Industrial Automation and Control
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Lecture - 30
Pneumatic Systems – II

Welcome to lesson 30 of Industrial Automation and Control. In this lesson we are going to look at continue to look at Pneumatic Systems.

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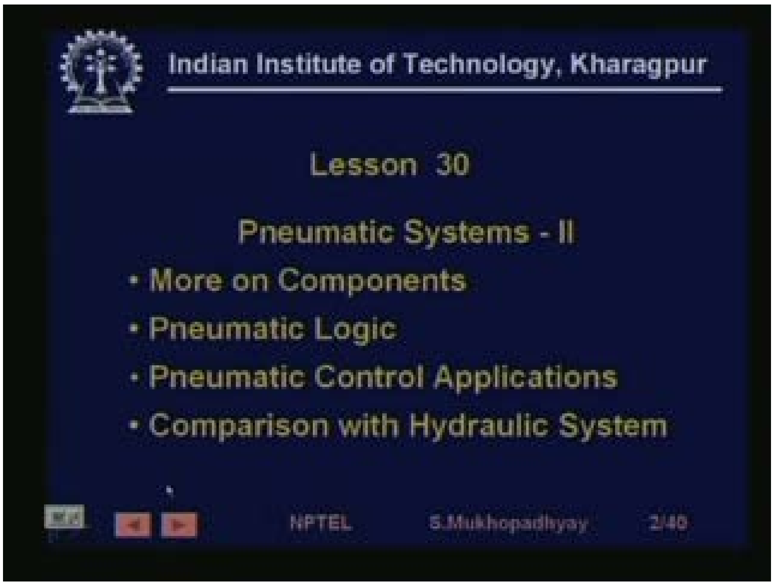

So, in lesson 30 we will look at more components pneumatic components, we will look at a kind of logic or pneumatic logic and we will see some control applications and finally, we will see a comparison with hydraulic systems, so and the instructional objectives are firstly to you know.

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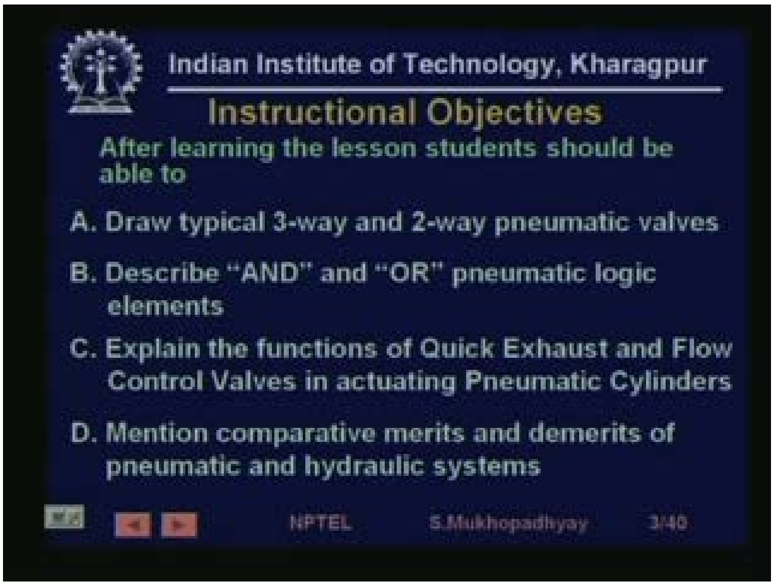

Be able to draw some typical valve constructions, describe and or kind of pneumatic logics explain different functions of some special kinds of valves which are used in pneumatics like a quick exhaust and flow valves, mention comparative merits and demerits of pneumatic and hydraulic systems and also be familiar with some control applications. So, we have already seen direction control valves we have also seen them during hydraulics, so there is nothing much new here.

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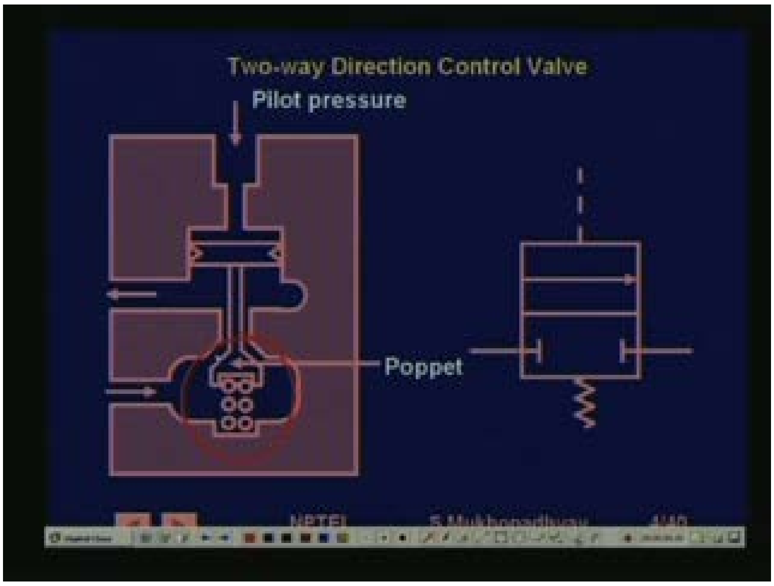

So, the valve is actually shown here there are, so you can see the inlet, inlet and the outlet ports, so you can see that this is the when the pilot pressure is there, this is as you can see that there is a spring here let me choose a proper pen here. So, this is the pilot pressure, so in the pilot pressure is not there, there is a spring I see this is selected as a eraser I have to choose pen first and then, choose this color.

So, it is spring loaded, so when there is no pilot pressure then the spring is going to push it up and this is going to be closed this. So therefore the valve is closed on both sides. So, therefore this symbol is shown and when the pilot pressure is applied then this goes down, so there is flow symbol to a valve then we come to three way valves.

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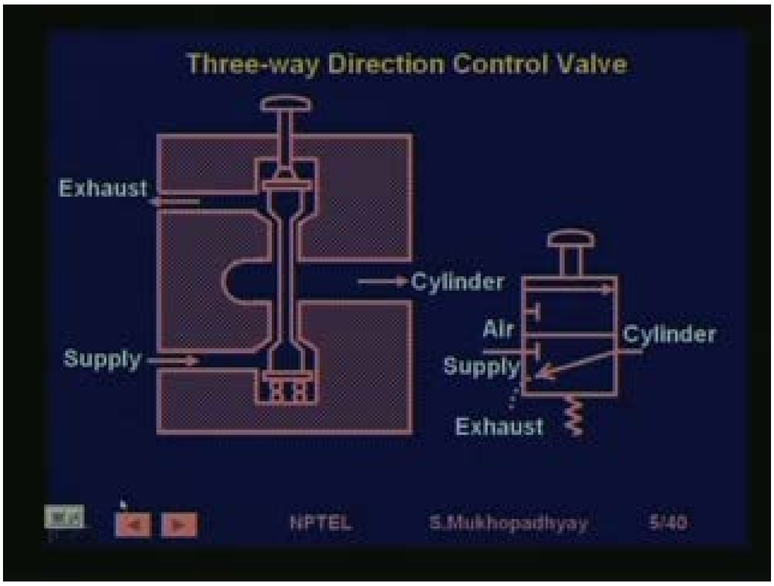

Basically, this is a there are two ports one is supply the other is exhaust and again as you can see this is also spring loaded, so when there is no this is when this is button operated, so when the push button is not pressed then this is supply is closed and cylinder is connected to exhaust. So, therefore when this is pressed this will, this will open and this will close this will close.

So, these points will close and the supply would get will get connected to exhaust, so this that is this rectangle, these are standard we have also seen them during the hydraulics course. So, we will we are going little fast on this, so then we have a this is a special kind of valve which is called a quick exhaust valve.

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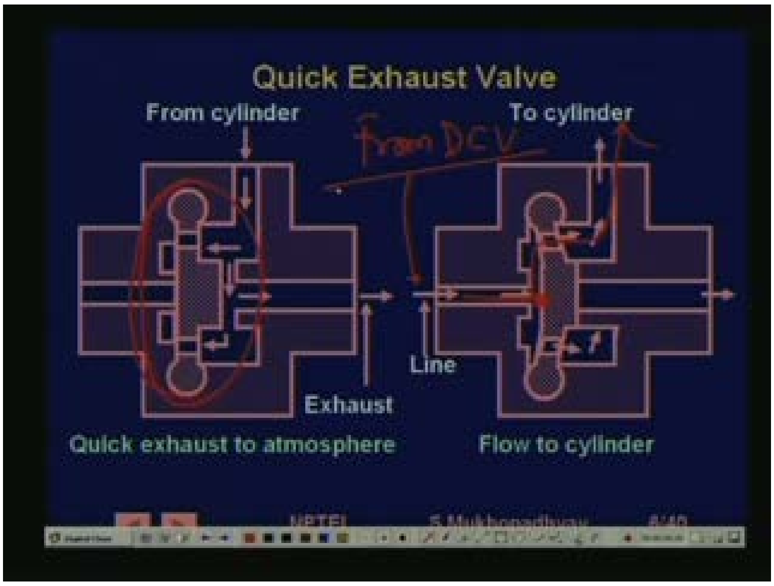

This is needed, because if you do not use it then the as you said that in pneumatics there is no return line, so the air is generally released into the atmosphere. Now, the question is the earlier you release it to atmosphere, the better it is in terms of pressure across an actuator or in terms of because, the air will not take because that much pressure will not be required for driving the air through the tubing and also the time response of the system will improve.

So, therefore, these valves are sometimes used when you do not release the air at the direction control valve, the air is driven by the direction control valve, but is released right at the actuator using the quick exhaust valve. So, you can see a construction here where, so when the when you are driving pressure into the cylinder they are typically connected with cylinders then this is the, this is the basic mechanism this is the mechanism.

