INDIAN INSTITUTE OF TECHNOLOGY
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NPTEL
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On Industrial Automation and Control

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Topic Lecture – 41
Pneumatic Control Systems – I
(Contd.)

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So here also you can have singular multiple stages the other option which is non positive displacement offence they are generally used where high flow volume capacities are needed but at low pressure so in such cases fans are used and they can be centrifugal or they can be axial.

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I am sorry let me see what is here yeah so obviously compressors apart from that mechanism requires other accessories like for example lubrication is very important in pneumatic systems firstly because they are not self lubricating just like hydraulic so you have to have special lubrication mechanisms here and second also because there is the tendency of air to leak is actually much more than the tendency of oil because of because air has very low viscosity and oil as high viscosity so oil does not tend to leak out as easily as air does.

So therefore all seals everything are much tighter to prevent air from leaking and that creates a lot of friction so lubrication is more necessary similarly cooling because the compressor is actually doing a lot of work so a lot of heat is produced which needs to be cooled and you need unloading systems you know compressors are energy guzzlers so whenever you do not need when you have a decoy created adequate compressed air supplies then there has to mechanisms by which these compressors are actually unloaded.

And finally there has to be control mechanisms for shutdown as well as for duty cycle control duty cycle control means that especially stroke length control and for how much time you are going to that is how quickly you are going to operate the piston so all these control devices are

we will create we will actually operate the compressor at in such a manner that the current requirement of compressed air will be met at the with the best possible energy efficiency so the compressor is not run generally not run. When the compressed air supply is not so much required.

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So compressor service much for example this is a typical compressor where you know this is can we can see it on the picture that this is a IC engine driven compressor and this is the compressed air supply so that so that is the accumulator and it looks like it is portable it is just a picture which is you know downloaded from the net so compressors are available at various you know sizes or capacities and so 150 PSI up to 150 PSI would be low pressure low pressure 150 2000 is medium and greater than 1000 PSI will be high pressure.

The capacity of the compressor so there is a pressure rating which is decided and then so compressed here is actually supplied at that rating and then the capacity of the compressor is basically decided by the volume of air that it can deliver in minutes and that pressure so it is a often in engineering it is often described in terms of CFM which is called CFM cubic feet per

minute so how many cubic feet per minute of air the compressor can supply so that generally indicates it is capacity.

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Now we have pneumatic reservoir as we said this is a typical picture it is just a container with one inlet and one outlet and holds air under pressure and the capacity of the basically that is the you know pneumatic energy so the presence of pressurized air is the pneumatic energy which is used to do what and the in the amount of energy that can be stored is basically decided by the by two quantities that is at what pressure how much air is stored and what is the pressure.

So they are generally a multiplicative relation because I mean volume and pressure will both if you have high volume and high pressure then you are going to have high energy.

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So as I said that is towards pressurized air for fast delivery of air volume and it is like a capacitor somewhat if you appreciate and electric analogy then just like for supplying suddenly supplying large currents without causing the voltage to drop we all we always connect a big capacitor across a power supply because the capacitor can supply a lot of current instantly and therefore I mean as long as it has the charge to supply the current so therefore a capacitor is generally kept charged at the circuit output.

So that current demands large transient currently owns can be met without causing the terminal voltage to drop so in that sense they the accumulator is actually a capacitor now the pressure in the accumulator I say as the pressure in the accumulator has to be controlled because we so as if air is really drawn from the accumulator at any time then the pressure in the accumulator will fall and then we you know we need to make that make up for that loss of pressure and make the pressure again back to the standard one and that is typically controlled using a delay with hysteresis.

And then use with pressure regulator to actually deliver to valve and cylinder at 6 at around you know 60 psig is a very typical figure.

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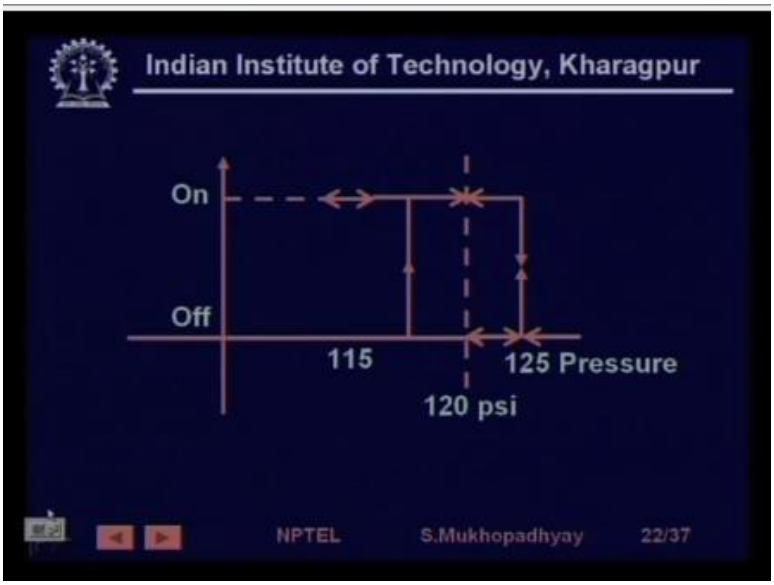

