Oil Hydraulics and Pneumatics
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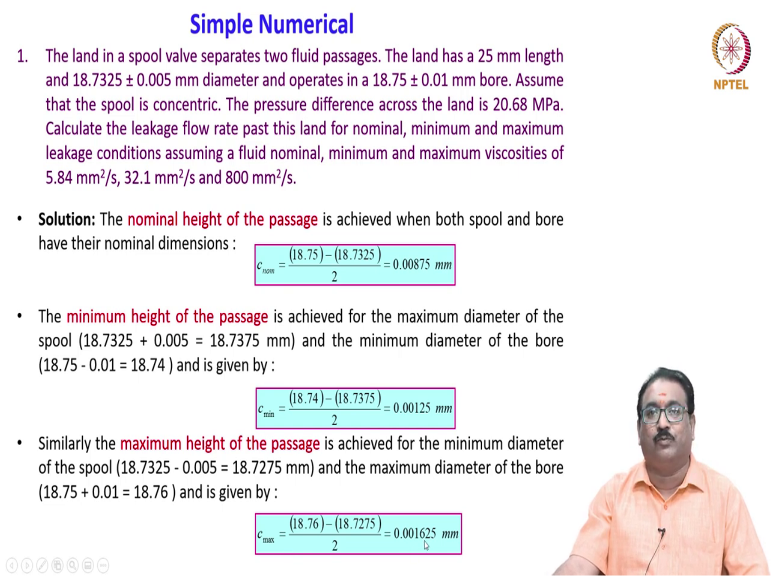
Part 2: Numerical on DCV, PCV and FCV
Lecture – 44
Estimation of leakage through spool and housing bore and Numericals on DCV, PCV and FCV



My name is Somashekhar, course faculty for this course, correct friends? Now, I will solve some of the simple numerical problems for the directional control valve, pressure control valves and a flow control valves very quickly. The problem is like this. The land in a spool valve separates two fluid passages.

The land has a 25 mm length and 18.7325 plus or minus 0.05 mm diameter; meaning is upper and lower limits I mentioned here and operates in a 18.75 plus or minus 0.01 mm bore. Again upper limit and lower limit for the bore is given. Assuming that the spool is concentric the pressure drop across the land is 20.68 mega Pascal.

Calculate the leakage flow rate past this land for nominal, minimal and maximal leakage conditions assuming a fluid nominal, minimum and maximum viscosities of 5.84 mm square per second, 32.1 mm square per second and 800 mm square per second. Kinematic viscosity cSt is given.

So, solution how to do it? The nominal height of the passage is achieved when both the spool and bore have their nominal dimensions because a nominal height. Nominal height means what? Here you will see 18.7325, 18.75 divided by 2, correct? Here you will see friends you will take directly the bore is 18.75, spool is minus 18.7325 by 2 is a nominal height or a clearance when I am considering the nominal dimensions. This is given by 0.00875 mm.

So, the minimum height of the passage meaning I am taking the lower limits now, the minimum height of the passage is achieved for the maximum diameter of the spool, correct? 18.7325 plus upper limit 0.05 is equal to 18.7375 mm and minimum diameter of the bore the bore is here 18.75 minus 0.01. And, is given by same here what I did here I took here 18.74 minus 18.7375 by 2 here I am getting 0.00125 mm, c minimum it is.

Similarly, c max we have to find out. What is that? Maximum height of the passage is achieved for the minimum diameter of the spool minimum diameter is you will see up lower limit here and the maximum diameter of the bore and is given by same 18.76, correct minus this 18.7275 by 2 because it is a clearance. This is given by 0.001625 millimetre.