So, this is getting pushed up and when it is pushed this is closed, so the air path is shown the air is flowing into the cylinder, this is coming from the DCV this is from DCV or Direction Control Valve. On the other hand when it is coming from the cylinder when it is coming back from the cylinder then, it does not need to go to the DCV and it is released, so this is this will press it and therefore, this will be closed and the air will actually flow out into the atmosphere locally at the cylinder, so it quickly exhausted right, so that was the idea, so you can see this that.

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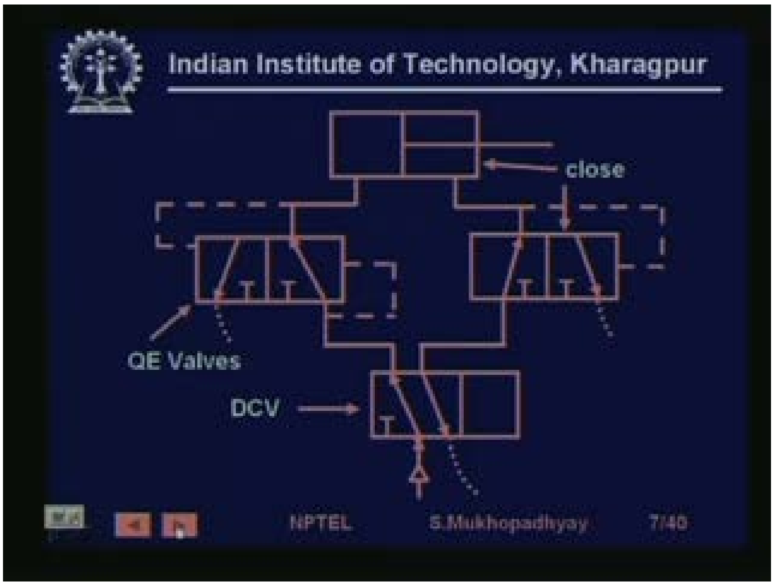

So, this is an actuator which is being driven, so what happens is that the air flow this is the DCV, so the air the air flows into this goes through this and raise the actuator, so the actuator moves when it moves it actually expels the air. So, you know it actually expels the air, so because this is a your know pressure driven, so when this pressure line increases this valve, this valve is going to shift as we have shown the mechanism.

So, then this gets is actually connected to this and gets exhausted right there it actually does not have to come back to the, it actually does not have to come back to the DCV, so this tubing is not used for the return path and the air is exhausted right here. So, this is the, this is the function of quick exhausted valves, you can have similarly you know if you if sometimes you want that for you know synchronization purposes, you would like that after you put an actuator there are three valves will actually move one after the other.

So, if we have to realize this concept of one after the other then, you have to create gradually increasing time delays after which this valves would be executed will be shifted, so that is done this is the you know this is the typical construction. Basic idea is that when air is flowing to create pressure and shift the actual valve, if you just put a chamber in the on its path then, some time it will be required for the incoming air in from the pilot to fill that chamber before pressure can develop and shift the main valve. So, there will be a time delay, so now depending on the volume of the chamber you can create variable time delays, so exactly that is what happens here exactly that is what happens here.

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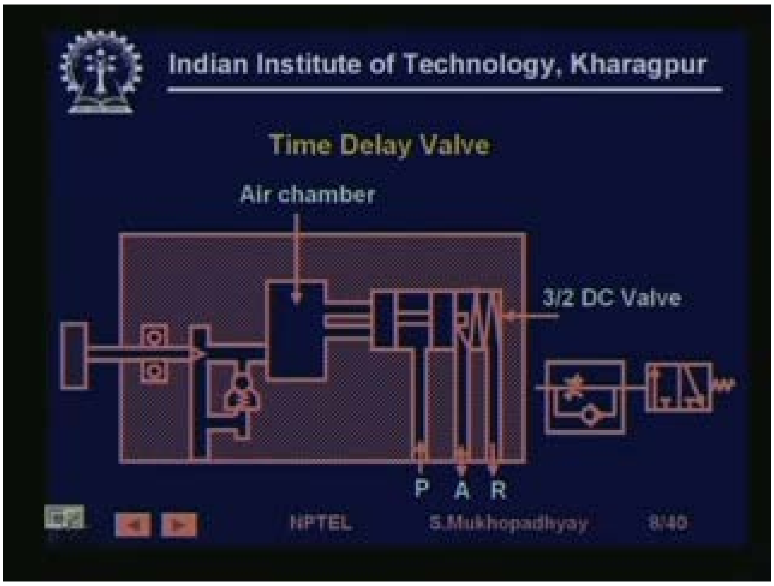

So, you see that air this is the pilot port, so the air comes and fills this chamber after it after this, so pressure builds up slowly because of the chamber and then, it shifts the valve then it actually applies the pressure on this pool and that will shift the valve. So, this is the, this is the basic mechanism by which time delay is created.

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Similarly, you have flow control valves, so in flow control valves are mainly used to have a controlled speed of the actuator especially when it is raising load, so you know sometimes as we have mentioned in hydraulics that sometimes we want that, sometimes we want that while it is retracting it should be at high speed to save time, but while it is driving the load it should be at lower speed.

Sometimes for part of the journey it may be at one speed towards the end of the journey it may at slower speed, basically because of the fact that the load typically tends to have an inertia and if you push the load too past then, the lot of kinetic energy can you know accumulate in the load and it can go and hit against something. So, towards the end of the stroke there is a need to reduce speed, so basically the flow control valve is used for controlling cylinder speed and you know you can put this flow control valve either in the path of the incoming air or in the path of the outgoing expelling, the air which is being expelled from the other half of the cylinder.

Now, it turns out that generally there is a benefit of you know these two, these two cases are called meter inflow control and meter outflow control, so meter in is when you put the flow control valve on the incoming airflow and meter out the when you put it at the outgoing airflow. So, generally people sometimes prefer putting it in the outgoing flow because, that creates a back pressure which you know kind of stabilizes the motion of the valve motion of the cylinder.

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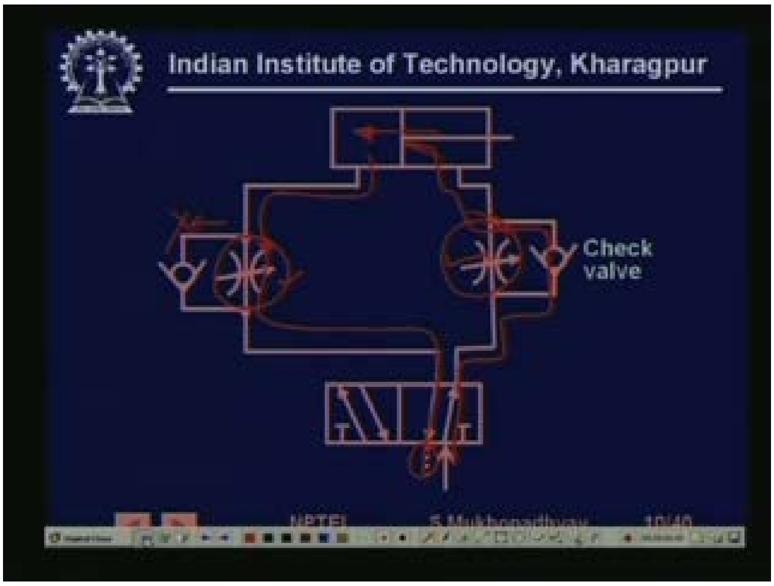

So, the moment the cylinder tends to move faster immediately the flow control valve, develop some pressure which tends to desolate the cylinder this is, so it is a kind of negative feedback and it will stabilize the cylinder motion. So, the application is shown here, so you see that this is this I think we have also discussed in the case of hydraulics that while the fluid is flowing, it is flowing through this path.

So, there is a check valve which is put, so it is a bypasses flow control valve, so it will go through this path and it will enter here, but while it is coming out the fluid which is being expelled; obviously, cannot pass through the check valve because, there is no this cannot flow this way. So, it will pass through the flow control valve and then finally, get expelled, so this flow control valve is used.

So, that the when the cylinder is moving this way there is a certain, there is a certain speed that maximum speed that it can it will generally achieve you can have different flow control valves settings here in these two valves. So, that you on two sides you can have different speeds of the cylinder, so this is you know the same concept you know sometimes what happens is that you can start.

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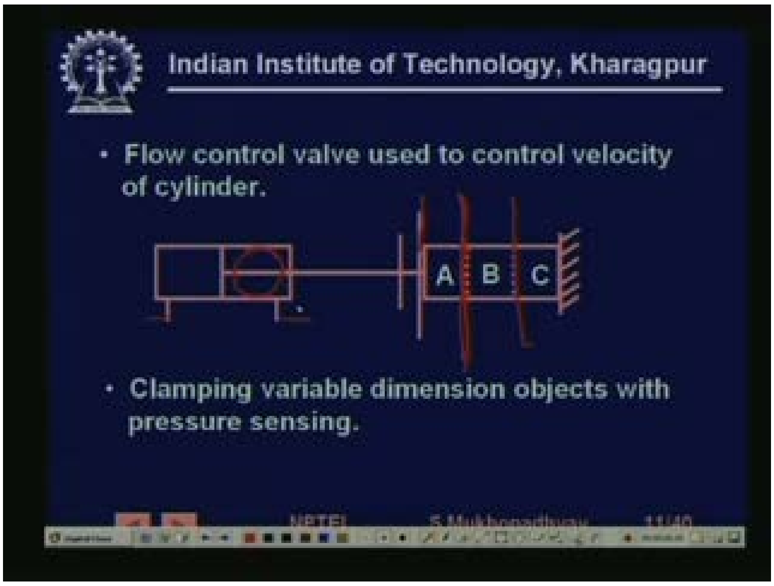

So, sometimes it happens that you can you need to for example, take the example where you need to clamp various kinds of objects of various size, so some objects can be large some object can be small. So, you are having an actuator which is advancing and when it meets the object it pushes it, till it gets clamped with a certain amount of clamping force, certain fixed decided amount of clamping force.