So the control is somewhat like this it just like you know you just like level control very simple very simple that say suppose the regulator is actually designed to work at 120 psi then there is a hysteresis in the sense that.

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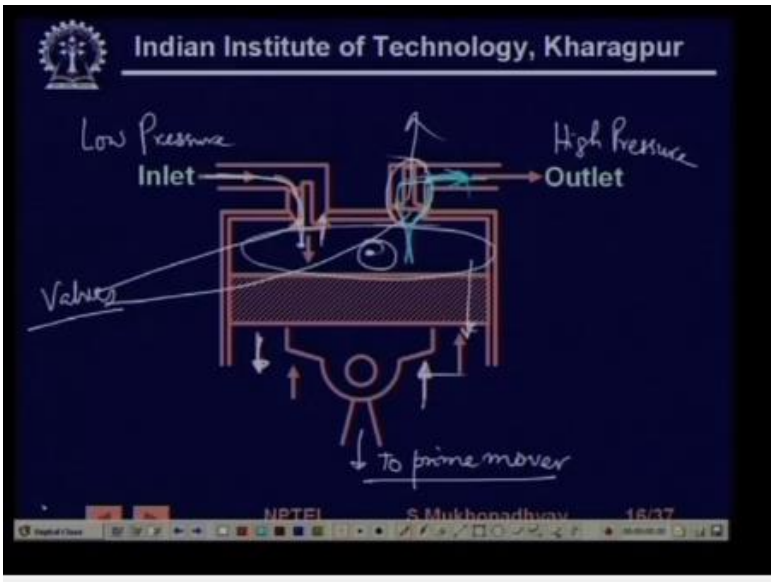

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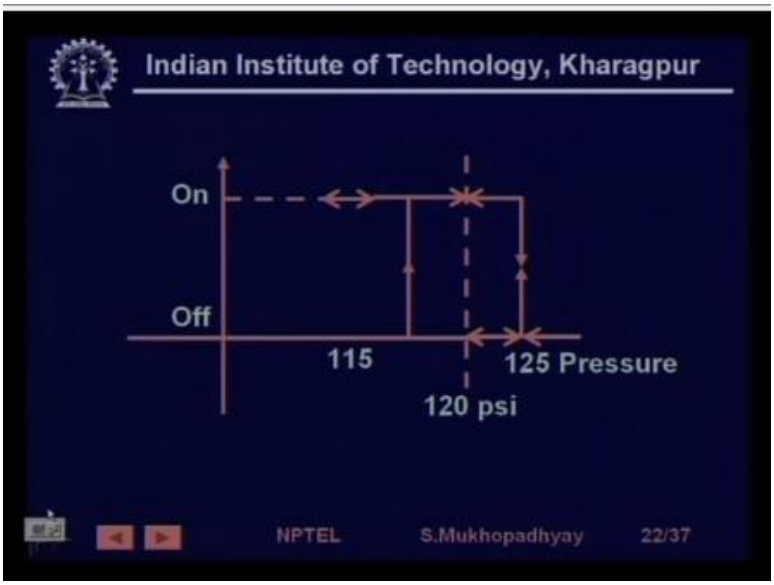

I do not know why is that.

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Anyway.

