INDIAN INSTITUTE OF TECHNOLOGY
KHARAGPUR

NPTEL
ONLINE CERTIFICATION COURSE

On Industrial Automation and Control

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Topic Lecture – 39
Industrial Hydraulic Circuit
(Contd.)

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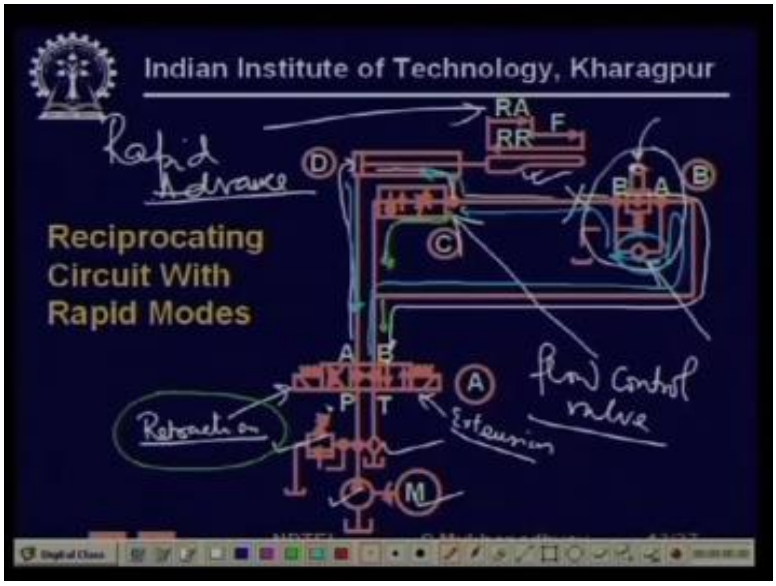

Now let us go to the next example.

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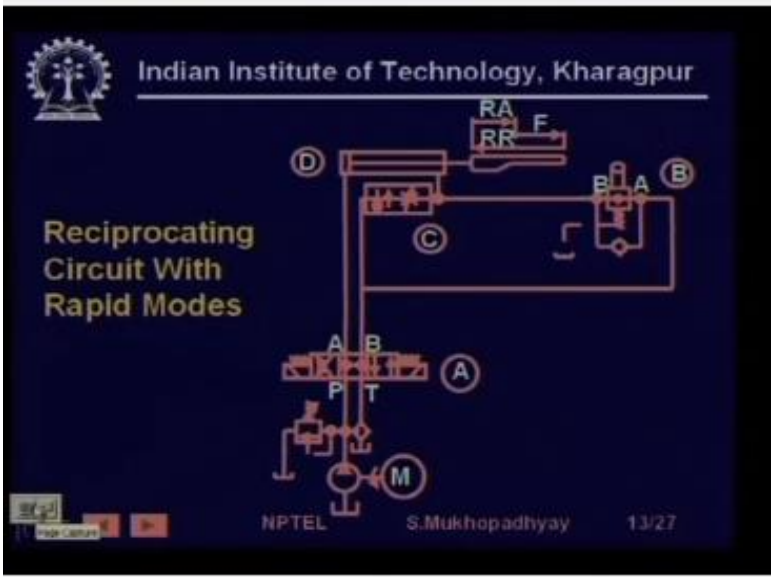

So in the next example what is happening is.

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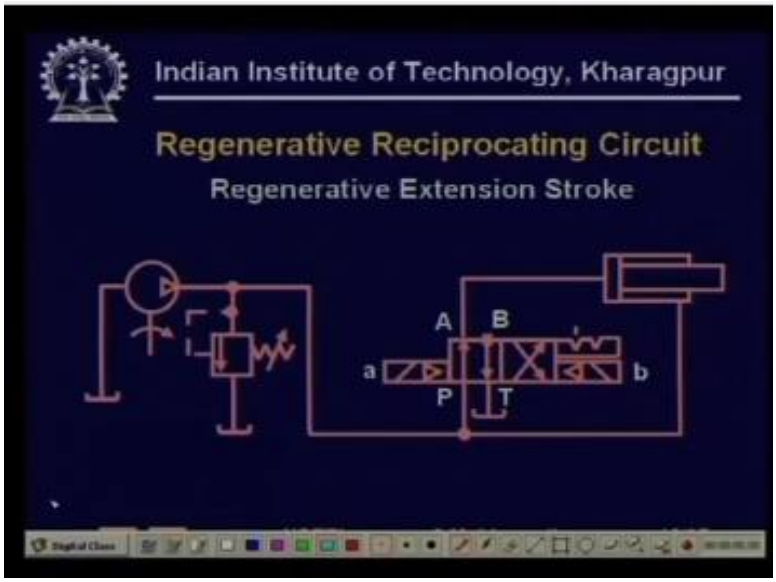

That we want to we are still having reciprocation circuits but now we now we want to have a regenerative configuration what is regenerative configuration, so previously you will you will recall that only in all your cases when you are trying to move the cylinder one and suppose you want to move extend the rod, so you push in fluid into the cap end and the fluid comes out at the rod.

So you connect basically you connect the Cap into the pump and you connect that rod into the tank, now here what we are saying is that we want to re-circulate some of the fluid which is coming out of the rodent into the cabin, so how that is possible.