So, you can see that depending on the object dimensions the stroke will require after which the required clamping force would be obtained depends on the dimension of the object. So, if the object is A then at this point only that, then at this point only the clamping force will be realized, if it is of the of the size B then at this point the clamping force will be realized if it is C.

So, how much the cylinder will move and where it will stop has to be determined based on the pressure developed in the chamber, so the pressure will develop the, I mean the back pressure will be developed in the chamber, when this cannot move again. So, you see that there will be this will actually then this will actually resist the moment, so therefore, at a certain pressure difference will arise.

So, normally this pressure difference will not arise and the cylinder will be free to move, so actually we can have this done what I am trying to say is that we can sense the, we can sense the pressures. We can sense the pressure initially what is the pressure difference, the pressure difference is just enough to accelerate this after that what is the, what is the necessary pressure difference, the necessary pressure difference is just to get a certain amount of clamping force right. So, by sensing the pressure difference across the two ports one can actuate the cylinder, so that it will stop after developing a certain amount of clamping force that is that is the whole idea.

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So, you see that you can start at a when see at the at a certain point you can start shifting and then, as it as it shifts the pressure at one terminal will fall and the pressure at another terminal will end will raise and then, when it raises up to a certain level then the then the shifting has to stop, so that, so that a certain amount of pressure is reached across the cylinder.

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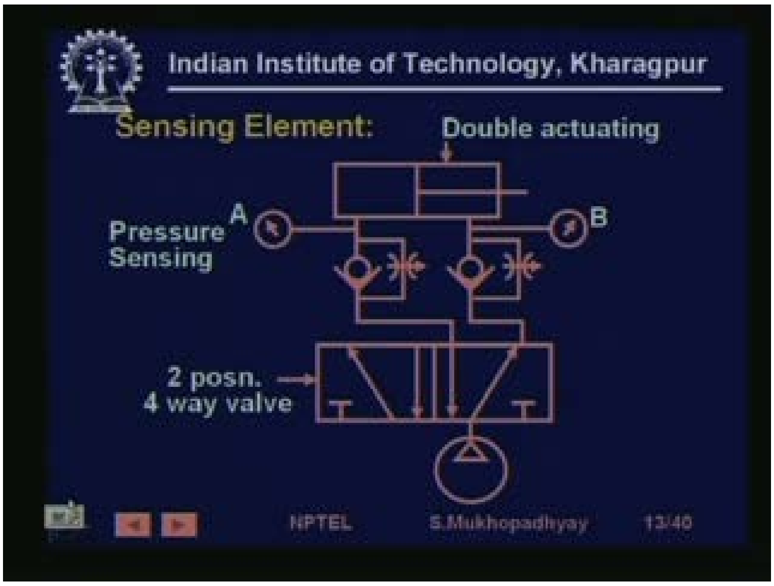

So, exactly that is shown, so you see that you are sensing this pressure A and pressure B and then, you have to use an appropriate logic to actually drive this valve, so that a certain amount of pressure is force is developed.

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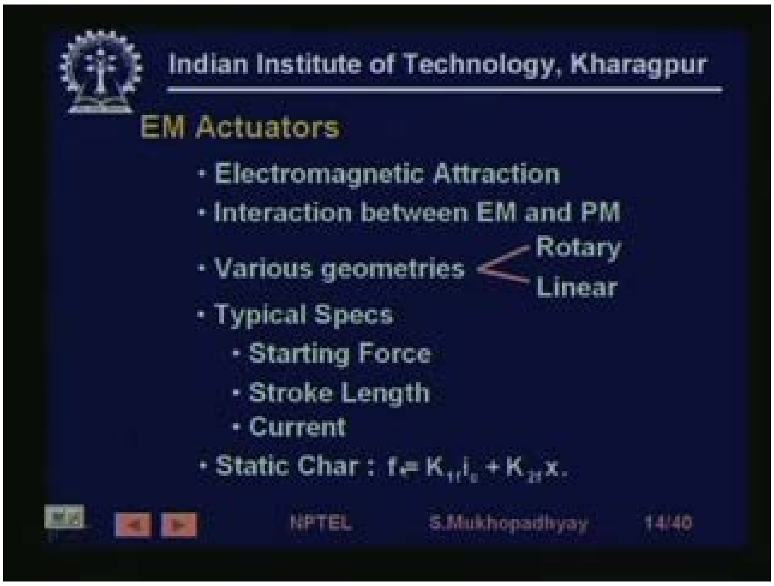

Now, so this is about valves now the valves these valves are can be actuated as we have seen that, we can have various kinds of logic for actuating valves and not only that we have after. So, the basically an electromechanical actuator on one side is going to interface with the logic elements which decide the condition under which the valve should move, so the on the other side when the valve should move, it should provide the necessary power for the main valve to shift. So, these are the two things which are necessary.

So, the electromechanical actuator can actually you know this providing power this can be done in various ways, for example it can be directly a solenoid driven valve and where some current is driven into a coil and it pulls this move. On the other hand as we have seen in the case of hydraulics also, that it can be directly pilot pressure driven generally, an air pilot is used or it can be you know sometimes it can be a two stage thing.

Where an electric signal will drive a pilot pressure, so there is an there will be some sort of an electric to pneumatic converter that is also possible. So there are various ways generally electric to pneumatic controller, what are the used because the electric signal can be very simply generated, and you can we can use computers we can use you know various kinds of signal processing on the electric signal. And then finally, convert it to the to a pneumatic signal for the purpose of either for the purpose safety or for the purpose of higher power, etcetera.

So, we often very often we have electromechanical actuators, so electromagnetic actuators, so basically it works by electromagnetic attraction between a permanent magnet and an electromagnet. So, when if you when you drive it or sometimes between electromagnet and an iron spool both are possible, so there could be various geometries, this actuators can may be rotary or linear and typically, the specifications involves starting force, stroke length by how much it can move and the current requirements.

So, the typically the force varies depending on depending on the current as well as the displacement because, you know basically it is by flux, so the flux actually depends the flux actually depends on the current because, the current decides the magnetic abortive force and it also depends on the reluctance of the flux path which depends on the gap which keep changing during motion. So, the force characteristic depend on current as well as the position.

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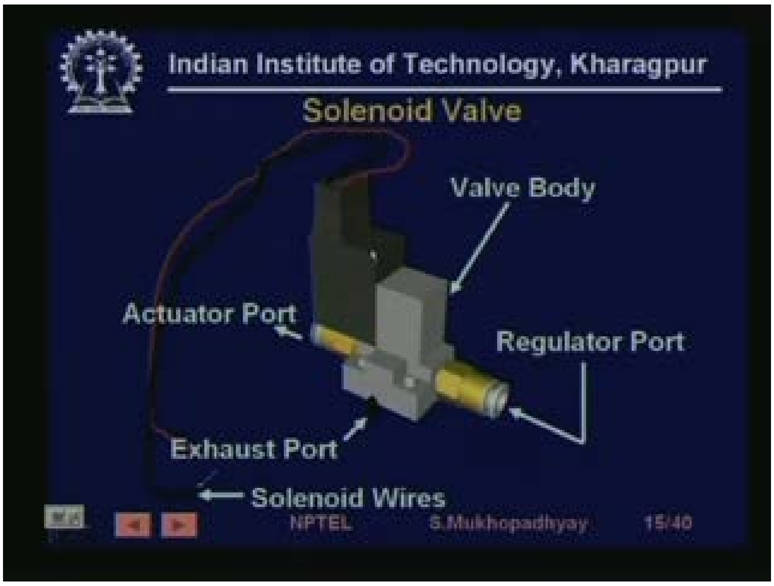

For example, this is a this is you know a typical solenoid valve, so you directly can drive current into a solenoid valve which will pull the spool, similarly you can have electronic interfacing, so this is a slightly more elaborate configuration.

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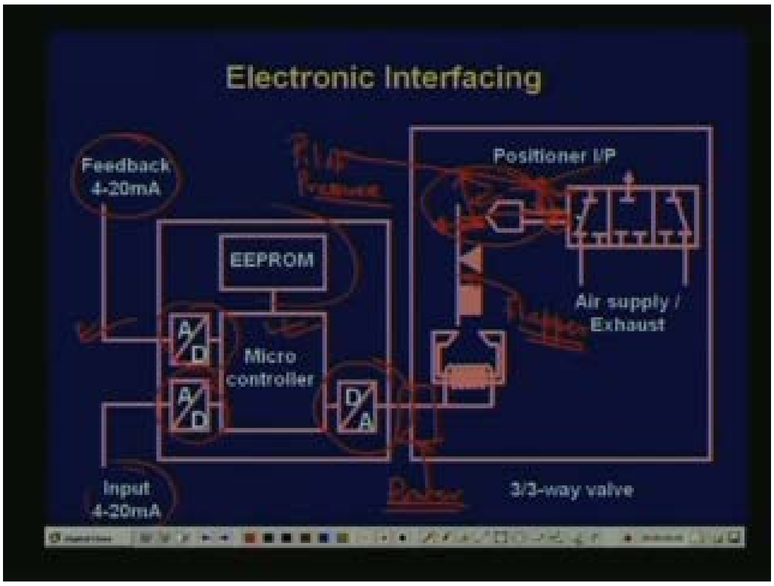

So, you have electric feedback of signals may be either displacement, so you can have position sensors or you can have a pressure sensing as we have as we have discussed. So, this these electric feedbacks comes from sensors using some transmission technology in this case, we have just mentioned 4 to 20 milliampere, it may be something else also and then they are taken in acquired these signals are acquired in a digital controller.