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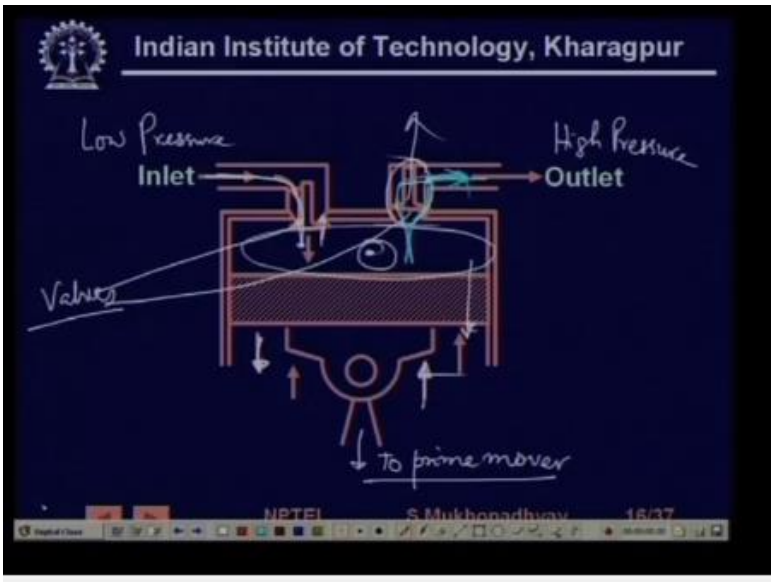

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Just a moment.

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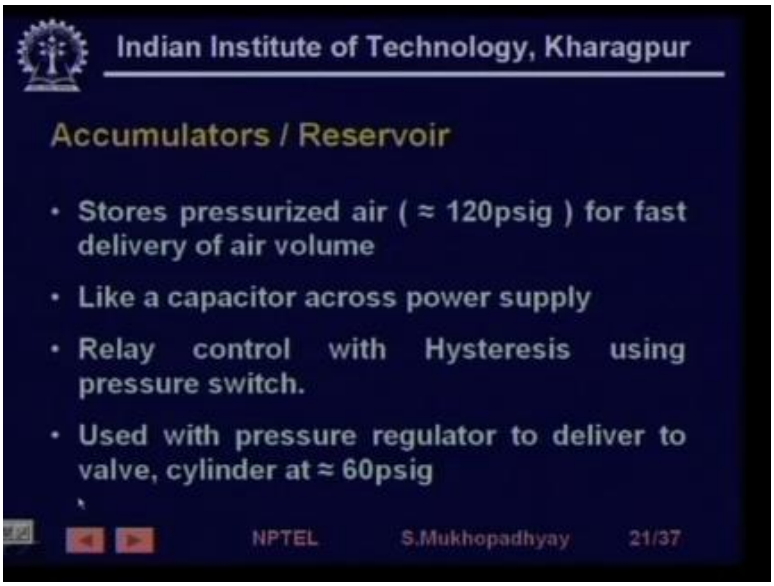

This is working okay so.

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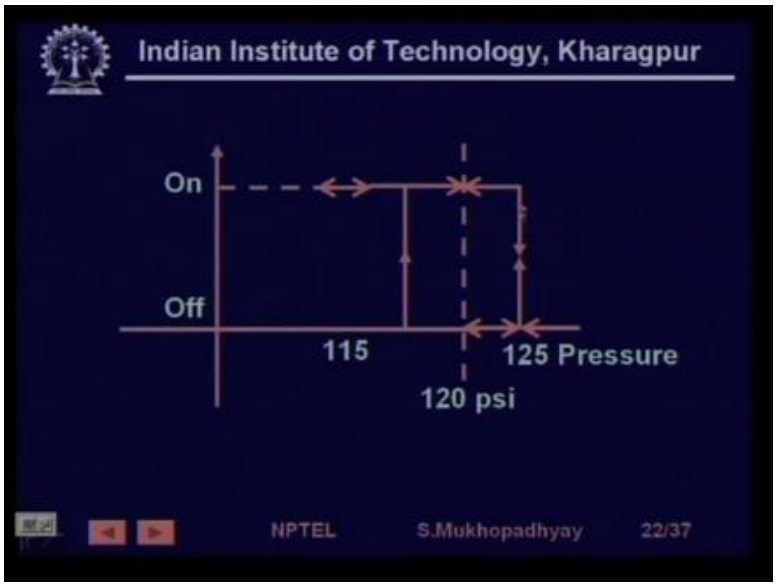

You see what we are trying to do is that if you have we have at a pressure setting they off let us say 100 to 120 psi now as you are drawing load so these this pressure will start falling and then at 115 psi you again turn on the compressor such that the pressure keeps rising and becomes so the pressure will so you actually make the you touch a turn on the compressor at this point of time and then the pressure builds.

Now as the pressure build so you are moving along this line the compressor is now on and then you actually also you want to keep it at 120 p 120 psi is the nominal voltage where you want to keep it but you actually let it build up to a certain point let us say up to 125 psi and then again then at when it reaches 125 psi you actually stop it so you come here right.

And then again as the loads will draw the air so the pressure will fall so you actually move around through this what is called hysteresis rectangle right, so now okay.