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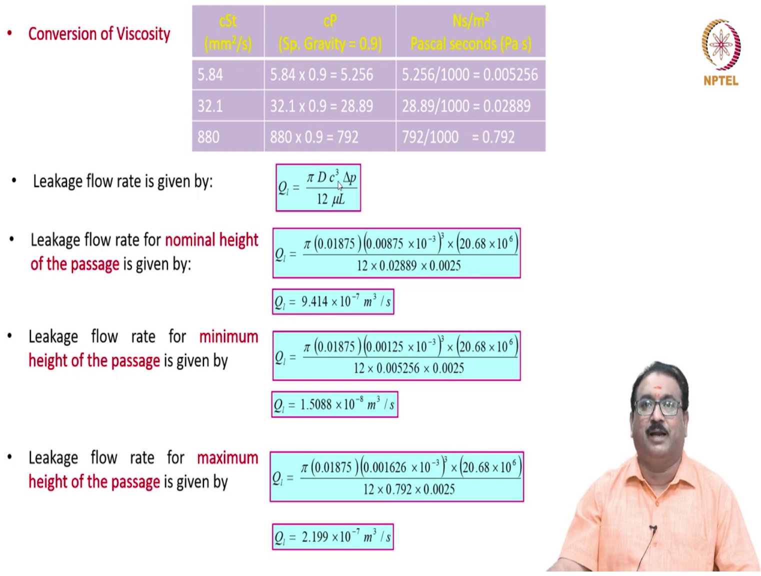

So, now viscosity as I have told you it is given in the cSt kinematic viscosity and converting into centipoise by multiplying with the specific gravity of the fluid assumed to be 0.9. I am converted here, then I am converting in to SI unit Newton second per metre square; Newton per metre square is a Pascal and second is a s. I am writing here Pascal second and converted here, how to convert? After getting this divided by 1000s.

Then leakage flow rate is given by already we know that pi D c cube by 12 mu delta p by L. You will remember very easily pi D c cube by 12 mu delta p by L. Substitute all the values for the nominal height for everything you have to find out. For the nominal height what is the leakage, minimum height what is the leakage, maximum height what is the leakage.

Already we found out in the previously previous slide I have shown you how to calculate the minimum height, maximum height, nominal height I am substituting here nominal height here. Then, only changes is here these two terms viscosity and this, correct?

Now, I will get the Q l equal to 9.414 into 10 to the power of minus 7 m cube per second. Similarly, the leakage flow rate for the minimum height of the passage. Here it will changes again, minimum height as well as this will change. Then it will come 1.5088 into 10 to the power of minus 8 m cube per second.

Similarly, for the maximum height of the passage is given by same substitute the c will changes and this will changes meaning dynamic viscosity will changes. You will get here 2.199 into 10 to the power of minus 7 m cube per second, very simple friends it is. Only thing you have to remember the leakage flow then possible to find out for the nominal diameter, minimum height and maximum height of the gap.

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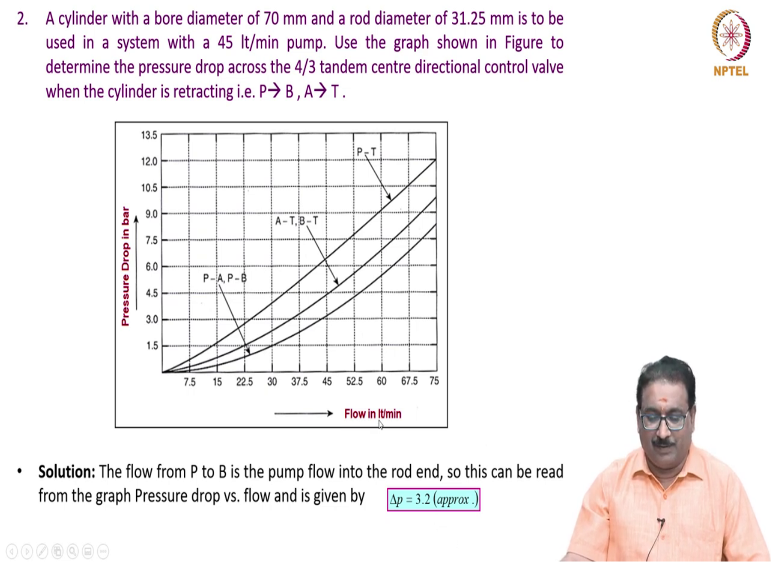

I will show you one more. A cylinder with a bore diameter of 70 mm and a rod diameter of 31.25 is to be used in a system with a 45 litres per minute pump, use the graph. Here the graph is given in the figure which will shows the pressure drop across the flow in litres per minute.

They are given the pressure drop versus flow characteristics for the different port configuration. You will see here first one is when P connecting to A, P is connecting to B, this is a flow rate passion.