So, finally the digital controller computes the necessary force that must be applied for control to the valve, so that is the output through a D to A converter, these are A to D convert because these signals are analog. So, they have to be converted to by A to D this is the here just for example, we have shown a sort of a shown just to indicate that it is also possible to use a detail, let us say a microprocessor to you know control these.

So, this is the microprocessor CPU and this is the memory, so the microprocessor finally gives a digital command which is converted to an analog command, in general actually there will be a there will be a power amplifier because, a microprocessor generally cannot drive a coil. So, typically one can use one can use relays or one can use power amplifiers, so this is the, so finally the current is driven once the current is driven using this is using this attraction principle this is you know what is called a this the I to P converter and often referred to as a flap and nasal system.

So, what happens is that if the if this current flows then this will start to move, this is the flapper this the flapper, this will start to move depending on the current and if it starts to move actually this gap is shown very exaggerated actually this gap is remains very small. So, and also what is not shown is that there is also a there is also a pilot pressure source, so there is a pilot pressure source which is a constant high pressure.

Now, what happens is that by changing the position of the nozzle see what happens is that, if you can if this nozzle is very far away then this pilot pressure is going to drop out and go through the go to the atmospheres right here at the nozzle. So, therefore this pressure which will develop here is going to be somewhere here you have exhaust pressure here you have a pilot pressure, so the pressure here is you know somewhere in between.

Now, as you bring this closer and closer you are here you have the nozzle, so you are bringing the flapper closer and closer, so you are closing the flapper you are rather closing the nozzle. So, if it was totally closed what would happen to the pressure, the pressure would have been pilot pressure itself because, there is because there is no exhaust if it was totally open then the pressure would have fallen close to the exhaust pressure.

So, as it moves and this and these movements are fractions of millimeters then you can have a very high sensitivity high gain variation of the pressure at the pilot port of the valve and the valves can shift, so you know such interfacings are possible for actuating the valves. So, we have seen different kinds of valves and we have seen how there are actuated, we have also seen that you know that they can be interfaced to for you know sophisticated actuations especially continuous movements, they can be also driven by things like microprocessors.

Now, while microprocessors can provide logic sometimes you know simple logic can be provided by also by pneumatically based, so this is required in some specific cases especially where you have big fear of explosion from electric devices like say let us, say let us say a natural gas plant they are using electric devices must be done with a lot of precaution because, one single spark may cause a big fire hazardous explosion.

Similarly, there are certain in some cases there are very hot environments where you know maintaining any kind of electric insulation is problem. So, therefore, in such application sometimes if the if the control logic complex, it is not too high one tends to use pneumatic logic, so you know, so pneumatic logic just a moment, so we are back.

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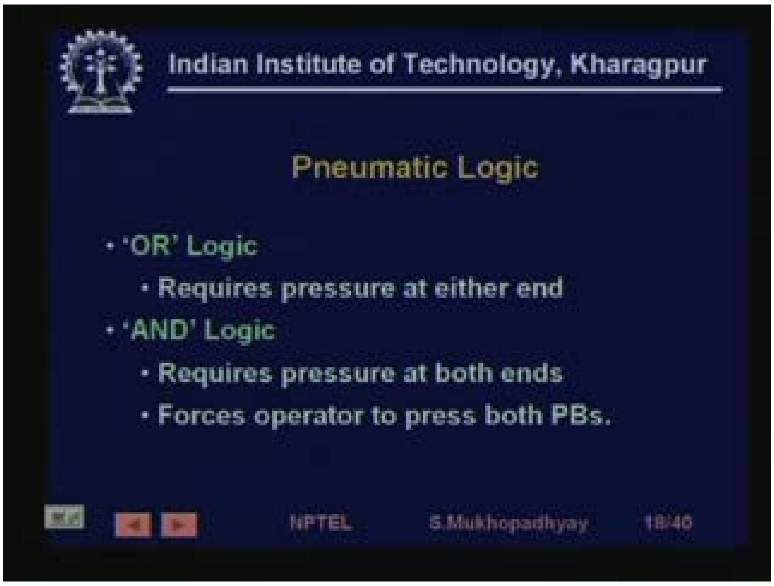

So, pneumatic logic means that we are basically trying to have realized you know some sort of a digital logic, so we need you know elements such as or we need elements such as and say for example, if you we can have OR logic which will require pressure at either end for the air to flow into the system pilot pressure. Similarly, if you have AND logic then you will require pilot pressure to be applied at both ends simultaneously for the airflow to be connected to for the pump to be connected to the load.

So, sometimes this AND logic is used to for safety applications where the operator is forced to press both push buttons, so that his hand where he is operating pneumatic systems are very much used to assist operators in operating various kinds of machines and sometime you know there are, there are safety hazards. For example, suppose we have too big rolls in which operator has to put some material typically, such things are used in may be used in you know thinning out kneading materials like in, like in the production of tires.

Initially rubber has to be needed before it can be molded in the in the form of tires, so in such cases they need to ensure that when the roll is rotating the operator's hand is nowhere any other roll. So, that can be ensured very easily by requiring that you rotate the roll you need to put press two push buttons simultaneously, so you are going to use both hands, so you cannot make a mistake, so for such cases, so for example let us see OR logic first.

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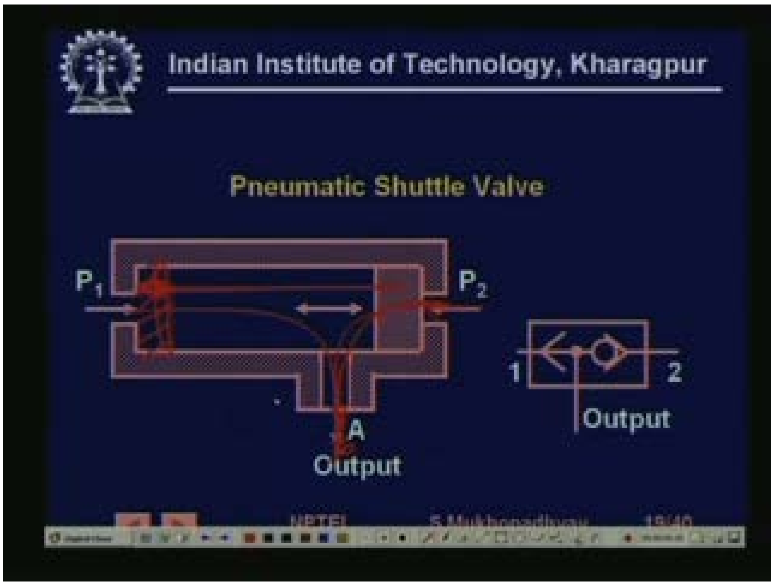

It is a very simple construction pneumatic shuttle valve, so you see that you see that output if you have pressure at this end then, you are going to get the pump connected to the to the system. On the other hand if you keep pressure at this end also then, then also this will shift this way that why it is called a shuttle this is, so this will shift and close this one it will take up this position and air will start flowing, so here is OR logic where even if you apply one of the pressures then, you are going to get the air flowing into the system.

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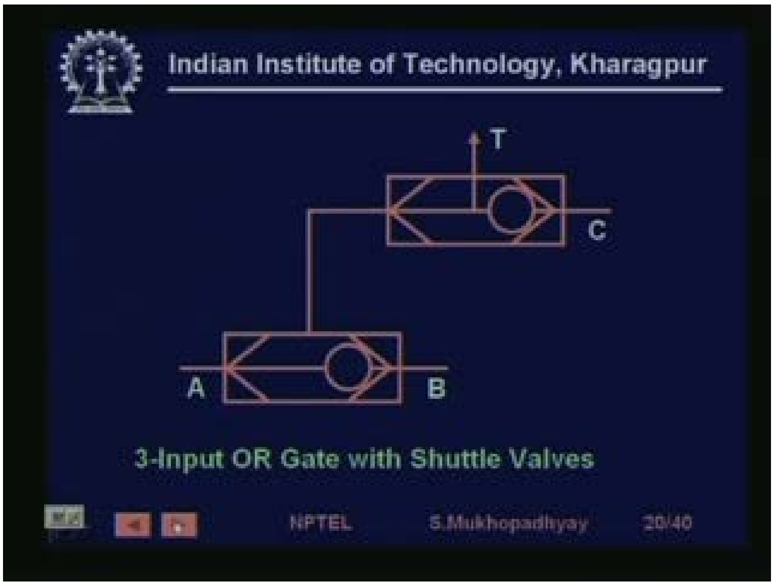

This is just an example which shows that by you know by casketing this shuttle valves you can have a three input OR gate also. So, that is, so you this at this point you have pressure applied when it A or B and then that is applied to one port. So finally, the pressure is applied to the system when you have A or B or C, so it is a three input OR it is a it is a three input OR.