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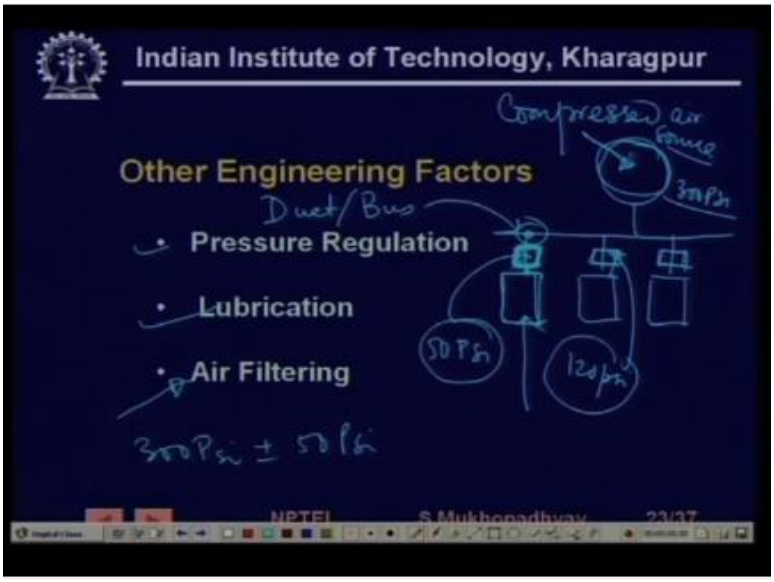

But there are so this is 1 this is the way of you know controlling the reservoir or the accumulator but there are many other some other pieces of equipment needed like for example you need pressure regulators now why you need pressure regulator is actually very simple that is see generally in pneumatics you have one pressure source right so suppose this is the compressed air source compressed air source so as we have just now seen that firstly and from there generally typically up and a kind of duet bus runs which provide air supply to a number of equipment.

Right and firstly all this equipment may not be operating at the same at the same pressure so some of them may be working at let us say 50 psi some of some may be working at 120psi whatever so but the fact is that remember that we said that why pneumatic system is cheap it is cheap because you are going to use one compressor so the compressor cost is going to divide is going to get divided so just because these require are going to require these are going to require different pressure.

So we are going to connect three different compressors which will individually supply this equipment so therefore we need a device here we need a device here which will take in this maybe this is some you know 300 psi, so which will take in this 300 psi pressure and will

convert it to 50 or 120 so we are going to put actually we are going to put different pressure regulators for all these equipment and have a single compressor so firstly that is going to be cheaper second thing is that as we have seen just now when we saw the hysteresis controls of that of the reservoir that the this pressure source is going to fluctuate.

But that but for our operation precise precision operation it is not good that the pressure supply of this equipment fluctuate so therefore if you put if we put a pressure regulator here then the pressure regulator is firstly going to convert a high pressure level to a low pressure level and secondly it is going to so even if the pressure here so suppose this is a 300 psi bus so even if the pressure here varies 300 psi plus minus let us say plus minus even 50 psi but the pressure here is even if it goes up and down the pressure here is going to be regulated by the pressure regulator to exactly very close to 60 psi.

So the pressure regulator actually does these two jobs first converts pressure levels and secondly it holds the pressure steady secondly as I said that we need lubrication so lubrication is needed as I said that frustration of self lubricating secondly because of tightness of seals you tend to increase friction so therefore lubrication explicit lubrication necessary and we also need air lot of air filtering because we are sucking in air from the atmosphere which contains many particulate matters and which are going to get clogged inside the equipment and then cause further problems of maintenance in terms of you know sealing says in terms of increased friction etc…

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So we need equipment to take care of these so a regulator is used to drop pressure up to a level which is appropriate for a machine and it prevent pressure fluctuations on the air distribution duck to reach the machine and settings generally for regulator settings can be adjusted and it is self relieving in the sense that if the pressure I mean there is too much inlet pressure then it is it generally relieves that pressure.