Similarly, A is connecting to tank, B is connecting to tank middle one, top one is as I have told you P to T because it is a tandems neutral. Tandem neutral means P is connecting to T in the middle position, A and B are blocked; then parallel configuration, crossed configuration you are seen already this, ok.

Now, this for combination this combination you have to determine, P is connecting to B, A is connecting to T meaning a crossed configuration, meaning it is retracting, correct? For this now what we will do? The flow from P to B, correct, P to B means pump is connecting to B meaning P rod end and it is correct. So, this can be read from the graph pressure drop versus flow.

How to read this friends? It is here you will see here the one of the bore diameter is given, rod diameter is given then here the flow 45 we will see here 45 litres per minute you will move up I want to get from the what is that P to B how much. P to B how much I will get here? You will see friends 45 I will get here approximately 3.2 approximately, for the port configuration of P to A, P to B here down curve.

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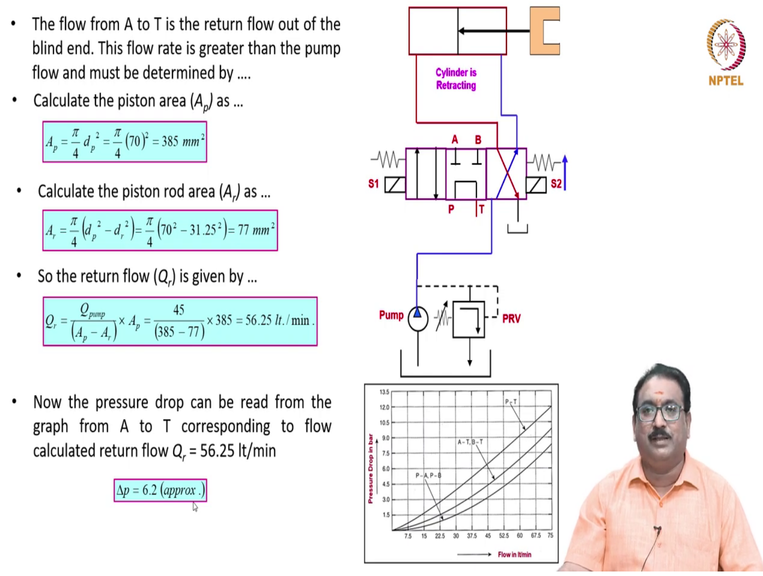

Next, this is a configuration as I have to P to T, A to B, now they are asking for the crossed configuration. They may asked for this also. Now we will see the pump flow is connecting to the tail side or a rod side, the head side is connecting to the tank. So, the flow from the see here A to T how it is A to T is the return flow out of the blind and this flow rate is greater than the pump flow, correct?

Pump flow what it is coming here because area is very less and must be determined by A p equal to pi by 4 d p square you know the area of the piston after substituting I will get here then calculate the piston rod area also d p square minus d r square pi by 4 you will get 77 mm square meaning I finding out here piston area and the rod area this area, this area.

Then for the return flow here return flow is given by Q pump divided by A p minus A r into A p substitute all the values I will get the return flow is 56.25 litres per minute using this you have to find out the pressure drop you will see now. Now, the pressure drop can be read from the graph A to T know A to T it is, correct. A is connecting to T A to T corresponding to the flow rate return flow how much it is? 56.25.

You will see here you will mark here approximatively the 56.25 and you will move up here move up approximately I will get here 6.2 correct, 6.2 the pressure drop for the return flow. Very simple like this how to read this you have to learn. Very very simple whether it is a crossed configuration or here or here you have to find out the same weight.