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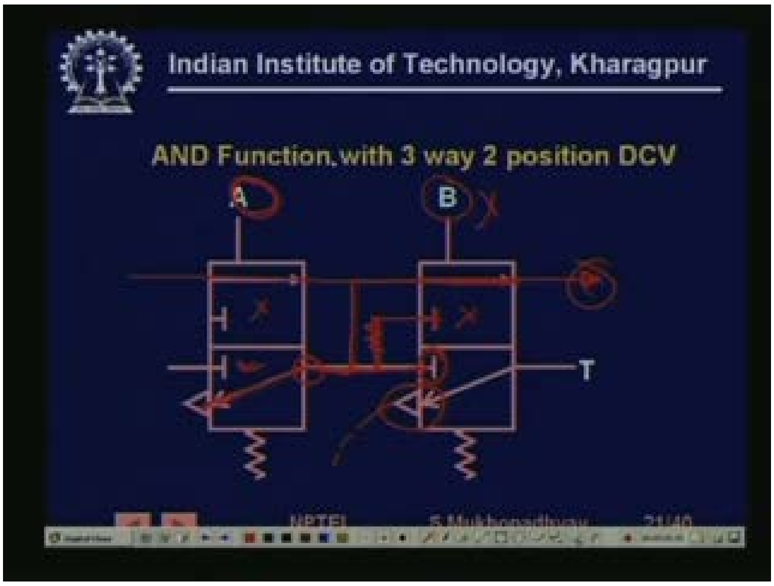

Similarly, this is a realization just to just to show that how this these pneumatic elements can be use to generate various Boolean condition, so this is this is an realization of an AND gate using three way two position direction control valves. So, what happens is that when both these pressures are on then this is in this box and this is in this box, so therefore, the supply directly goes to the tank.

Now, suppose this is not there which means that now this is the position, but here it is there, so therefore, you see that in this position this gets connected to this position or rather this gets connected to actually this position. And, no rather this is connected to this position you see this is actually connected to this to this second side, so actually it will not go there it will rather go to the left one, so then so the system will be connected to exhaust if this is taken off.

Similarly, if this is taken off then what will happen is that the system will directly be connected to the exhaust this is the exhaust. So, in if anyone of these inputs are taken off then the, then the system is going to be connected to the exhaust even if both are taken off it is still connected to exhaust, so it is AND logic.

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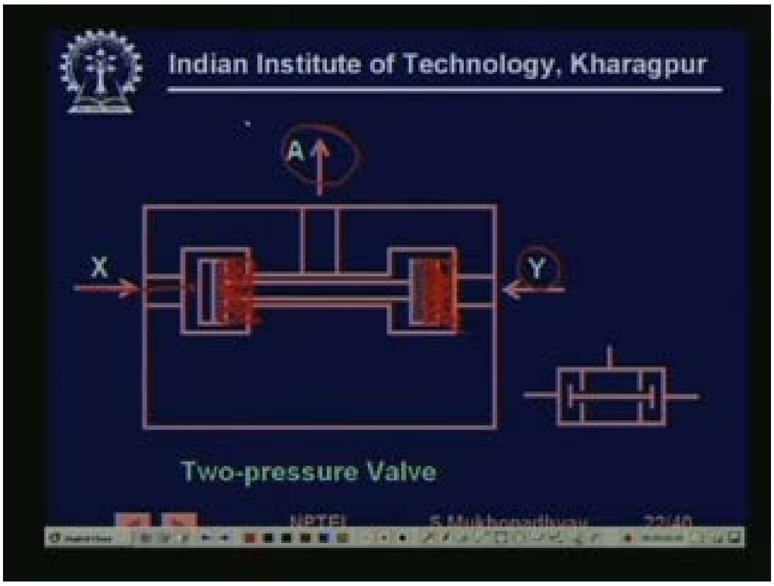

Similarly, that was realizing and logic using two direction control valves, but some but you can also have a single element in which you can have AND logic, so that this is such a construction basically schematic. So, in this case if you have either one of them is not there then, it is going to be suppose this is not there then, this pressure is going to push this shuttle and bring it in the into flush with this and this will be flush with this, so this will be the position if Y is not there.

So, then you can see that both ports are cut off similarly, if X is not there it will shift to the left and then again both will be cut off. So, this will be there this port can get the pressure only if both X and Y pressure ports have been applied that is why it is AND logic, so and there was saying that this is a you can have a safety application.

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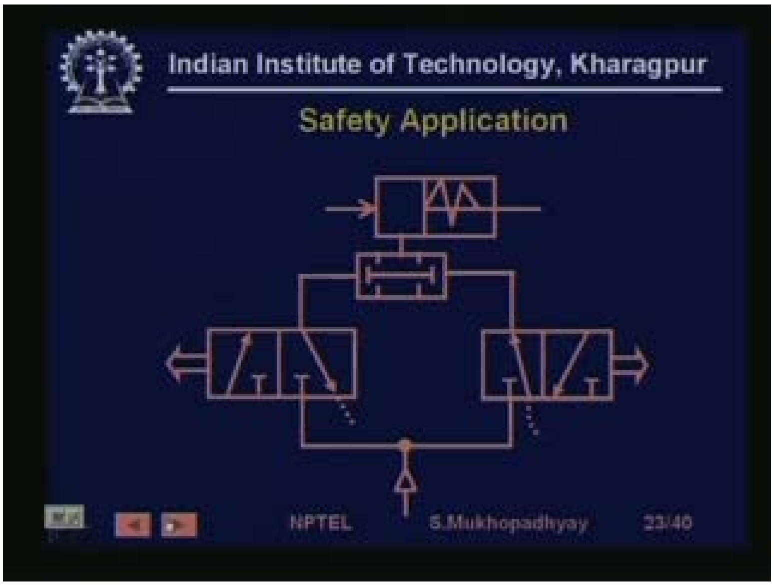

So, in this safety application you know only when both these pressures are applied with this cylinder get pressure, so therefore, it cannot move, so for example, there is some pneumatic cylinder coming down and probably pressing something stamping something. So, you need to ensure that while it is stamping by mistake your hand is not on the, your hand does not come on the ram, so you can, so if you want to move the ram which is the movement of cylinder then you have to press both these switches right.

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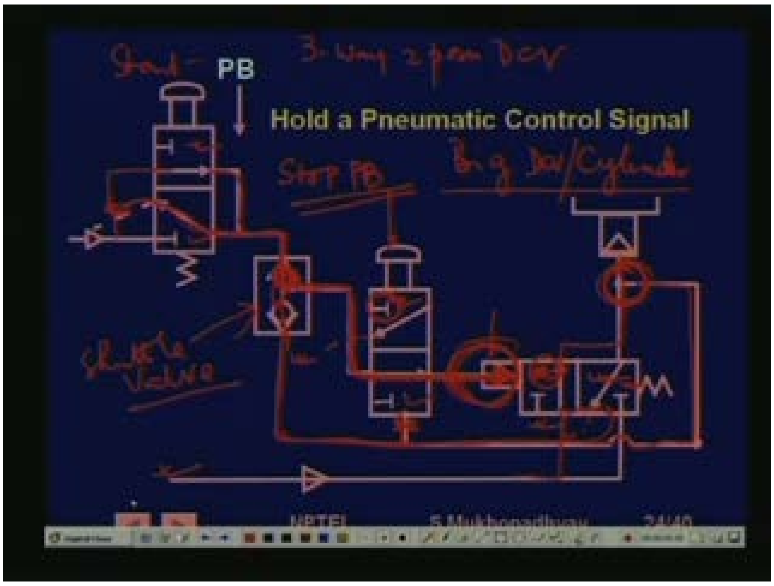

Similarly, have we show another application this is a very interesting application where we are showing something like a, we are realizing something like a pneumatic latch you know in diesel electronics we have studied about latches. So, we are talking about latches, so then what happens we actually want to move this is the cylinder or this is may be it is a big DCV.

So, we want to apply pressure here that is our final objective and the pressure comes from this line, now this is a this is you can see that this is a it is a, it is a three way two position valves DCV and this is suppose this is start P B. So, suppose I press this P B initially, initially what happens is that see this is the port if this gets pressure this will then the valve will shift and be in this position, so in this position the control pressure will go to the final load.

So, we have to apply pressure to this one to finally apply pressure to this one, now when there is in the normal position you see when this is this is not pressed and this is not pressed they are actually in this block and this block. So, this is get directly connected through this through this to this charge, so there is no pressure here, so when, so there is no pressure here when there is no pressure here this is actually here, so therefore, the this pilot is also connected to exhaust.

Now, suppose this the start P B is pressed, so then it will be in this box, so immediately this pressure will be applied through this shuttle will move this is a shuttle valve, this shuttle will be pressed and air will flowing through this and it will create pressure . The moment it will create pressure this valve will shift and come to this position it will come to this position when it comes to this position, this pressure this gets connected and therefore, this gets pressure.

Now, the interesting thing is that this push button need not be one need not keep it pressed because, once the pressure develops here that same pressure is going to be fed back and this connection is wrong fed back and it should be connected here, this connection is wrong. So, it is set back here, so now when this pressure is there build up now, if you release this pressure release this then, it will get this the this part will immediately get connected to exhaust and since there is pressure here.

So, this shuttle will be pushed and it will come to this position and then, this pressure itself will go through this and keep the valve in this position note that this is a spring loaded valve, so if the pressure will be held. So, the pneumatic pressure is going to be held even if the start push button has been released, that is the point that we are trying to make, now if you want to reset this, how do you come out of this, so you press this push button this is the stop push button.

So, what happens is that the moment you press this, this is going to be this is this valve is going to be shifted shift here, so then this is going to get exhausted, so the moment this now what happens is that this gets exhausted and this line which was coming through this gets blocked here. It is a normal three position a three way two position valve, so the pressure will go here and the and this valve will now shift to this box which means that this pressure will now drain to exhaust.

The moment this pressure tends to exhaust then, this is no longer in this position and, but it is free, so now, if you again press the start push button then again this can move here and it adjust. So, basically you see that we can, so this is a kind latch where once the start push button signal is, it is something like there auxiliary contact of a PLC logic or a digit or a latch in digital logic.

So, even if you release the start push button this the pressure at this pilot port will be held and therefore, this valve will maintain in this position and the pressure at this main load port is going to be maintained. So, this is one application which seems interesting, so it is basically such things are realized using pneumatic logic, now we come to the actuator elements or the pneumatic cylinder.

