrosive environments are expected. However, they are very expensive and should be used only if necessary. Copper conductors should not be used in the hydraulic systems because the copper promotes the oxidation of petroleum-based fluids.

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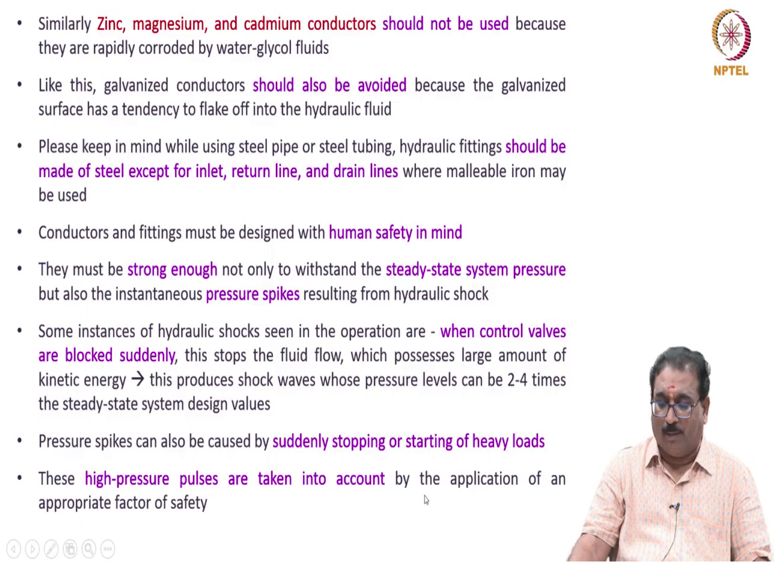

Similarly, zinc, magnesium, and cadmium conductors should not be used because they are rapidly corroded by water-glycol fluids. Like this, galvanized conductors should also be avoided because the galvanized surface has a tendency to flake off into the hydraulic fluids.

Please keep in mind, while using the steel pipe or steel tubing, hydraulic fitting should be made of steel except for inlet, return line, and a drain lines where malleable iron may be used. Conductors and a fittings must be designed with human safety in mind. They must be strong enough not only to withstand the steady-state system pressure, but also the instantaneous pressure spikes resulting from the hydraulic shock.

Some instances of hydraulic shock seen in the operations are when control valves are blocked suddenly, this stops the fluid flow, which possesses a large amount of kinetic energy.

This produces such shock waves whose pressure levels can be 2 to 4 times the steady-state system designed values. Pressure spikes can also be caused by suddenly stopping or starting of heavy loads. These high-pressure pulses are taken into account by the application of an appropriate factor of safety.

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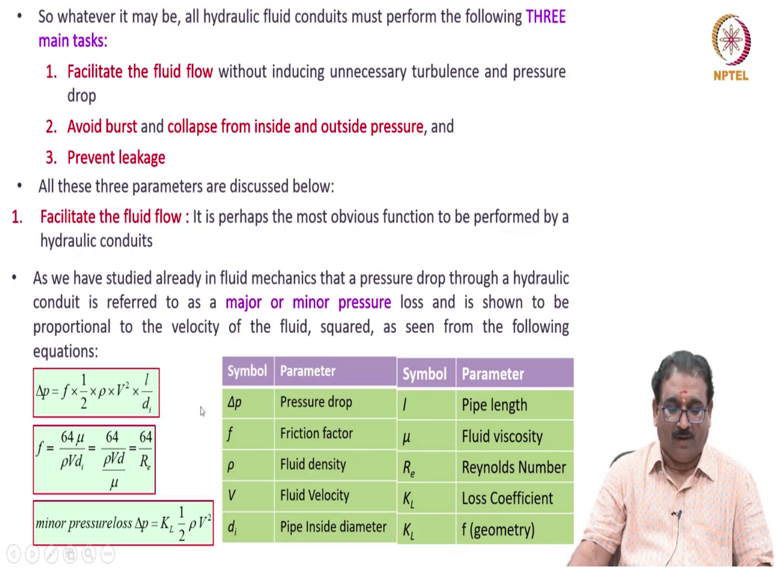

So, whatever it may be, all hydraulic fluid conduits must perform the following three main task; what are those? First one is facilitate the fluid flow without inducing unnecessary turbulence and a pressure drop. Second one is avoid burst and collapse from inside and outside pressure and third one is it prevents leakage. All these parameters are discussed briefly below.