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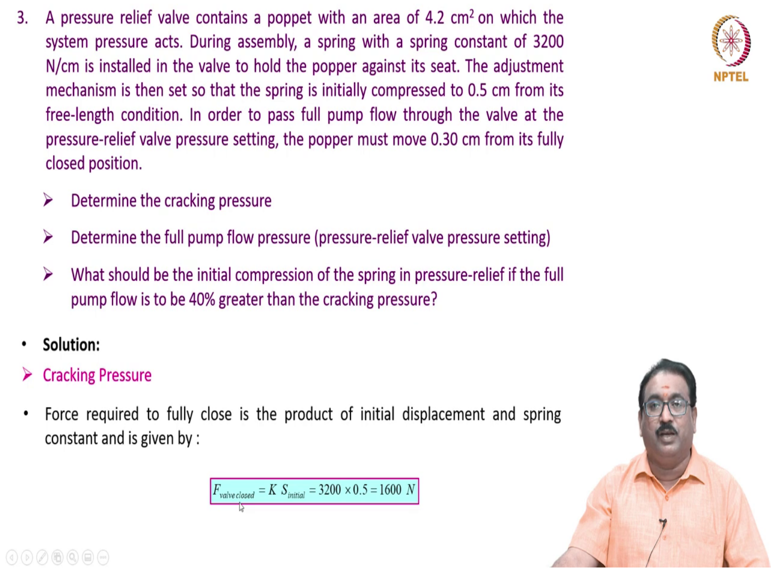

Third quickly we will see one more problem: A pressure relief valve contains a poppet with an area of 4.2 centimetre square on which the system pressure acts. During assembly a spring with a spring constant of 3200 Newton per centimetre is installed in the valve to hold the poppet against its seat.

The adjustment mechanism is then set so that the spring is initially compress 2.5 centimetre for its free length condition. In order to pass a full pump flow through the valve at a pressure relief valve pressure setting, the poppet must move 0.30 centimetre from it is fully closed position determine the cracking pressure, determine the full pump flow pressure meaning it is a pressure relief valve setting.

Then third one is what should be the initial compression of the spring in pressure relief valve if the full pump flow is to be 40 percent greater than the racking pressure? Ok, as usual it is a poppet valve it is. We have to find out the first cracking pressure determine the cracking pressure.

So, we know that the force required to fully close is the product of initial displacement and the spring constant and is given by F valve closed force required to close K into S initial value; initial value is 0.5 is given. Therefore, 3200 in to 0.5 meaning 1600 Newton this is the initial force required to close the valve.

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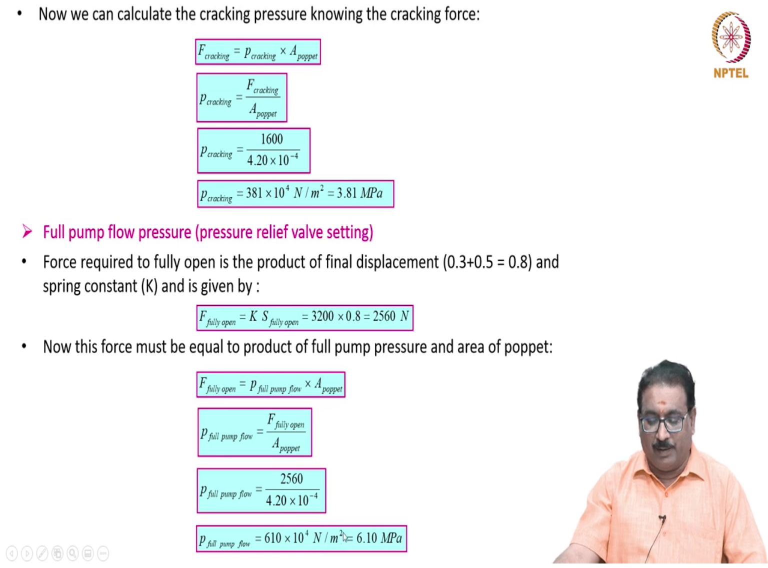

Now, we can calculate the cracking pressure knowing the cracking force; the F cracking equal to P cracking into a poppet area of the poppet. So, P cracking equal to F cracking divided by a poppet. Now, we will substitute the value 1600 area of the poppet is given, but please take care friends all unit should be in the same unit, all centimetre I am converting into the metre. Now, we will get here Newton per metre square, then it is nothing but 3.81 mega Pascal.

Next one is full pump flow pressure meaning the pressure relief valve setting. Here the force require to fully open is the product of final displacement; final displacement means 0.3 plus 0.5 is nothing, but the 0.8 full opening and a spring constant multiply these two then I will get the F fully open fully opening the force is K into S fully open, correct? Meaning 2560.

Now, this force must be equal to the product of full pump resistance and the area of the profit meaning F F fully open equal to P full open into area of the poppet. What you will do now? The P the pressure of the full pump flow F fully open divided by A poppet.