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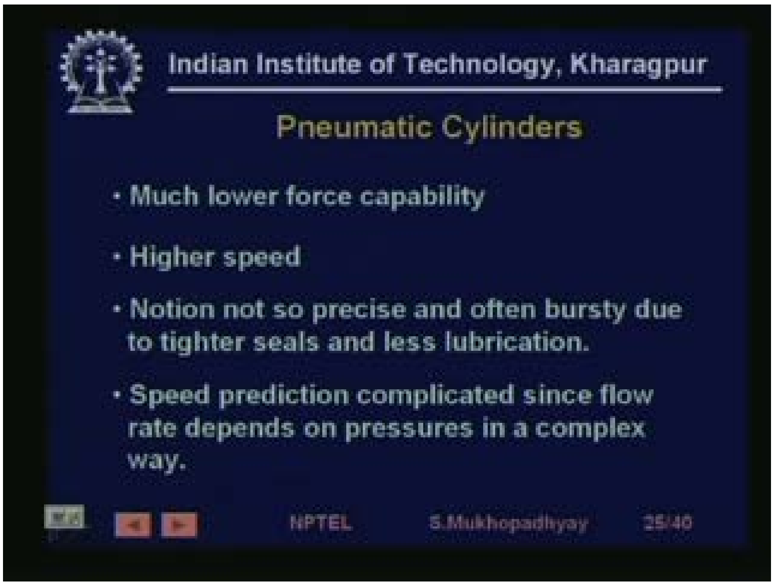

The pneumatic cylinders have lower force capability and, but they have higher they have high speeds because, they are generally driven against slower loads it also and the, this is not notion this is motion, so motion is not. So, precise because of the fact that you know there is the fiction is higher and there is seals are tighter, because to prevent air leak, so that you know the energy developed by the pump is not wasted.

So, because of the high friction there tends to be you know stick slip motion, so the motion needs to tends to be burst here precise motion control as is possible in hydraulics is not possible here. In fact, the applications are also less demanding, so generally such precise motion control demands are also not there from the application side.

Similarly, speed prediction is also complicated because they are actually complicated functions of pressure temperature etcetera because, you are talking about a gas here, so there are a lot of compressibility issues. So, the speed prediction the speed can vary a lot and therefore, again that is also another reason why precise motion control may not be possible.

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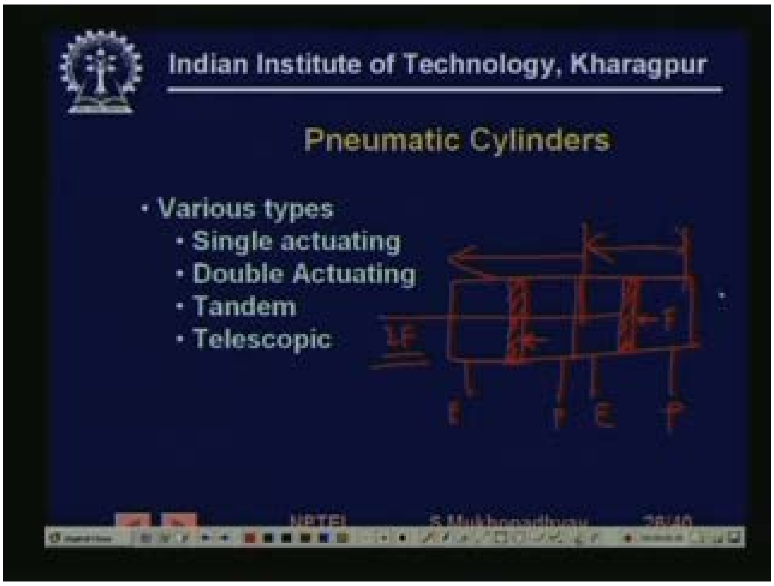

So, in such cases one uses you know pneumatic cylinders and they can be of various types, they can be single acting where may be spring loaded, so from one side you apply the pressure. So, it moves only this side retraction is may be by a spring generally it is by a spring, so that you actually do not require motion on the other side, if you have a double acting cylinder then the connecting rod can move this way, that way in both ways and you apply.

So, you apply you can apply pressure on the both two both sides of the piston, similarly sometimes it happens that you cannot if you want to have a higher force then, you cannot increase this the cylinder area either because of size requirements or because of speed requirements if you increase the cylinder area, it takes more time for the air to flow. So, sometimes you can you put basically you put two cylinders in tandem like this with the common rod.

So, you have a common rod, but you have two separate cylinders, so you applied pressure here and here and exhaust here and here, so on this surface some force will develop on this surface some force will develop F and F, so total force on this is two F. So, two cylinders effectively there are actually two cylinders are put in tandem sometimes such things are done similarly, you can have telescopic cylinders where you know separate where you can have a large stroke lengths, so there are various such things are possible we will not look at them in great detail, we will just see a picture of a pneumatic cylinder.

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So, you see this is a cylinder where this is a cylinder body you can see the piston and the rod which gets connected to the load you as we have seen that you can put a flow control valve here sometimes, you can put a quick exhaust valve here. So, this is a normal pneumatic cylinder, similarly you can have pneumatic motors.

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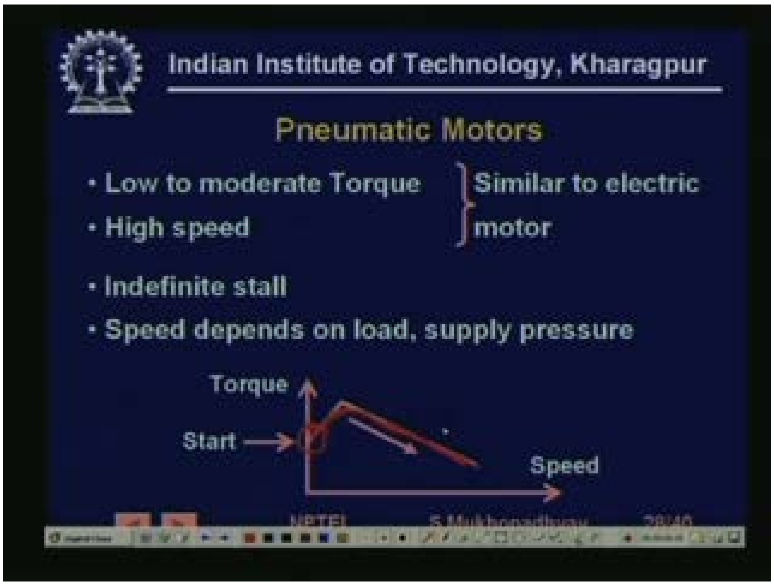

They can be again of different type positive displacement type, non positive displacement type, so you can have vane motors or you can have piston motors just like we had in hydraulics. So, but these are used generally for low to moderate torque and high speeds and somewhat like electric motors, generally one advantage is that they can be easily stalled you know electric motors cannot be stalled because of, because that will create a make a large very large current to flow through this motor and there will be heating etcetera.

And, in turns out that you can see that the typical you know typical kind of torque speed characteristics for pneumatic motors, so initially the torque is low because of you know the available torque is low because of static friction being high. And, then at some point of time this at this static friction reduces, so the torque raises and then after sometimes the so, called you know linear or viscous friction takes over and then at high speeds again a good amount of torque gets wasted in frictions, so the overall torque available characteristic falls for a given supply pressure.

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So, this is a picture for a radial piston motor, so you see that if you apply pressure to this if you apply pressure to these pistons in sequence cyclically then, this because of this mechanical arrangement there will be there will be a there will be a rotational motion. So, this is naturally this is of a positive displacement type, there is at a in every cycle of the piston movement a certain amount of air is air goes through the system. Similarly, you can have non- positive displacement type, here we have not shown a figure, but it is exactly similar to the vane motor of hydraulic systems in principle although there may be constructional differences in design.

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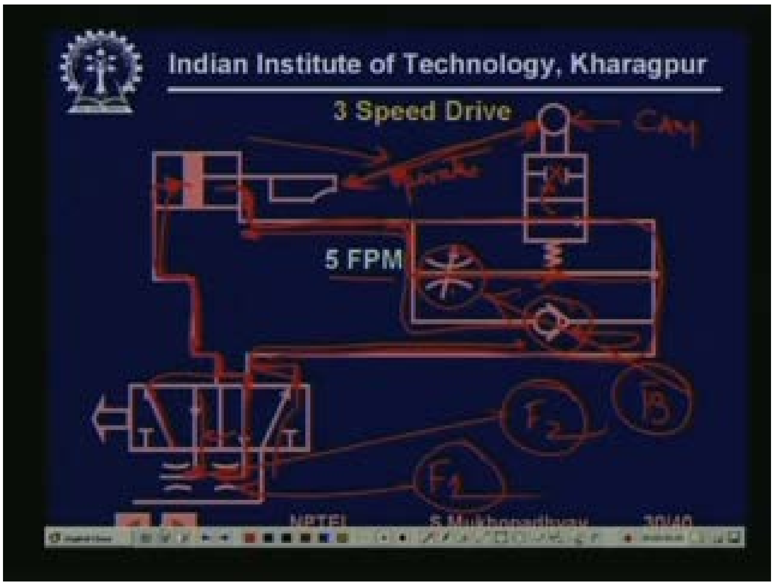

Another application is a three speed drive, so in the three speed interesting, so in the, so in the three speed drive we can quickly see what we are doing, so you see that when suppose actually this is wrongly connected, it should have been here and this one should have been here. So, when it is in this position then, air flows like this like this it goes through this passes through the check valve.