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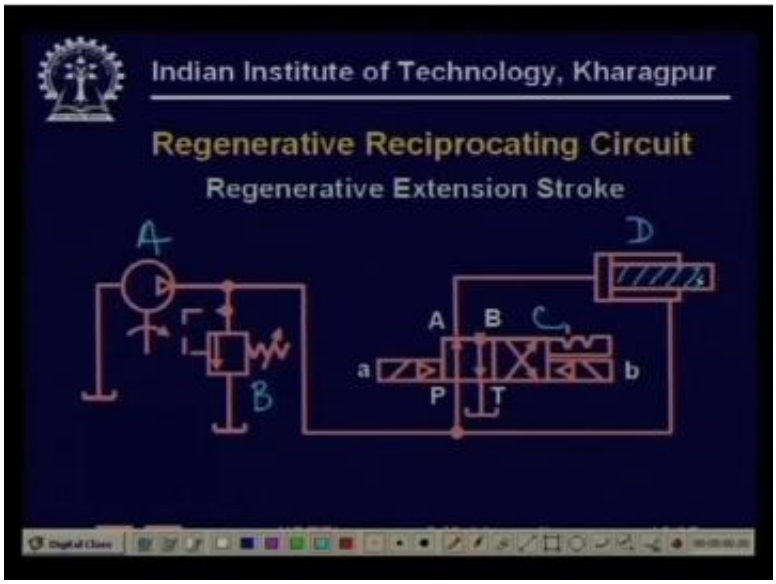

So that is exactly what is being shown here, so you see again identify components first so you have this is say A pump this is B relief valve this is C directional valve and this is D a cylinder, now see that we have drawn the cylinder rod a bit thick just to ensure that the rod area is not negligible to the cylinder piston area this is the piston ad a capital A and this is the rod area small A.

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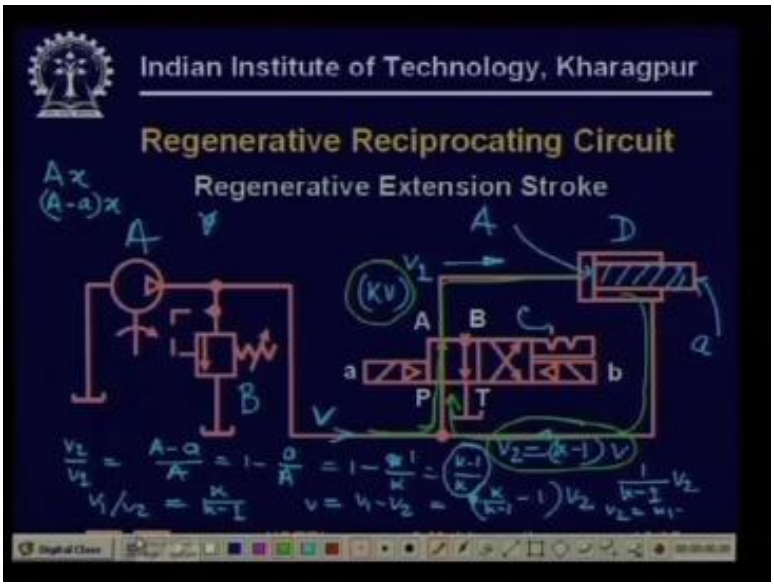

Suppose so what is happening is that now the two side areas are different right also look at this particular directional valve which is to position and it is kind of you know it is depended in the sense that so when you what happens what happens when both the solenoids are off so the both the solenoids are off then it stays in the position corresponding to the last operation of the solenoid.

So if last of the solenoid A was ON then it will even if you take a off it is going to remain at the left position so that is due to a mechanical you know arrangement so that is that is the tension, okay. So now what is happening here is look at look at this that suppose the pump flow here is V right. So what is happening is that this part what is the flow this part the flow is if this is V see the ratio of the flow into the suppose it moves by a distance X.

Then the volume field is A x X and the volume which is expelled is (A-a)x, so if this is V1 and if this is V 2 is coming out then v1, v2/v1 = A-a/A = 1-a/A = 1- 1/K = K-1/K, so this V2/V1 and V1/V2 = K/K-1, okay. So now what is now so again v = V1 – V2 = V2 yes = V1, v1 – V2 so it is V1 -, v1 = k/ k – 1 it is v2, so it is (K/K-1 – 1)V that is equal to what? That is equal to 1/(K-1) V2.

K-K+1 SO 1/(K-1)V2 And so V2 = K-1 that is let us write it a different place so we get two equations we get v2 = (K-1) V and therefore v1 = KV these are the two that means set within a different color these are the final expressions. So these are the flows you understand similarly so you see that so if typical case is this is the case during extension stroke so actually you see that though the flow rate is K x V typically k>1.

But the actually the fluid drawn is from the pump is small V right. Now what happens in the retraction stroke, in the retraction stroke so in the extension stroke it is going to go like this like this it enters like this and then again part goes this and part good this is the flow patterns in the extension through, what happens in the retraction stroke?

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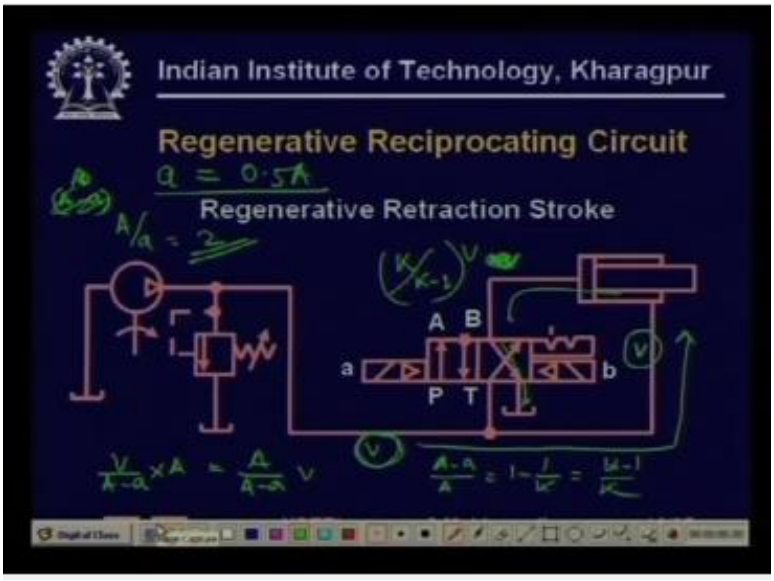

In the retraction stroke in the retraction stroke now you are in this position so now this simply this is the path directly this is the part that is there is no there is no fluid addition or anything so now what is happening is that if this is V then this is V and obviously because the directly goes into this and what is going to be this, this is going to be naturally this will be so a into another (A- a) v.