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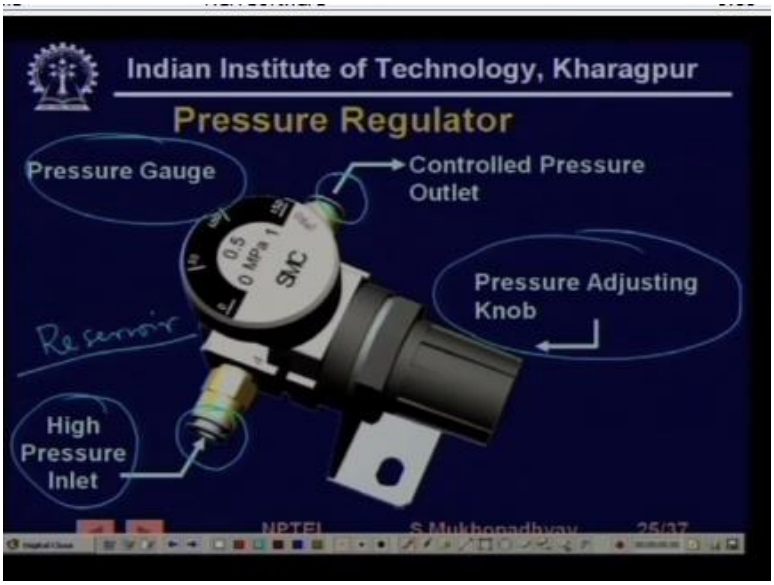

So this is just atypical picture of a pressure regulator and so you have this high pressure inlet you have the low pressure or the controlled pressure outlet so this is going to the system or the equipment where the pressure is needed this is coming typically coming from the reservoir so now the pressure setting can be adjusted by this pressure adjusting knob and often there is a pressure gauge so that you one can see that the inlet pressure variation.

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So then the filter can be connected at is generally connected at compressor intake and various types are possible paper element type is a popular one and sometimes you put additional filtering you need just before the equipment to you know ensure further that these are that you that your components are protected and so it removes the large particles and it also removes moisture because especially particulate matter and moisture you know creates a very sticky mix which leads to all kinds of problems like increase friction sticking.

So the term friction actually comes from that so the static friction main may increase substantially unless moisture and this particular matter is not removed.

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So we have explicit lubricators because air has little lubrication and low viscosity and so the lubrication is generally achieved by spraying fine oil means to air flow so you it is very difficult to you know in a distributed system to lubricate the system so just like an hydraulics the oil itself is the lubricator so as it travels throughout the system it actually lubricates the whole of the system in this case air is not itself the lubricant so but it is nevertheless travelling throughout the system so it so it is simple so the delivery of the lubricant can be easily done using the air itself.

So therefore oil lubricating oil is actually in a kind of atomized form it is spread to the air flow and then the air flow takes it to various points and where it provides the lubricating function so if you have smaller droplets you have longer lubrication and sometimes you can have autumn I atomization but this oils remember that the moment you are going to put this oil mist you cannot directly release it you can release it you need not return the air that is fine but at the same time you cannot release the air just like that into the atmosphere because of the oil missed because it is going to be health hazard.

So sometimes so you actually before releasing into atmosphere it must be this oil must be filtered since this filtering regulation and lubrication are very common requirements so we have you

know like we have like combo units where this filter regulator lubricator are designed together so filter + regulator+ lubricator unit typically this is a symbol.

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So you have regulators lubricators and actually filter so typically some typical pictures of these this equipment.

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Then we come to Direction control valves right these are very similar to the direction control valves that we have studied in hydraulics and it so it controls and changes direction of airflow from time to time there are various functional types as we know their it can be two-way it can be three way it can be four way even it can be five way then there are various positions so it can be a two-position or can be a three-position valve so what I mean is that based on their functionality and based on their construction there are various categories of these direction control valves.

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For example at this is a typical three-way valve which is manually operated using this knob.

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And it has three operational modes.

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So namely off vent and on so it can be made off in which case air will not flow if it is on then the air will move from inlet to the outlet and if it is in vent mode then the inlet and outlet will be connected to the atmosphere.

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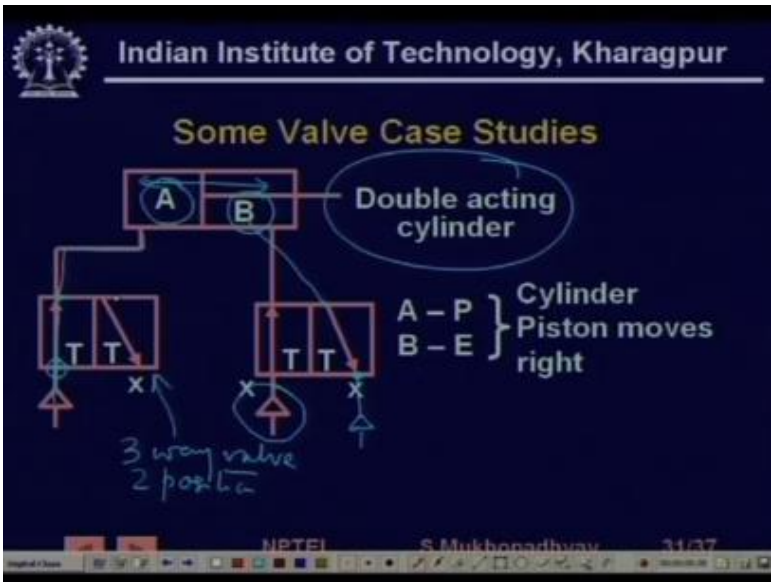