So, it does not pass through this or this, so it goes like this and flows in and then, comes out through this path and will get connected see this is connected to this path, so how much will be the speed depends on the rating of this flow control valve suppose it is F 1. On the other hand when it is trying to move this side from left to right that is the position corresponding to this box of the DCV, so now the DCV is going to get connected through this and this port will get connected here.

So, it will flow through this into the cylinder freely and then while coming out, so while coming out initially it will see this is a cam operated this is a cam actually this cam and this, these are mechanical linkage. So, these so initially this is this cam is not operated, so therefore, this is the position, so it flows through the valve and returns and flows out through this path, so the flow rate is F 2 after sometimes when this actuator moves out this is going to operate the cam.

So, operates this will operate the cam and then the cam will shift, so therefore, this valve will shift and go to this position and then will get locked at that point of time, the flow will pass through this because this is closed and this is also closed, this is a check valve. So, it will pass through this, so after a certain time the flow is going to be only 5, you know FPM means just fifth cube per minute that is that is a unit.

So, it is going to be only 5, so you see, so may be this setting is F 3, so you can realize three settings F 1 F 2 and F 3 using this circuit pretty good. So, as we have seen that pneumatic systems have main one of the main drawbacks is that their time responses are slow.

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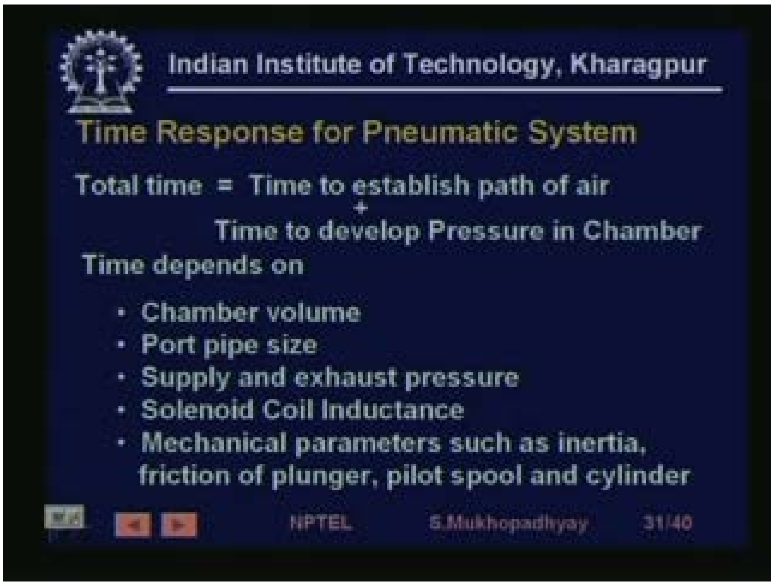

And, basically happens because time is required to establish path of the air, the air must flow into the final chamber and then time to develop pressure in the chamber, so from the air source to the chamber air must air path must be established and then, pressure in the chamber must develop before something will move. So, this times depend on lot of factors like chamber volume, port pipe, size, supply exhaust pressures, what is called the ratio of these upstream and the downstream pressures. Similarly, there are also you know these are times required for solenoid coil inductance, inertia etcetera, they are generally smaller compared to you know the pneumatic part, but these all these factors will affect the time response of a pneumatic system.

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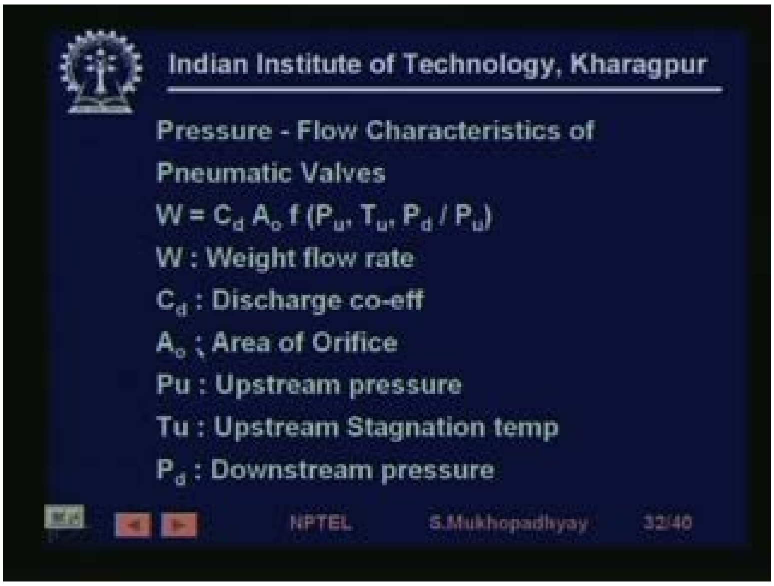

If you see the pressure for example, if you see the pressure flow characteristics of pneumatic valves, it turns out that it depends on a number of factors, so for example, it will depend on this is the weight flow rate it will depend on discharge coefficient and area that is standard for any flow, but because it is compressible flow it is going to also depend on the upstream and the downstream pressures which particularly the upstream downstream pressure ratios. It will also depend on the temperature, so these are the special influencing factors for pneumatics you know.

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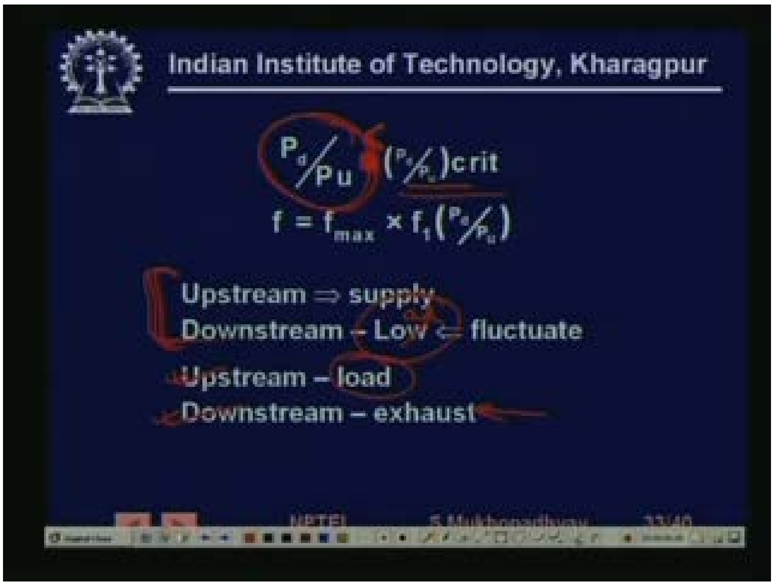

So, it turns out that the in fact, in this depends depending on the valve configuration these upstream downstream pressures keep varying, for example in a given situation it may be, so that the that the upstream is actually connected to supply while the downstream is actually connected to load this is load. So, see if the load pressure varies this ratio is going to vary it may also happen that the upstream is connected to the load and the downstream is connected to exhaust, in this case this is constant, but then this may vary.

So, again the P d by P u relationship will vary, so in such cases what is said is that if you want to have a you know a constant flow characteristic then, you should maintain this P d by P u ratio beyond a critical value. Actually, it should be less than a critical value not greater than this is this greater than is wrong, so it turns out that.

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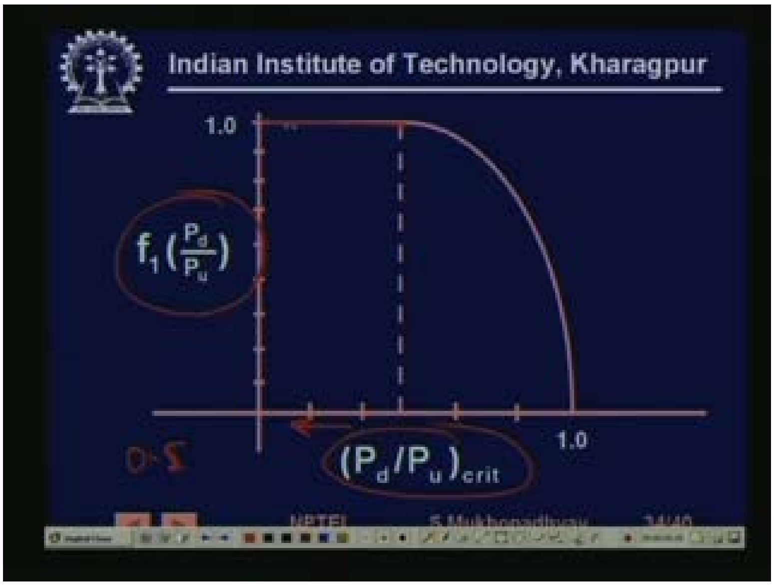

So, for example you see that depending of the P d by P u if the P d by P u, this function for a given this function causes fluctuations in the flow rate depending on P d by P u, so but if you keep the P d by P u ratio below a certain factor like you know some something like 0.5 then, what happens is that this function becomes constant and then, the flow rate will only depend on you know things like one pressure discharge coefficient area etcetera, that is the flow fluctuations will be less, so sometimes this P d by P u ratio needs to be maintained.