Already we found out already we know here 2560 divided by area of the poppet is known substitute. I will get here 6 10 into 10 to the power of 4 Newton per metre square or what you will do? Divide by the 10 to the power of 5 you will get the mega Pascal 6.10 MPa. This is for the pressure for the full pump flow.

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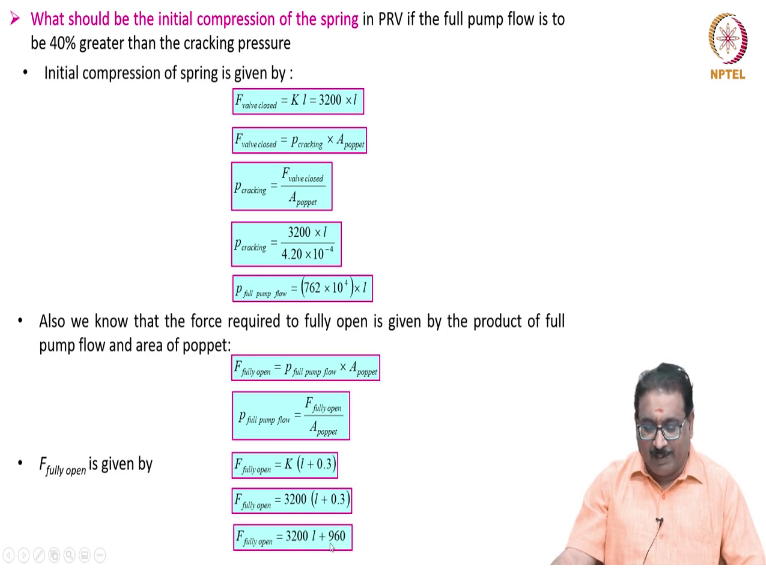

Next one is, what should be the initial compression of the spring in PRV if the full pump flow is to be 40 percent greater than the cracking pressure? Now, initial compression of the spring is already we know that F valve closed K into l meaning K already we know 3200 into l.

Now, F valve closed equal to same P cracking into a poppet. Now, P cracking equal to F valve closed by A poppet. Substitute the value here. Here already know F valve closed is 3200 into l divided by area of poppet. After doing this I will get here 762 into 10 to the power of 4 l.

So, we know that the force required to fully open is given by the product of full pump flow and the area of the poppet, correct here? Now, P full pump flow same F fully open A poppet. F fully open is given by K into l plus 0.3, we have to find out l now, that is why I am telling. So, F fully open equal to K is 3200 then I am simplifying this 3200 into l multiplied by this 960 ok.

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- Now "$p_{full\ pump\ flow}$" is given by

$$p_{full\ pump\ flow} = \frac{F_{fully\ open}}{A_{poppet}}$$

$$p_{full\ pump\ flow} = \frac{(3200\ l) + 960}{(4.20 \times 10^{-4})}$$

$$p_{full\ pump\ flow} = (762\ l + 229)10^4$$

- We can now calculate the ratio of pump full flow pressure to cracking pressure as

$$\frac{p_{fully\ open}}{p_{cracking}} = \frac{(762\ l + 229)10^4}{(762\ l)10^4} = 1.6$$

$$\frac{p_{fully\ open}}{p_{cracking}} = \frac{(762\ l + 229)}{(762\ l)} = 1.6$$

$$\frac{p_{fully\ open}}{p_{cracking}} = \frac{762\ l}{762\ l} + \frac{229}{762\ l} = 1.6$$

$$0.3005\ l = 0.6$$

$$l = \frac{0.6}{0.3005} \cong 2\ cm$$

Now, the pressure when full pump flow which is given by F force by an area fully open and poppet substituting the value here, then after simplification what I will get here? 762 l plus

229 into 10 to the power of 4. We can now calculate the ratio of pump full flow pressure to the cracking pressure P fully open P cracking, correct, which is equal to their given condition 1.6 after substituting this. This is given condition.

I will do the simple modification here 762 l 762 l plus 229 by 762 l; this is how much it is friend 1 plus 229 by 762 l. This 1 will go this side meaning 0.6 229 by 762 is nothing but 0.3005 into l.6, then l equal to approximately I will get it 2 centimetre.