First one is facilitate the fluid flow. It perhaps most obvious function to be performed by the hydraulic conduits. As we have studied already in fluid mechanics that a pressure drop through a hydraulic conduit is referred to as a major or a minor pressure loss and is shown to be proportional to the velocity of the fluid, squared, as seen from the following equations.

We have already studied in the fluid mechanics; delta p equal to f into 1 by 2 rho V square into l by d i; where delta p is a pressure drop, f is a friction factor, rho is a fluid density, V is a fluid velocity, d i is a pipe inside diameter, then l is a pipe length. Then, this f is there know, f is a friction factor which is given by 64 mu rho V d i or you have to arrange it 64 mu will take down, rho V d by mu.

Rho V d by mu, already we know that it is a Reynolds number. Minor pressure loss delta p is given by K L 1 by 2 rho V square. Here, all the parameters are given, but you will remember K L is the loss coefficient which is a function of geometry.

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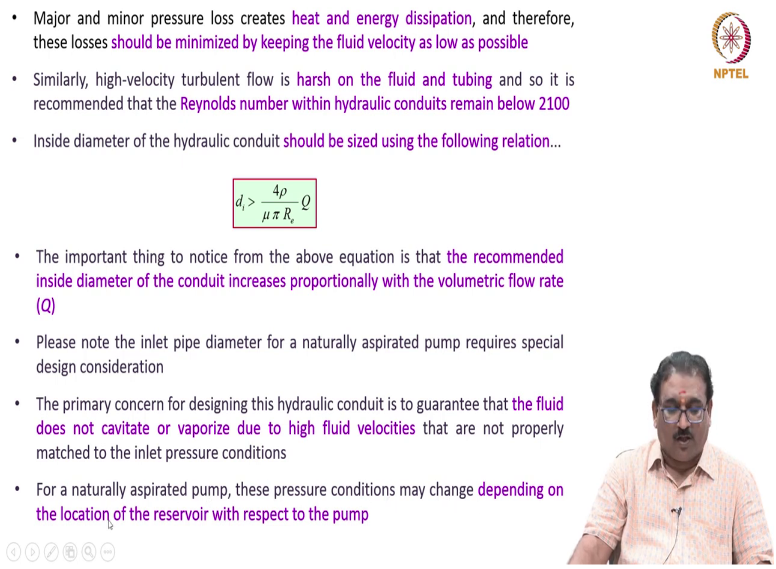

Major and minor pressure loss creates heat and energy dissipation, and therefore, these losses should be minimized by keeping the fluid velocity as low as possible. Similarly, high-velocity turbulent flow is harsh on the fluid and a tubing and so it is recommended that the Reynolds number within the hydraulic conduits remain below 2100.

Inside a diameter of the hydraulic conduit should be sized using the following relations; d i is greater than 4 rho mu pi R e into Q. The important thing to notice from the above equation is that the recommended inside diameter of the conduit increases proportionately with the volumetric flow rate Q.

Please note, the inlet pipe diameter for a naturally aspirated pump requires a special design consideration. The primary concern for designing this hydraulic conduit is to guarantee that the fluid does not cavitate or vaporize due to high fluid velocities that are not properly matched to the inlet pressure conditions. So, for a naturally aspirated pump, these pressure conditions may change depending on the location of the reservoir with respect to the pump.

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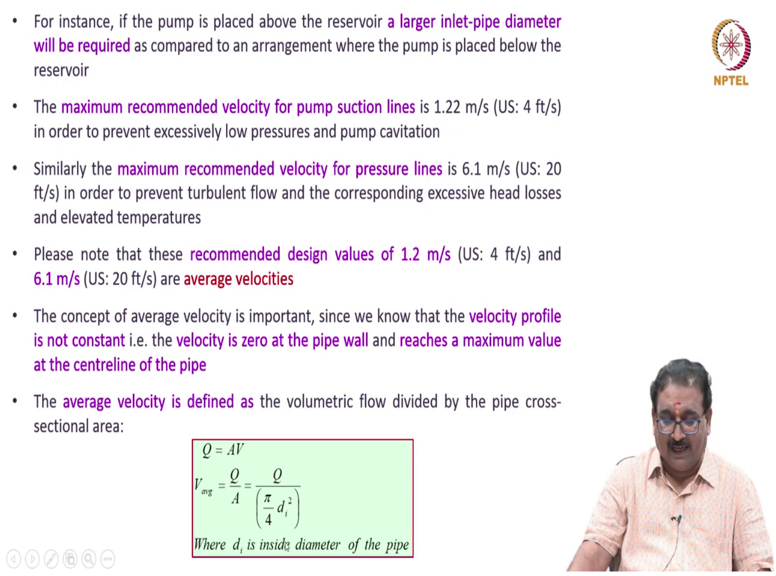