Suppose it moves to distance X so if this is V some of the idea is half then this side it will be K x V, the distance moved in unit time is actually V / A – a if V volume is flowing this is the distance traversed so that into A will be the volume which will be expelled, so it is going to be A/(A – a) V = A/ a, A- a/ A = 1 – 1/K = K-1/K so A/A – a is going to be K / K – 1 yeah so it is going to be K / (K -1)V.

This is the rate at which the fluid will get expelled, okay. This is the fluid, so what are we achieving by doing this similarly if you look at the pressure if you look at the pleasure then you will find that so you see that suppose the one interesting thing that happens is that suppose A = 0.5 (A) or rather A/ a = 2, right.

So then what happens is that you can you can see that the for example with the same pump flow rate V the distance traveled per unit time is going to be if this is V this is going to be the flow into this is going to be V and in the previous case what was happening in the previous case what was happening is that if you go to the previous case how do wego to the previous case yep little fast yeah.

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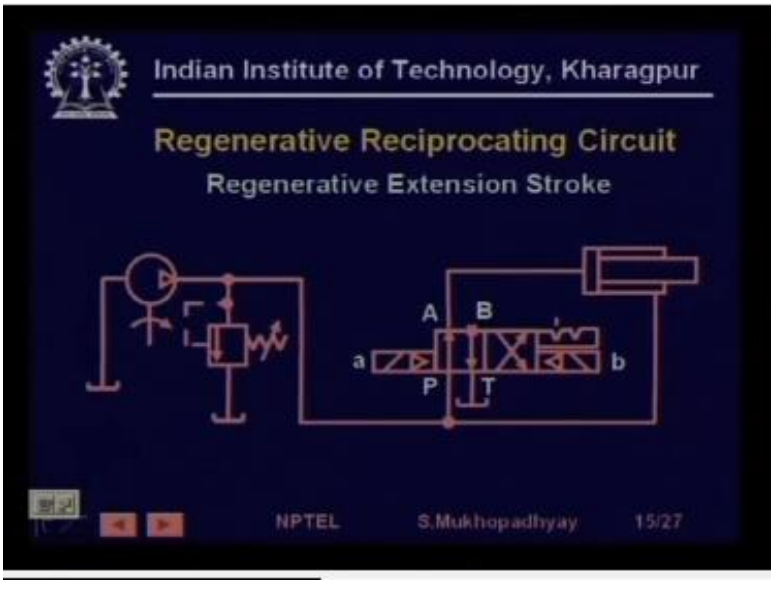

In the previous case we were having so you can you can you can actually find out that we have do it again we can actually find out.

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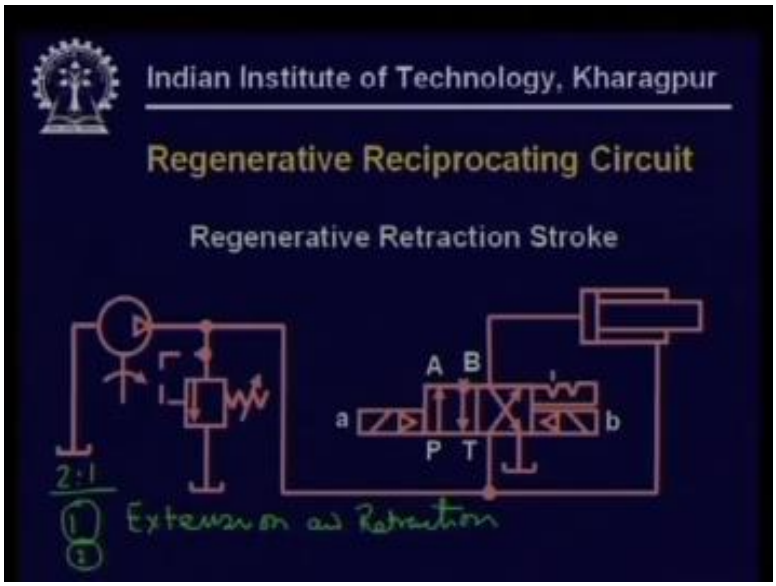

That the interesting point is that you can work it out in fact this can be a nice exercise that there are two things that will happen the first thing is that you will you will find that number 1, two points number one is that say let us say 2:1 area ratio then you will find that the extension and retraction speeds are same but they are not going to be same for other area ratios that must be remembered.

Similarly you will find that so you see we can find that at a at a smaller if you directly connected to two tank so in the case of the extension stroke if it directly connected to connected this to pump and that to tank then you would have had a slower motion with the same pump flow rate we would have got a slower motion which we are so the advantage of regeneration is that with the same flow rate rating pump we are able to generate faster motion.

But at the same time we will see that we will require higher pump pressure right. So what happens is that I mean basically for that is when we will require higher pump pressure if we want to drive a load which requires the same force to be driven then in the regenerative circuit we need higher pressure so basically we are trading of pressure with flow that is we are we can use a slower flow rate pump to achieve a certain speed.

But at the same time if you want to achieve a certain force then we have to give higher pressure, so this is the basic feature of a this regenerative attraction circuit.