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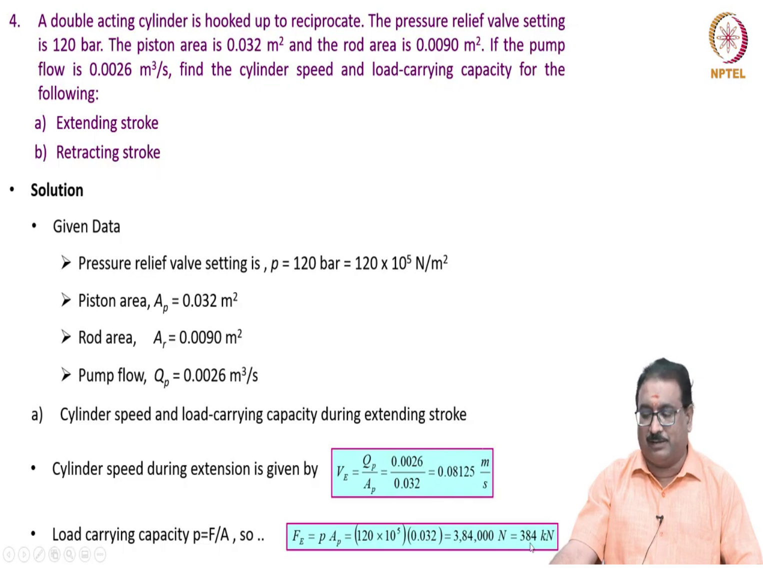

A double acting cylinder is hooked up to reciprocate the pressure relief valve setting is 120 bar. The piston area is 0.032 metre square and the rod area is 0.0090 metre square. If the pump flow is 0.0026 m cube per second, find the cylinder speed and load carrying capacity for the following meaning for extending stroke as well as retracting stroke.

So, quickly we list it out the given data. The pressure relief valve setting is given as 120 bar is there given. I am converting to Newton per metre square by multiplying 10 to the power of 5. Now, the piston area it is given in metre square, no need to worry and rod area also given in metre because Newton per metre square I am choosing. All unit should be same, please remember friends.

Then pump flow Q p equal to 0.0026 m cube per second, all are in the same unit you will see friends. Cylinder speed and load carrying capacity during extending stroke cylinder speed during the extension is given by V E Q p by A p head side correct Q p is known, A p is known you will get 0.08125 metres per second.

Similarly, load carrying capacity p equal to F by A, F then F equal to p into A meaning p into A p, correct p I know 120 and A p I know. After this I am getting here divided by 1000 you will get it 384 kilo Newton.

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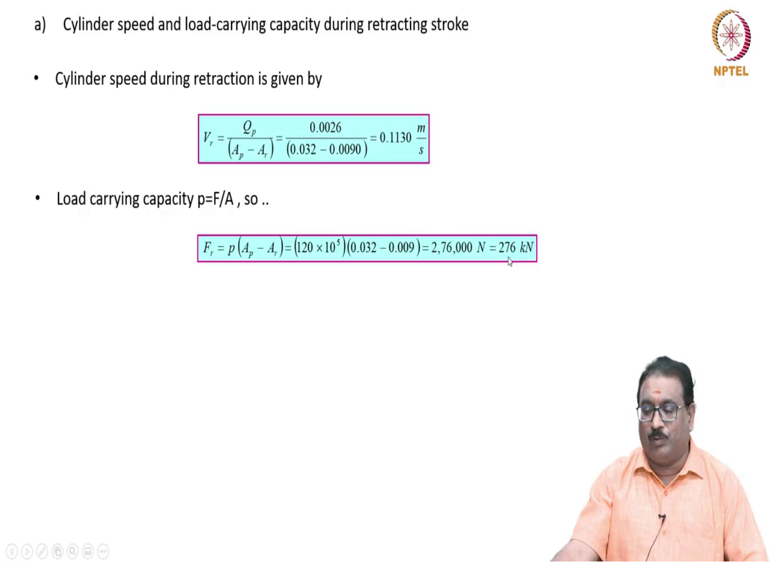

Similarly, you have to calculate for the cylinder speed and load-carrying capacity during the retracting stroke, correct? Cutting speed during the retracting stroke V r equal to Q p by A p minus A r, correct? You will substitute all the value I will get it 0.1130 metre per second.