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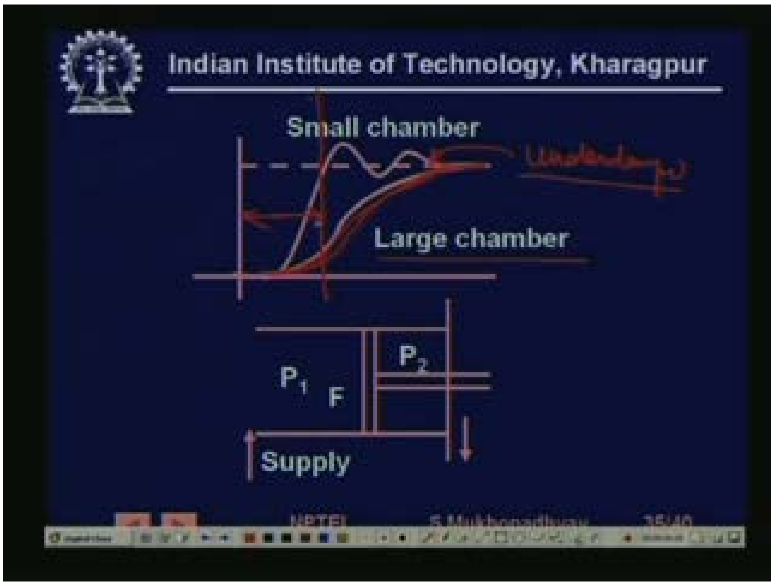

Similarly, if you see time response then what happens is that see the whole air mass moves into the cylinder chamber and depending on the capacity of the cylinder chamber and the flow rate and the air mass rate, you can have different kinds of you know if you measure the pressure after the valve is suddenly opened. Then, if you measure the pressure variation with time you can get, you can get various kinds of responses for example, for small chambers it is going to be an under damps response.

So, the pressure will build up then, it will overshoot and gradually settle to the real pressure while if you have large chamber sometimes this can be an, this can be an over damp response, but in any case a certain amount of time is going to for example, let us say it is, so this much of time will be required before the actuation will take place.

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Now, we come to the last topic which is the comparison of hydraulic and hydraulic electric and pneumatic systems, so it turns out that for low power low complexity high volume applications of course, a generally pneumatic system sometimes tend to give an advantage that is why it is used in you know things like in use in pneumatic tools in large you know assembly shops like in an automotive factory.

So, there you see theses individual tools do not require low power there is no complexity, general jobs are like you know screw driving clamping etcetera, but there are large number of operator stations. So, what happens is that you can have a very low cost implementation of controls because, of the fact that the major equipment that is the compressor, regulator, etcetera, they can be shared over these numbers of applications.

So, you have you must have a high volume application and the requirements are performance requirements are very ordinary. Some of the cost advantage comes because there is there is as we have said that there is no return line. So, main I mean that say it is a lot of cost half the tubing cost is gone just like hydraulics and pneumatic there is no stalling problem when in electric, there is in pneumatic there is no fire hazard, in hydraulic there is because the oil itself is prone to fire while in the case of electric if the environment is if the environment is hazardous then, there can be fire, but in pneumatic there is no fire hazard.

Generally, in electric and pneumatic one has reduced temperature sensitivity because than hydraulics because, in hydraulic there is the oil velocity can change and give you know performance variations in an electric, there is no question of viscosity and in pneumatic the air viscosity change is not that predominant.

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However, hydraulic is mainly preferred when you have a very precision motions and very high forces are required that is not the case of pneumatic, in pneumatic you know lower is used for lower force and pressure ratings for a given size, response is slow for pneumatic definitely slower than hydraulics comparable to electric. In pneumatic there is a problem of leak and leak is not, so easy to determined, but it will you know reduce the efficiency of the system this in turn will cause, if you want to prevent leak you have to that will increase maintenance cost.

It will also make the seals tighter and will increase friction which in turn will cause further for inefficiency, so leak is a big problem for pneumatic systems, interface cost may be prohibitive you know sometimes you may have to interface with the electronics and other elements. So, therefore for very sophisticated controls sometimes you know electric actuators may be preferred because they can be driven in using in all electric system. Lubrication is additionally required while in hydraulic it comes along with the oil, so lubrication is required and obviously, motion control is less precise in pneumatics than either hydraulics or electric.

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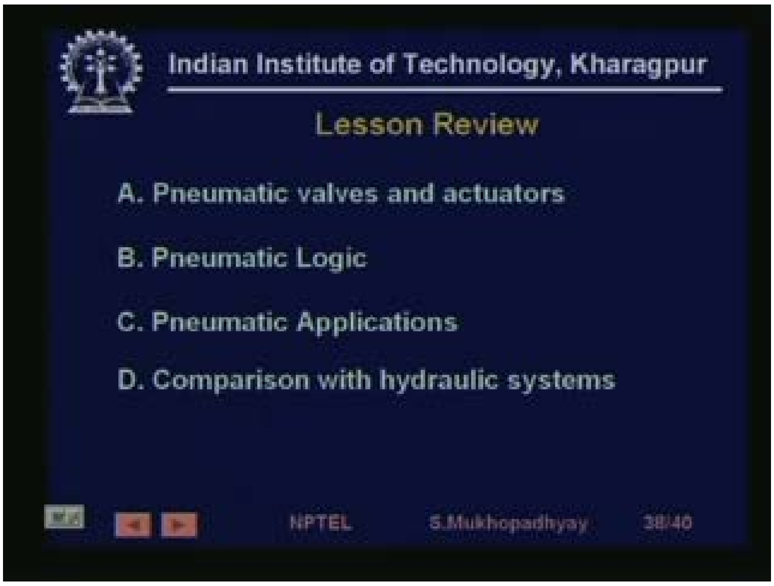

So, we come to the end of the lesson we have seen pneumatic valves and actuators we have seen some elements which are used in pneumatic logic, we have seen some pneumatic typical pneumatic applications and we have seen comparison with hydraulic and in some case electric systems.

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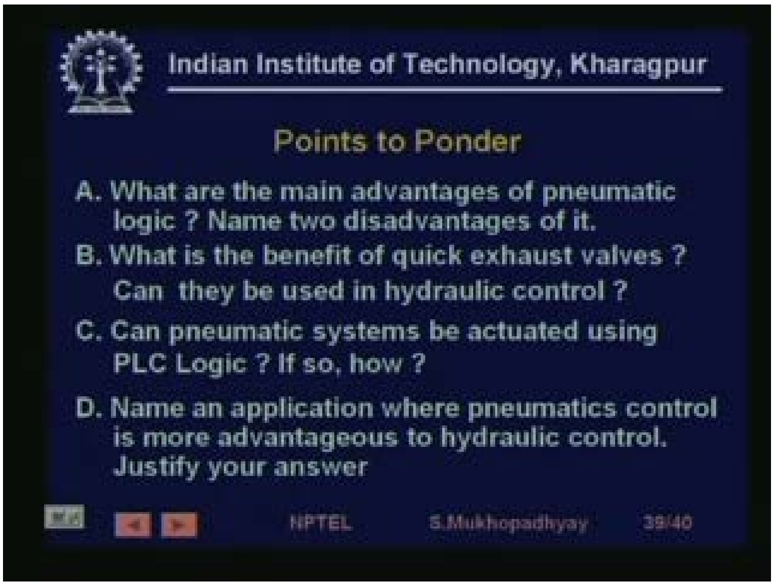

So, points to ponder there are some question what are the main advantage of pneumatic logic, so we have already stated that and what are the disadvantages obviously, disadvantages in terms of speed and complexity. What is the benefit of quick exhaust valves we have and can they be used in hydraulic control of course, cannot they of course they cannot be can pneumatic system be actuated using PLC logic if.

So, how actually they there are in many cases actuated using electric logic, actually this pilot actuation is typically as we have said that you know we have seen how a microprocessor can actually control a pneumatic system. So, PLC is actually nothing, but a microprocessor as we know, so it can surely be used to control, but we might need if you need if you are an air pilot you might need I to p convert that is all. Name an application where pneumatic control is more advantageous to hydraulic control, so I have given an application which is assembly tooling you can think of others, so that is all for today thank you very much.

Industrial Automation and Control

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Lecture - 31

Energy Savings with Variable Speed Drives

Welcome to lesson 30 industrial automation and control, in this lesson which is entitled Energy Savings with Variable Speed Drives. We are going to explain and demonstrate that for a kind of application, which is very predominant in the industry, very common how what are that, firstly we are going to see what are the various kinds of flow control applications.

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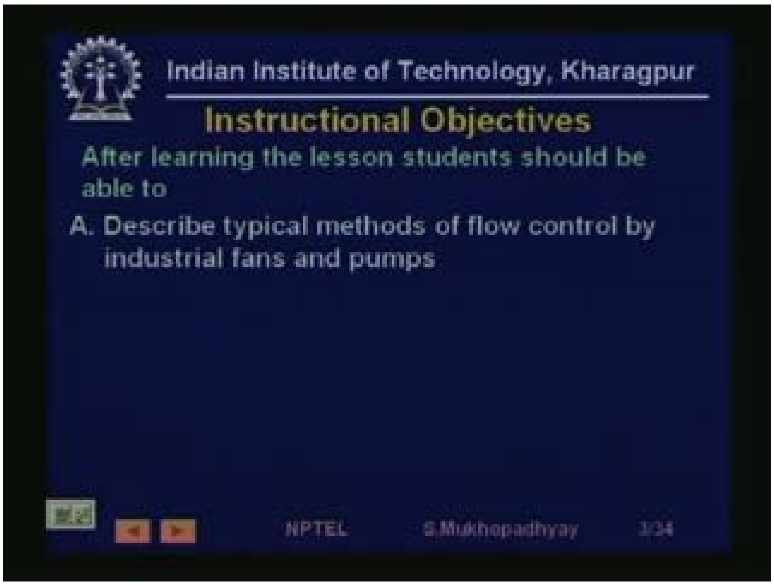

That is the application that we are trying to consider, so the flow can be of gas or liquid, so accordingly we have either what are known as fans or blowers or we have pumps. Fans, blowers and pumps constitute an enormous a very significant fraction of the loads which are driven by motors and motors which consume a large amount of electrical power in the industry, so they are very common and common applications and very significant from the energy point of view, so we are going to see that in such applications, how flow is to be controlled.