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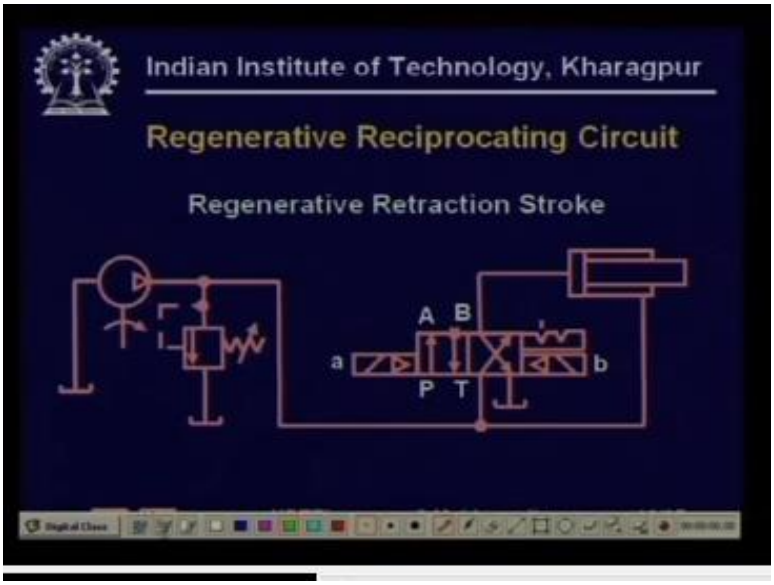

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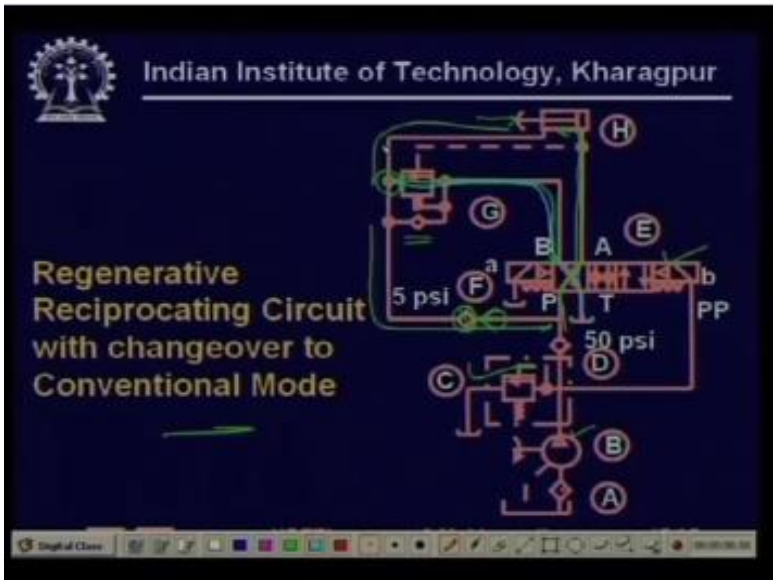

So moving on to the next one, this is a regenerative reciprocating circuit with changeover to conventional mode so what is happening here basically the same type only thing that is happening here is that here you see initially we have again pump I am sorry what is this happening here again you have pump you have any valve you have three positioned Direction valves with solenoids and hydraulic pilot.

And so in the first case in this position that is shown flow is like this like this to the cap and starts moving goes this way and this is wrong actually, you should draw it like this so comes freely and there is regeneration, right. So initially there is regeneration so with the given pump flow rate speed will be higher now if at the end there is a higher force encountered which cannot be which cannot be supported by the prime mover at that flow rate.

Then what is going to happen is that the pressure here will build up whenever this faces resistance the pressure here build up, when the pressure here will build up and this is opposite so this is going to be connected like this, so now you see that it will be after the after the pressure builds up it will connect like this and flow through this so now across this there will be a full pressure and there is no regeneration.

So therefore the speed will fall and therefore it will be it will still be able to handle the pressure right, Now so at the end if there is a higher forcer requirement it will it will change over by this valve from a regenerative circuit to a conventional reciprocating circuit, what will happen in the in the other position, in the other position it is very simple in the other position it will be here.

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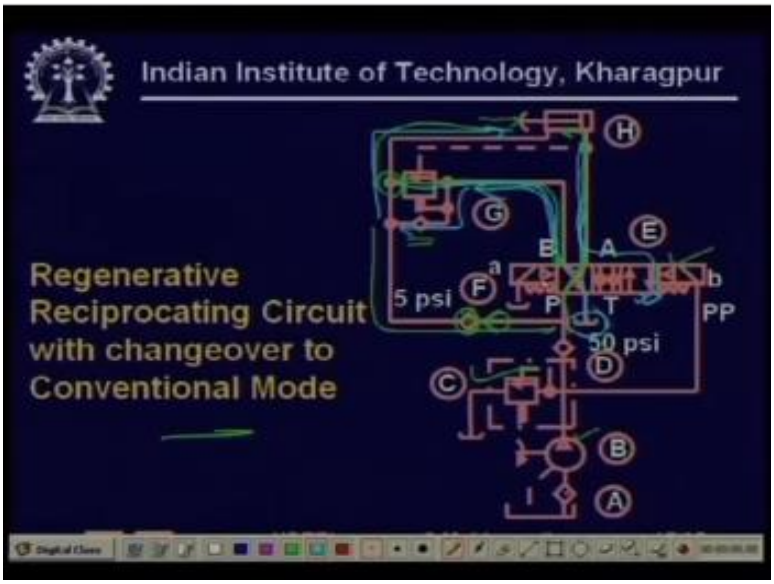

So then what will happen is that the this is this will be the flow, so it will directly flows through this check valve straight and it will comeback directly it will actually come back here and it will get connected to tank so that is a very conventional mode so in this case it will that is there is no pressure requirement and it will it will come back, so on the only advantage is that since we are we have higher force requirement.