Looking at some very typical valve case studies so very standard this is a this is a double-acting cylinder and so double-acting means we need to move it this way as well as this way so here we have connected and this is a two-port valve this is a this is a three-port valve there is a three-way valve 2 position so it can connect either this to this or it can connect in this position will connect this to this and this side will be connect can be again connected either so they are actually independent so depending on the positions of these valves if there in the position shown then this side is also pressurized and this side is also pressurized.

So the valve is locked right on the other hand on the other hand if you connect this end to this position and this end if you connect to this position then what happens is then the piston will start moving right because this chamber will be connected here but this chamber will be connected high pressure so the piston will start moving right and then there is vice versa if you connect it the other way this in this position and this in this position is start moving the other way if you keep both of them so there are four combinations and if you keep both of them in this position in this position then actually the cylinder is floated.

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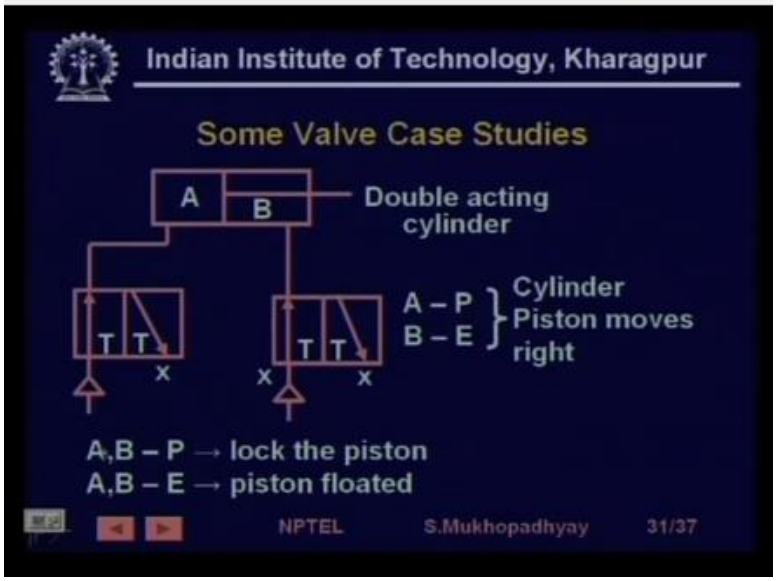

So it can move it is free to move because both ends are connected to vent so yeah so A to AB to P locks the piston and A B to E locks means exhaust the piston is floated.

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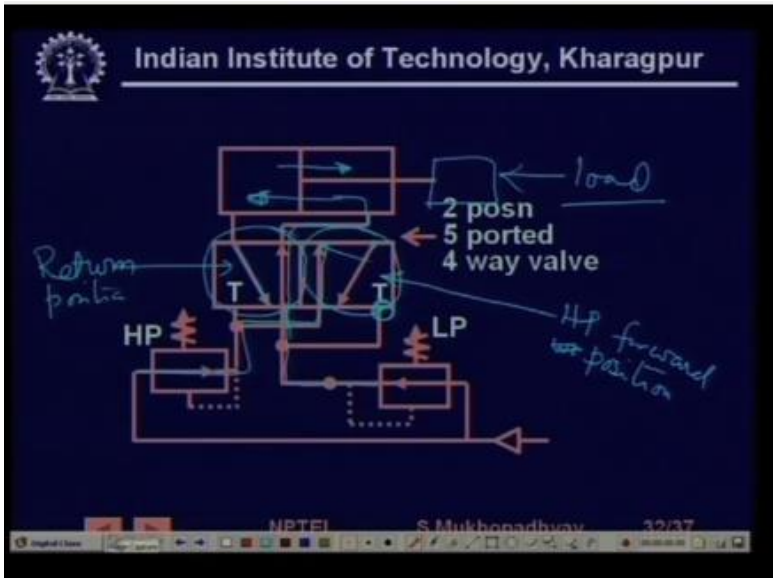

Similarly this is a case where this is at two position five ported four-way valve so five ports because one, two, three, four, five. Five ported and two position because this is one position and this is the other position okay, so what happens is that sometimes you know these Pistons when they are moving the load they will require high pressure operation because a lot of force is to be created and when they are returning then is a low pressure operation.