Similarly, load-carrying capacity p equal to F by A, correct? The load carrying capacity F equal to p into A, that is why I am doing p into A p minus A r, substitute all the values. Afterward I am getting 276 kilo Newton. Correct? Very simple it is. Very very simple substituting the value you will get it.

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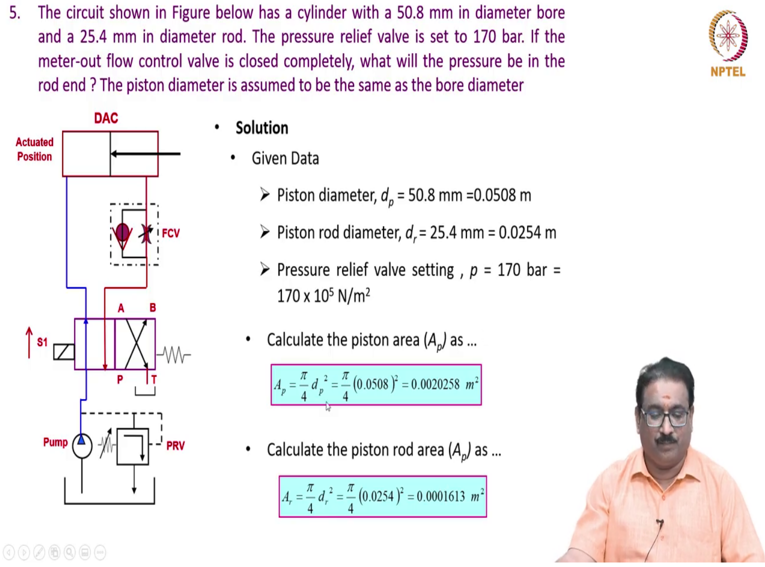

5th problem; the circuit shown in figure below has a cylinder with 50.8 mm in diameter bore and a 25.4 mm in diameter rod. The pressure relief valve setting is 170 bar. If the metre out circuit because you will see here metre outflow is controlled metre outflow control valve is closed completely, you will see here if the metre out flow control valve is closed completely what will be the pressure be in the rod end? The piston diameter is assumed to be the same as a bore diameter.

Quickly list it out what are the given data now? The piston diameter is given d p 50.8 mm. Always you will convert into same unit. The piston rod diameter d r equal to 25.4 mm convert into the metre. The pressure relief valve setting is given 170 bar, I am converting into Newton per metre square.

Now, we will calculate the piston area A p pi by 4 d p square; d p is given here you will get it here. Similarly, the piston rod area you will calculate pi by 4 d r square friends, substituting the value directly.

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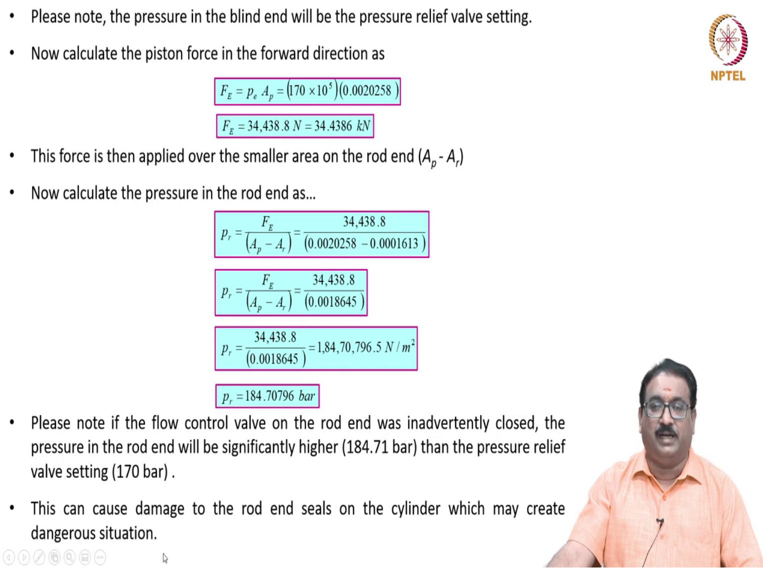

Please note the pressure in the blind end will be the pressure relief valve setting. Now, calculate the piston force in the forward direction. So, the forward direction F E p e into A p, correct? I am substituting the setting pressure and area I will get a F E equal to this much Newton divided by 1000 will give you the kilo Newton 34.4386. Now, we will see this force is then applied over the smaller area and the rod area rod area is A p minus A r, correct.