So as long as the force requirement is manageable by the pump we are going for a regenerative circuit having so with the pump flow rate we are achieving a higher speed but whenever the force requirement goes up so we are immediately switching over to our of the system automatically switches over to a conventional circuit pressure is now full applied so we can

manage and the flow rate falls. And with the flow rate we have a lower speed, so that is the advantage of this circuit.

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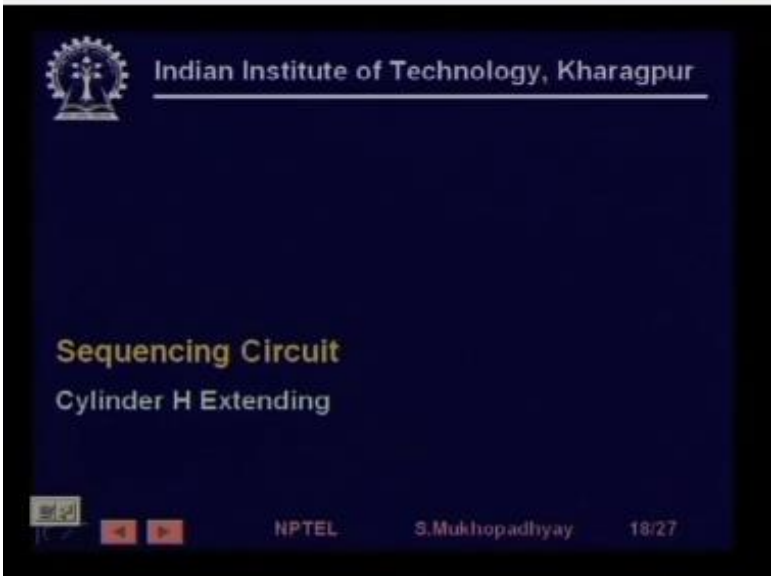

Next we have a sequencing circuit so in the sequencing circuit what is happening is that here now in this example we were we have more than one cylinder so far what we have been doing is that we are we have handled only one cylinder but sometimes it happens that you need to operate multiple cylinders and for example suppose you have you have you have a wood working machine, right.

You have you have a planning machine so before you play in the machine before you start moving the planning cutter you have to hold the job so the sequence is that first operate the holding cylinder then start moving the planar so the planar extends then the planar retracts then remove the clamp cylinder, so you see that we are we have every time we operate we have to operate it in first clamp then extension of planning cylinder then retraction of training cylinder then unclamp.

So this is a particular sequence of two cylinder which have which have to be operated, so now we will see how we can achieve this one, right.

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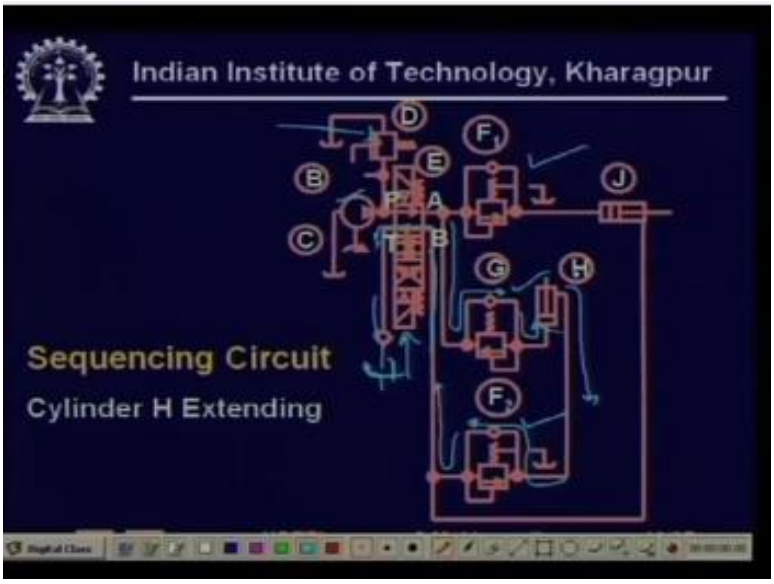

So here we are so here is the circuit so what are we going to do look at this circuit so we have we have here we have two cylinders one is J another is H, right. And we have we have normal pump this is the main valve okay which is being operated here is the relief valve D and these are the three valves which actually cause the sequencer, right. So now what happens is that initially cylinder H extending, right.

So it is in this position look at the position then what is the flow cylinder H extending means it flows through this check valve open direction flows into cap end goes out through this flows through and returns, this is here is time. So this is the position and so the cylinder H is extending going up this is the first phase of the cycle after sometime what will happen is that cylinder H will stop. Which has to it comes across so it comes across a mechanical stop.

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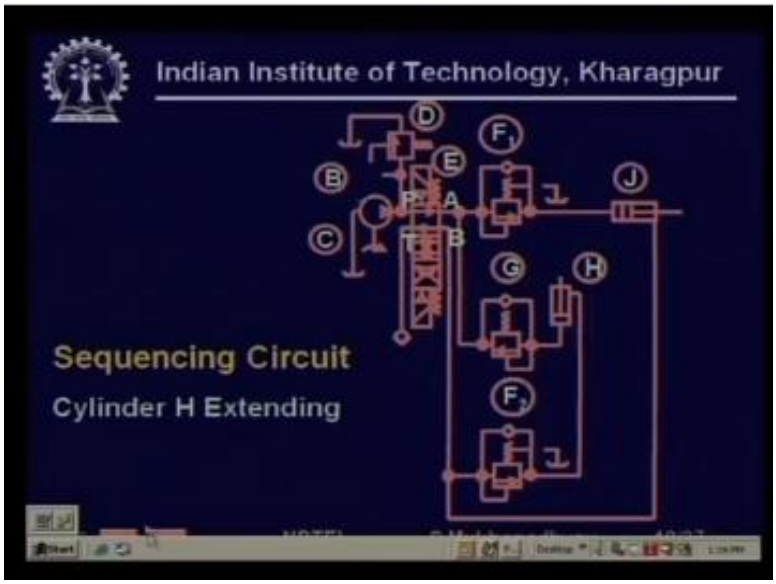

Now what happens?