So what happens is that see that the low pressure source is actually connected to this point this is this is sealed so this motion is going to actually occur and this is going to exhaust so this is the return position on the other hand it is going moving this way so this is the rod so the load is going to be connected to the rod load so when it is pushing the load at that time if this is the high pressure position HP forward position so in that case you can actually drive it using your high pressure source right. And so that will possibly save some energy.

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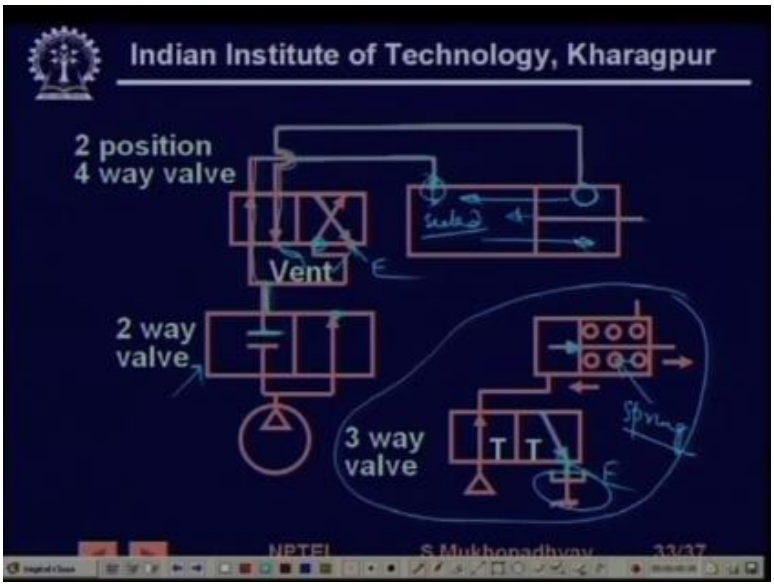

Similarly this is another application where for example see this is a three-way valve application where if you connect it to this position then the valve is will move this way these are Springs so valve is spring-loaded and so therefore further for the return you do not need any pressure and you just shift the valve so this will get connected to this port which is exhaust and then by spring action since this side when it connects to exhaust this side pressure is glow so by spring action the valve can return.

So you need only apply a pneumatic pressure for moving the valve to the right from movement to the left is actually achieved by this spring similarly if you connect it to this position then what happens is that the pressure gets connected here and then when this valve is in this position you see so this is sealed while the high pressure will go and the low pressure will return so the cylinder will move this way if you now shift this valve then what has happened what is going to happen is the high pressure will go this way.

So high pressure will go this way so it will be applied here it will be applied here and the this other side will be applied will be applied here so it will be so it will be exhaust this is also exhausted this you are vents you know this is went and this is vent so then it will move this way

right on the other hand if this valve is shifted to this position then what happens is that both sides of the cylinder for example then this sidle cylinder is free for example in if the valve is in the position shown then this is sealed right.

So therefore this chamber is sealed while this chamber is open so what happens is that now if you want to push the cylinder then the air will get compressed and some force will be created so it cannot be freely moved you know so it gets kind of soft locked that way so you can have various sorts of such circuits and we will see some of them later.

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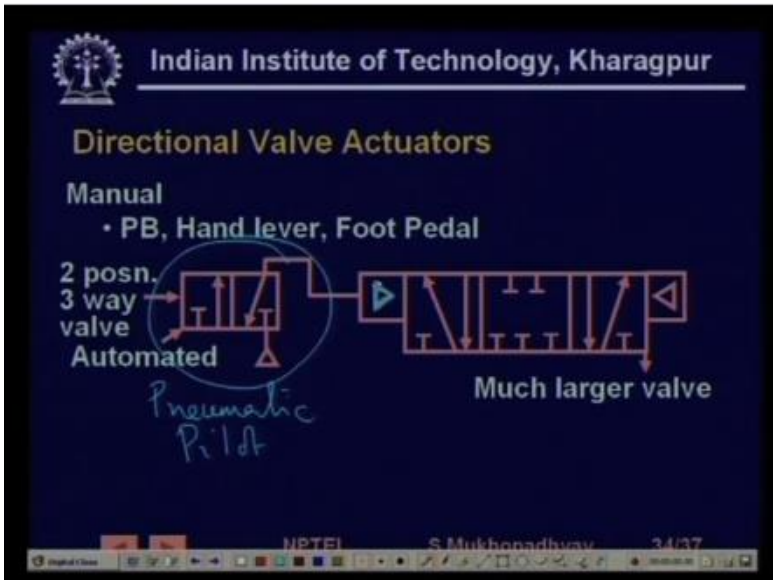

In our next lecture this directional valve sometimes they have to be there to move you know we were talking about moving the directional valve from this position to that position so how do we move that so there as just like in hydraulics there are various ways so you can have manual where you can have a push button you can have a hand lever you can have a foot pedal whatever you have or sometimes for very large valves we can for example this is a you can have a pilot valve.