For instance, if the pump is placed above the reservoir a larger inlet-pipe diameter will be required as compared to an arrangement where the pump is placed below the reservoir. The maximum recommended velocity for a pump suction line is 1.22 meters per second in order to prevent excessively low pressures and pump cavitation.

Similarly the maximum recommended velocity for a pressure lines is 6.1 meters per second. In order to prevent a turbulent flow corresponding excessive head losses and elevated temperatures. Please note that these recommended design values of 1.2 meters per second and 6.1 meters per second are average velocities; meaning, the concept of average velocity is important, since we know that the velocity profile is not constant through the pipes.

So, that is a velocity is zero at the pipe wall and reaches a maximum value at the centre line of the pipe. The average velocity is defined as the volumetric flow divided by the pipe cross sectional area that is Q equal to AV. Already, we know the continuity equation. V average is equal to Q by A here; A is pi by 4 d i square; d i is a inside diameter of the pipe.

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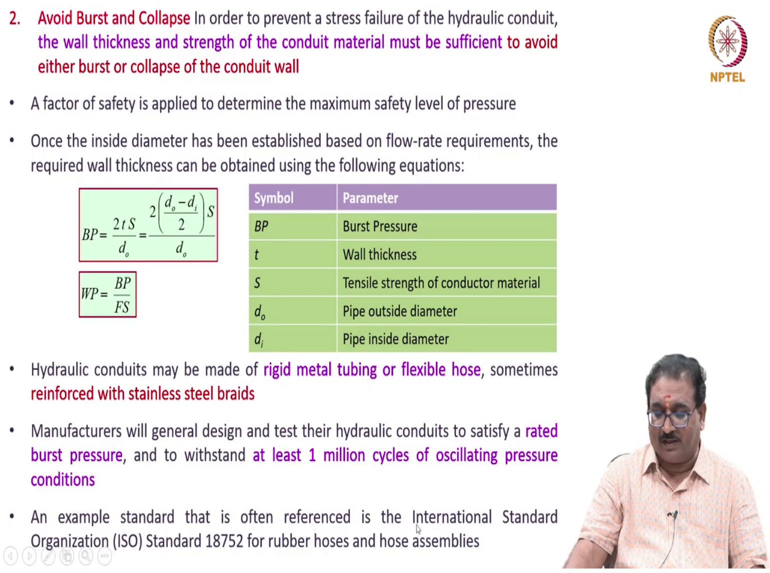

Next one is avoid a burst and collapse, second one. In order to prevent a stress failure of the hydraulic conduit, the wall thickness and strength of the conduit material must be sufficient to avoid either burst or collapse of the conduit walls. A factor of safety is applied to determine the maximum safety level of pressure.

Once the inside diameter has been established based on the flow-rate requirements, the required wall thickness can be obtained using the following equation. The BP, this is the burst pressure is equal to 2 t S by d o. Here, t is a wall thickness, S is a tensile strength of the conductor material, d o is a pipe outside diameter. Here, thickness how we will find out? d o minus d i by 2, I am substituting here.

The WP, BP by FS. This FS is a factor of safety. Hydraulic conduits may be made of rigid metal tubing or a flexible hose, sometimes reinforced with a stainless steel braids. Manufacturers will generally design and test their hydraulic conduits to satisfy a rated burst pressure and to withstand at least 1 million cycles of oscillating pressure conditions. An example standard that is often referenced is the International Standard Organization Standard 18752 for rubber hoses and hose assemblies.