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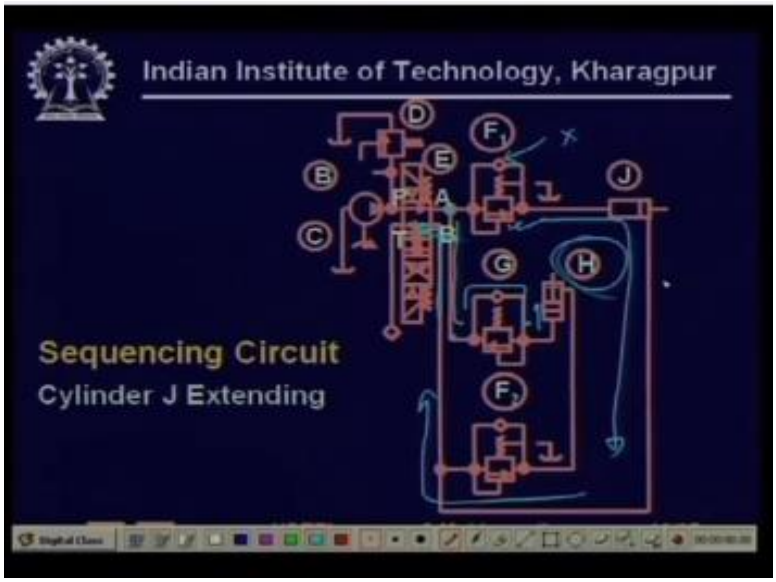

So the moment it comes to a mechanical stop here this pressure will now build up because there cannot be any further flow through this, flow is stopped. So immediately this point rises to pump pressure that will operate this valve, right. Cannot go through this cannot go through this at this point so it goes through this and starts pushing starts pushing valve J so flow goes like this like this like this.

So cylinder J extends right all through this remember that this pressure there is a pressure on this so this pressure is holding this is pressed cylinder H is pressed up, so there is a if you want if you are using it for clamping there is a clamping pressure.

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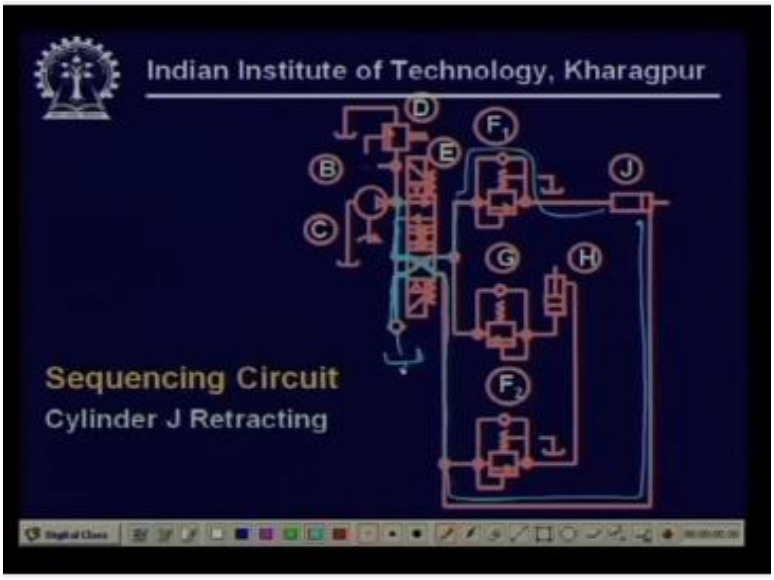

Next cylinder J retracting next what happens is now you have moved the solenoid so you have moved the solenoid and it is now actually this is wrong actually this should be this is wrong this should be connected to this point and this pump should be connected to this point so now the pump flow is connected like this goes through this goes through this send the J tracks flows out through this flow free flow. Check valve and goes through this goes through this to pump tank, cylinder J tracks, right.

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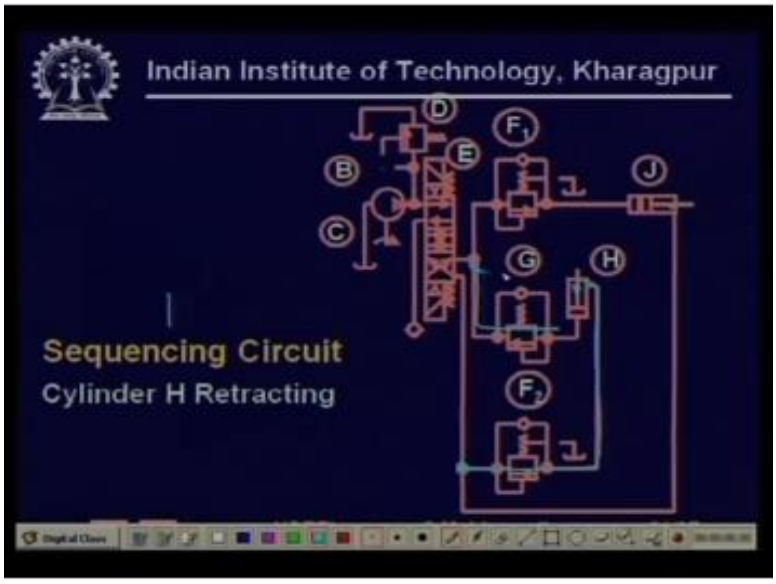

Next last point last point, now cylinder J has retracted fully. So now this pressure cannot so now the pressure here builds up, so the pressure here builds up so the pressure here also builds up and this now pushes the cylinder down but this time no node that it has to pass through this so therefore while the cylinder H is coming down there is there is always a back pressure this is not connected to tank because it is not passing through this it is passing to the relief valve.