Now, calculate the pressure in the rod end as p r equal to F E by A p minus A r. Substitute the value here whatever I am getting here. Now, we will get how much it is? You will get here in bar I am getting 184.70796 which is the you will see here friends pressure in retraction is

184.70, but maximum pressure setting how much it is? 172 10 to the power 170 bar I am setting, but in return how much 184.7 0 which is a very high which will leads to wear and tear of the rod area seals.

So, here please note if the flow control valve on the rod and was inadvertently closed the pressure in the rod and will be significantly higher, what I am calculating here 184.71 bar than the pressure relief valve setting 170 bar. This can cause a damage to the rod and seals on the cylinder which may create a dangerous situations.

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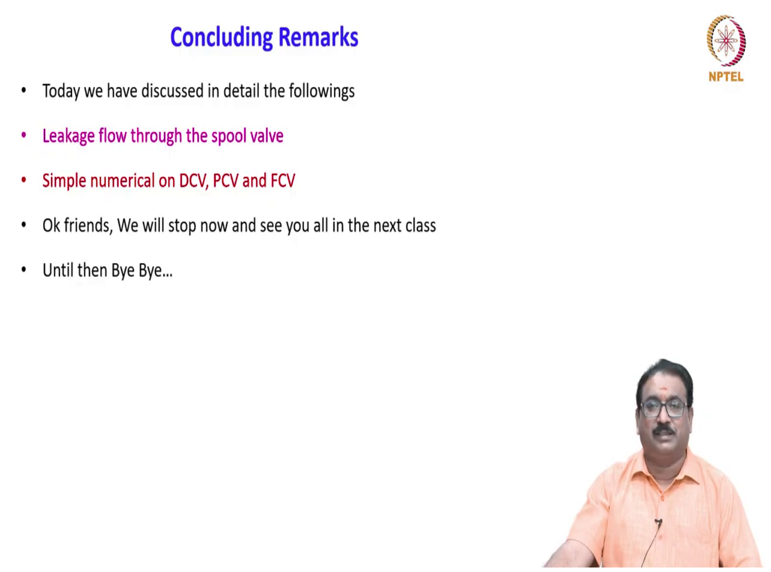

After knowing some of the problems very simple problems if they will give the any unknown data how to derive the known data, I told you in the some problems in the today's lecture. We will conclude. Today we have discussed in detail, the leakage flow through the spool valve which is very important. Simple numericals on DCV, PCV and FCV. Ok, friends, we will stop now and see you all in the next class until then bye bye.

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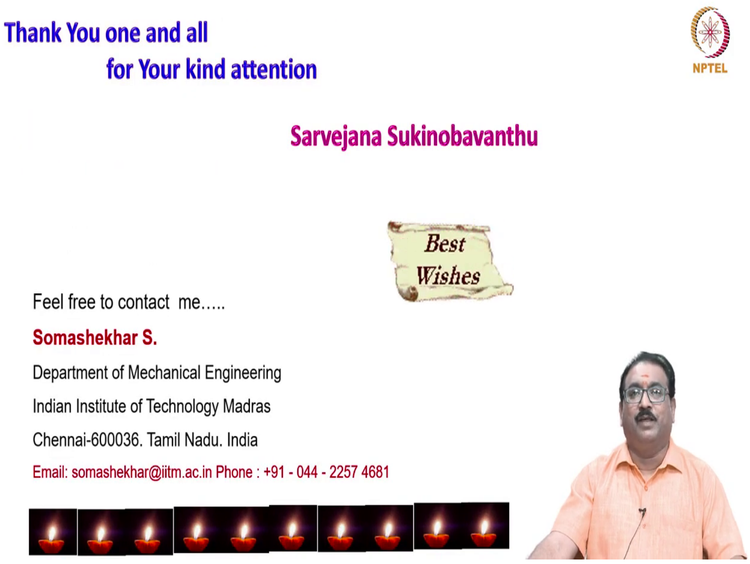

Thank you one and all for your kind attention [FL].