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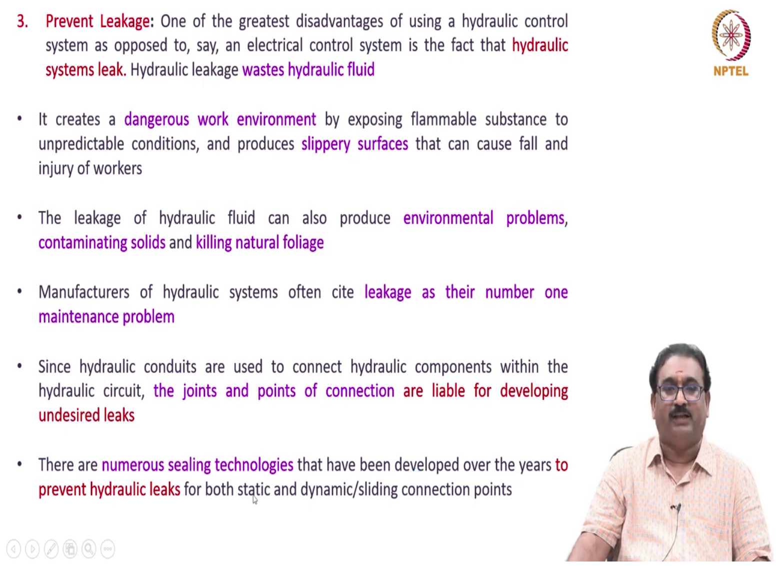

Third one prevent a leakage. One of the greatest disadvantages of using a hydraulic control system as opposed to say, an electric control system is the fact that hydraulic systems leak. Hydraulic leakage waste hydraulic fluids. It creates a dangerous work environment by exposing flammable substances to unpredictable conditions, and produces slippery surfaces that can cause a fall and injury of workers.

The leakage of hydraulic fluid can also produce a environmental problems, contaminating the solids and killing natural foliage. Manufacturer of hydraulic system often cite leakage as their number one maintenance problem.

Since hydraulic conduits are used to connect a hydraulic components within the hydraulic circuits, the joints and a points of connections are liable for developing undesired leaks. There are numerous sealing technologies that have been developed over the years to prevent hydraulic leaks for both static and dynamic or a sliding connection points.

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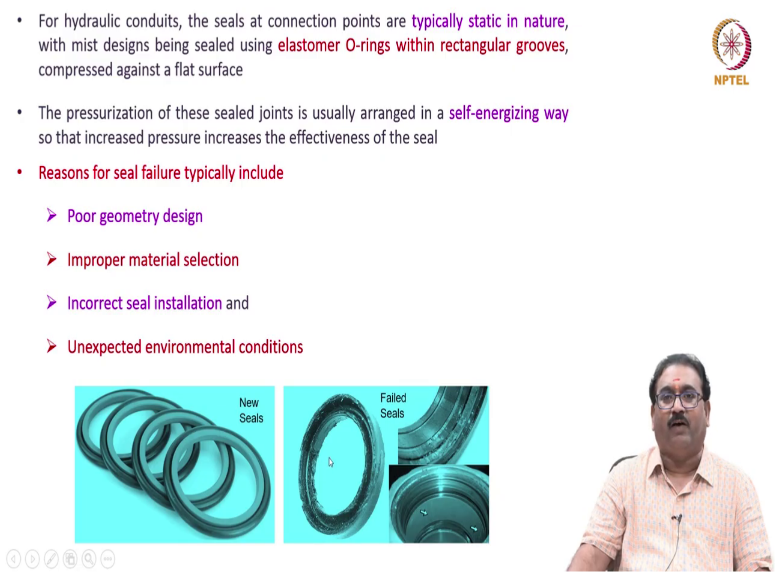

For hydraulic conduits, the seal at connection point are typically static in nature, with the mist designs being sealed using elastomer O-rings within a rectangular grooves, compressed against a flat surface. The pressurization of these sealed joint is usually arranged in a self-energizing way so that increased pressure increases the effectiveness of the seal.

Reasons for seal failure typically includes poor geometry design, improper material selection, incorrect seal installation and unexpected environmental conditions. These are the new seals, how they will look, we will see friends here. These are the failed seals; after using in the hydraulic component. We will see how they will worn out inside and also, side edges and these are carried in the fluids. Also, they will get contaminated.