So the cylinder H coming down is actually being here the net force is actually being controlled. So it is coming down slowly you know sometimes when you have vertical coming down etcetera underweight you want that coming going up is can be fast but going down has to be at a low force.

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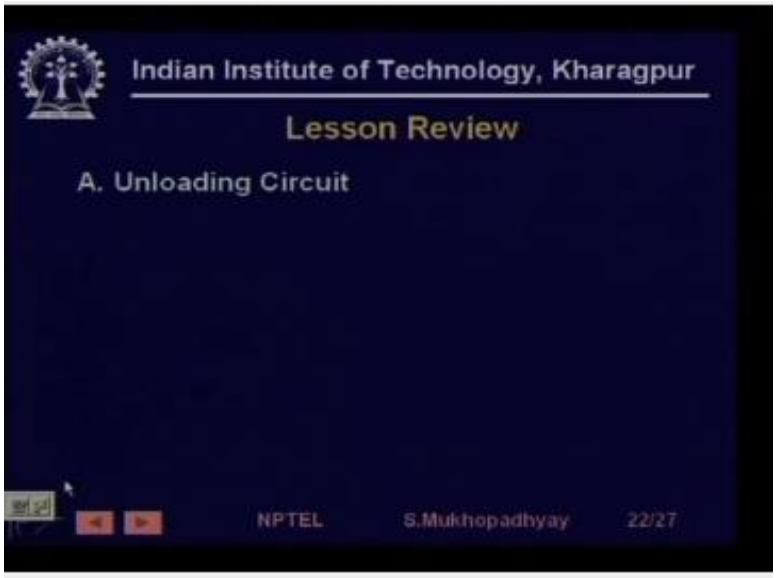

So this is what we have achieved by so we have achieved a sequencing, so these are some of the circuits and what we have seen in this lesson.

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We have seen unloading circuits system pressure selection circuits various kinds of reciprocating circuits reciprocating circuits with rapid modes, reciprocating circuits with regeneration reciprocating circuits with regeneration plus conventional and finally we have seen sequencing circuits which are basically receive reciprocating circuits with multiple cylinders, okay.

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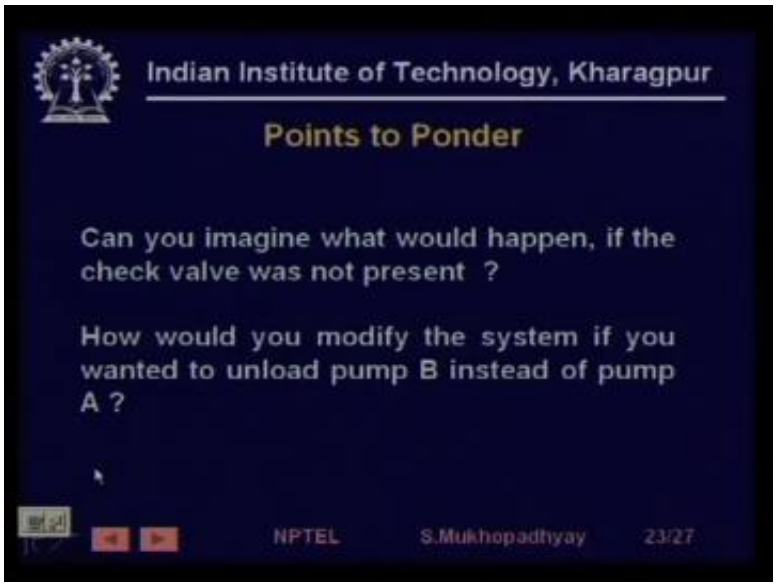

So that brings us to the end of the lesson, points to ponder many questions you can think of for example can you imagine what would happen if the check valve was not present in the first unloading circuit there will be problem, how would you modify the system if you wanted to unload pump.

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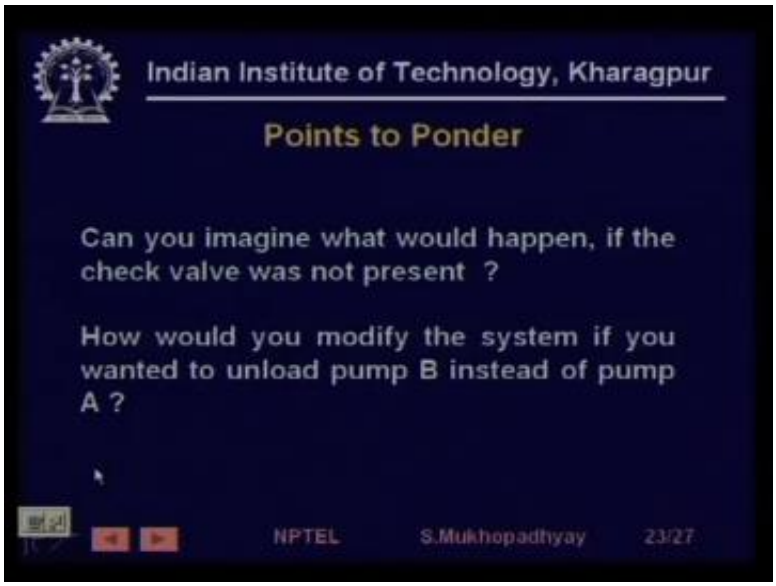

B instead of pump A in that first system that is very simple if the circuit is very symmetric so you will have to whatever you did for pump page you have to move for pump B.