So you know this is a large valve so to be able to shift that position you see pneumatic pilots are used so this is a this is a pneumatic pilot which is used to shift this main valve right this may be a this may be a big hydraulic valve also and this hollow triangle indicates pneumatics.

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So you can have hydraulic pilots you can have air pilots so even a large pneumatic valve can be driven by a small air pilot and the or otherwise there will be solenoids and sometimes as we have seen that they may have they may be spring-loaded such that the especially the return stroke as such does not require an actuation force so these are the various ways of activating a directional valve oh sorry.

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So this brings us to the end of the lesson so what we have seen is that we have seen the pneumatic system principles and benefits in particular we have seen that we are going to be pneumatic systems we you we are going to use compressed air and not only that we are going to use compressed air we are so compressed here you know has some benefits that we you know here is free and it does not require a return line etc…

But on the other hand the because of the compressibility of air the system response tends to be slower and there is another big benefit computed to hydraulics is that the fire safety is much more intrinsic and so there are so basically it means that there are certain very definite classes of application we have also seen that in certain cases where you need a lot of you know low power applications spread over a large area pneumatic systems come very much cheaper because it is you can use one compressor and then you can use an air duck system to actually you know reach the pneumatic power to a large number of places without requiring too much ducting costs.

So there are certain kinds of applications where pneumatic systems are quite well suited compared to hydraulic system so it is just a question of so just a question of the particular kind of application where these systems become more beneficial we have also seen the main system

components in the sense that you have seen talked about compressors talked about accumulators regulators and some kinds of Direction control valves as well as the cylinder.

Now there are made various other kinds of elements which we will talk about in that in the next lesson so we have seen the major kinds of system components compressors we have seen mainly the compressors are which are used a reciprocating or reciprocating compressors we have seen how they work and we have looked at some pneumatic control valves various kinds and we have also talked about accessories such as lubricators and filters.

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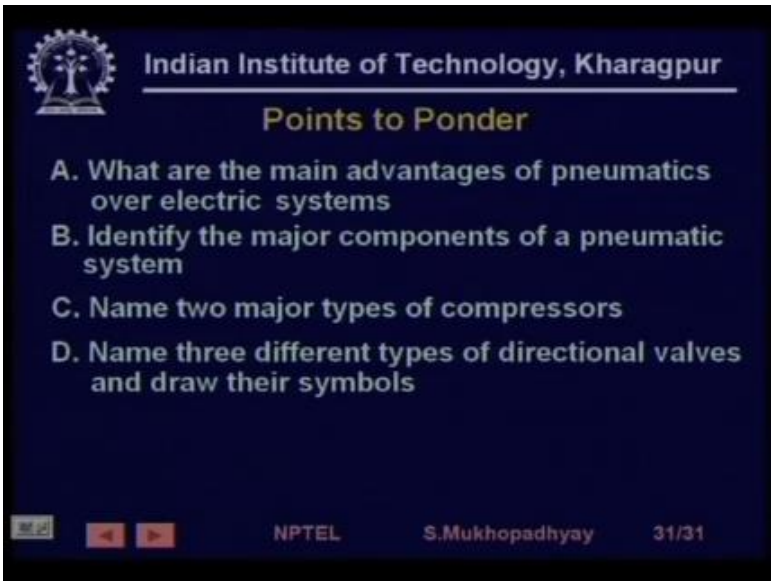

So coming to the end before the end let us look at some easy relatively simple questions what are the main advantage of pneumatics over electric systems and some of the main advantages of pneumatics over hydraulic systems and can you so for example one thing could be can you name some applications where a hydraulic system is preferred can you name some application whether we are a pneumatic system is preferred and identify the major components of a pneumatic system so major components we have discussed is name two major types of compressors so two major types of compressors could be you know reciprocating could be rotary valves type could

be fan type non positive displacement also then three different types of directional valves so we have seen these and draw their symbols so this is of course very similar to hydraulics.

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So that is all for today thank you very much