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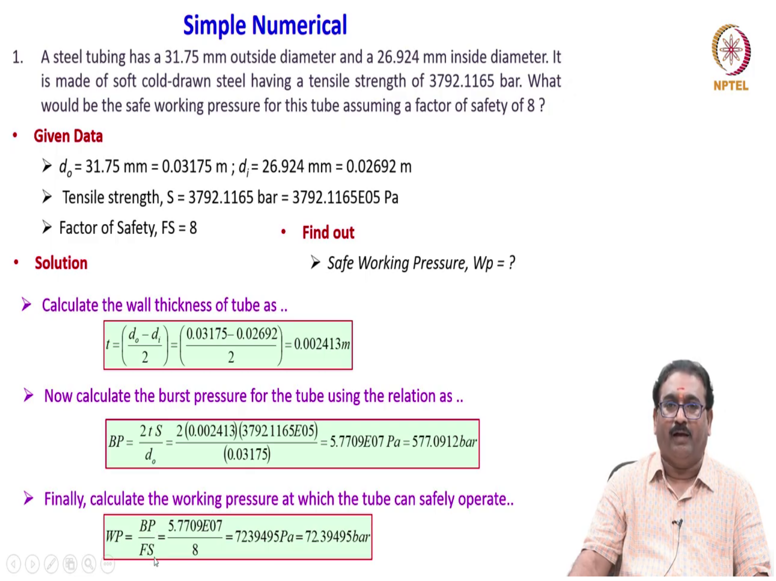

Now, quickly we will see one numerical on this fluid burst. A steel tubing has a 31.75 mm outside diameter and a 26.924 mm inside diameter. It is made of soft cold-drawn steel having a tensile strength of 3792.1165 bar. What would be the safe working pressure? Now, you have to find out WP, working pressure. How you will get it? WP equal to burst pressure divided by factor of safety. That is why the factor of safety is given as 8.

Now, very easy it is friends. There given data is d o, outside diameter of the steel tubing is given and converting into the meter. As I have told you units are very very important. Then, d i converted to meter; tensile strength is given in bar and converted to pascal by multiplying 10 to the power of 5; factor of safety, they are given 8.

Then, what to do? Safe working pressure, you have to find out; WP. Solution is very simple. Calculate the wall thickness of the tube; d o minus d i divided by 2, then now calculate the burst pressure. Already we know that the burst pressure equal to 2 t S by d naught; substitute all the values you will get 577.0912 bar. Finally, calculate the working pressure at which the tube can be safe is BP by FS factor of safety, you will get 72.39492 bar ok. We will conclude.

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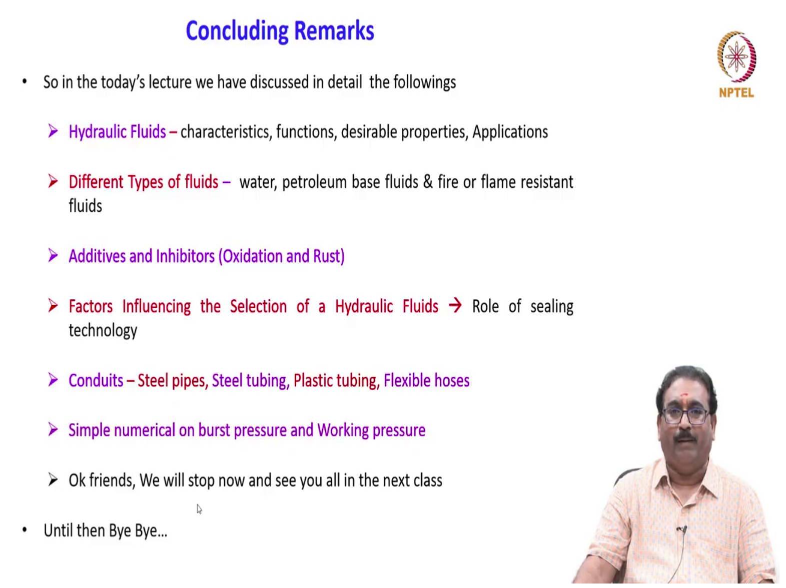

So, in today's lecture, we have discussed in detail the followings. Hydraulic fluids; characteristics, functions, desirable properties and applications. Different types of fluids; we are seen basically the water, petroleum-based fluids and fire or a flame resistant fluids and also, we have seen additives and inhibitors to enhance the hydraulic fluid properties.

Then, factor influencing the selection of hydraulic fluids, we have seen. Here, we are given importance to role of sealing technology. Then, we have seen the conduits; steel pipes, steel tubing, plastic tubing, flexible hoses and also, it includes the various connectors and a flanges. Then, simple numerical we have seen on the burst pressure and working pressure. Ok friends, we will stop now and see you all in the next class, until then, bye bye.

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