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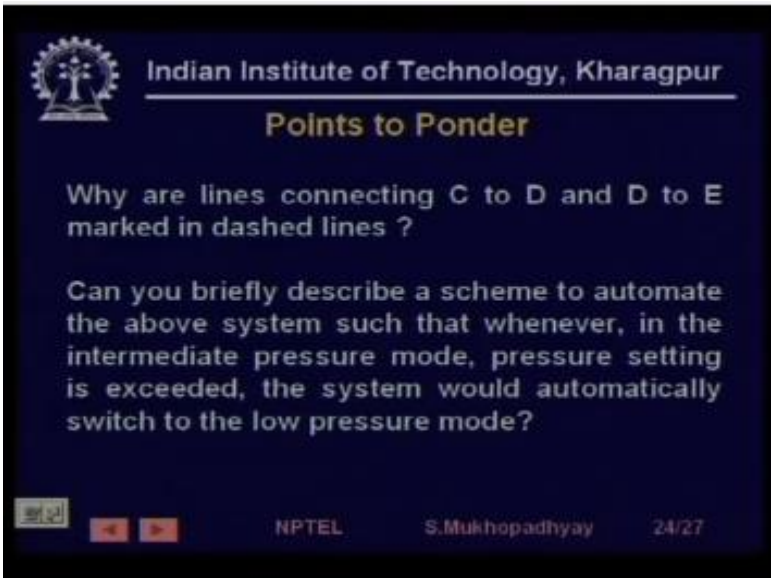

Why are lines connected to connecting C to D and D to E marked in dashed line this is the second one that is system pressure selection because they are pilot lines, sorry I already given an answer you are supposed to think about it can you one thing I wanted to mention is that in many cases you will find that I have said that some limits which operates and that operates some solenoids.

So how does that happen, so you have to have a scheme for that sometimes you can have a purely electrical scheme sometimes you can have a simple you know sometimes you can have a simple really a type scheme or sometimes you can have a PLC base scheme, so various special arrangements are needed.

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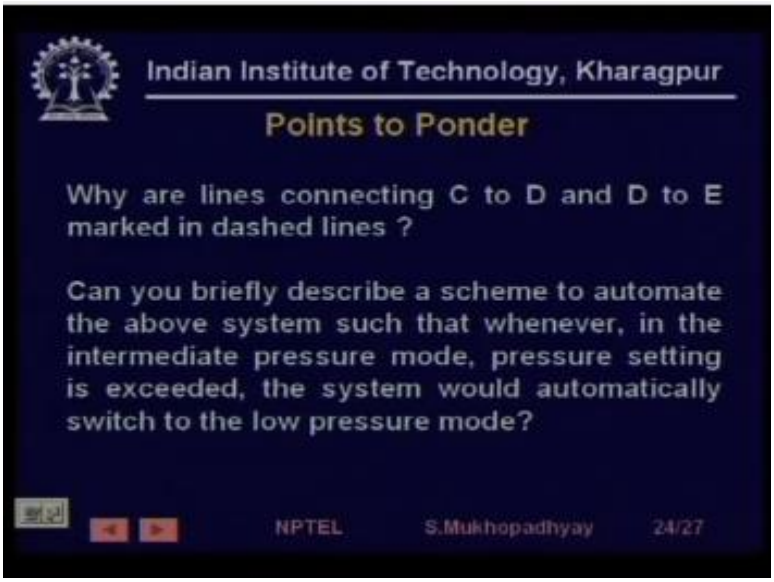

So for example I have given one can you briefly describe a scheme to automate the above system such that whenever in the intermediate pressure mode pressure setting is exceeded the system would automatically switch to the low pressure mode previously it was being done manually as it is shown in that, so you can devise a some control mechanism by which it will sense the pressure and the kill switch on.

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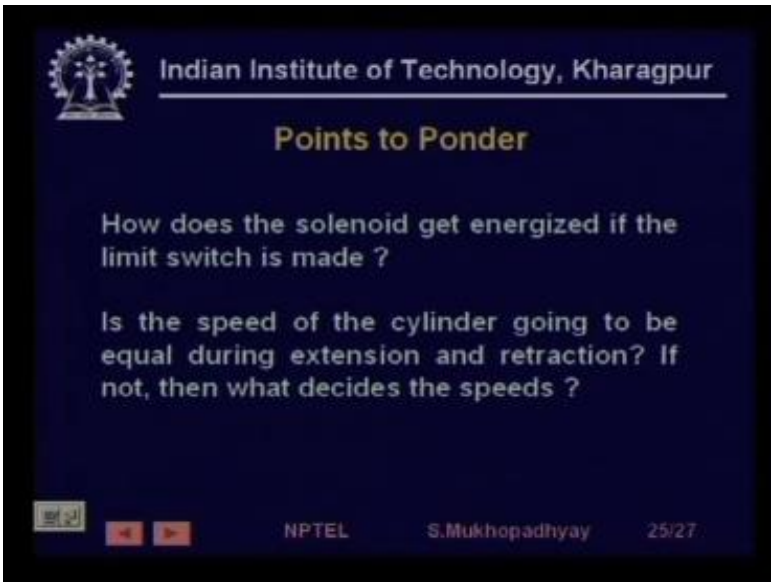

How does the solenoid get energized if the limits which is made same question, if the speed of the cylinder going to be equal during extension and retraction when you have a regenerative circuit if not then what decides the speeds we have analyzed this.

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It is the earlier issue but how does it decide that you figure out.

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Explain all parts of the symbol of the directional valve C basically same except for a very something special this is about the regenerative reciprocating circuit only the directional valve has a detention that was the only special thing.

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This is we have discussed regarding the issues regarding pressure and flow.

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So that brings us to the end of the lesson 28, thank you very much.