INDIAN INSTITUTE OF TECHNOLOGY
KHARAGPUR

NPTEL
ONLINE CERTIFICATION COURSE

On Industrial Automation and
Control

By Prof. S. Mukhopadhyay
Department of Electrical Engineering
IIT Kharagpur

Topic Lecture – 42
Pneumatic Systems – II

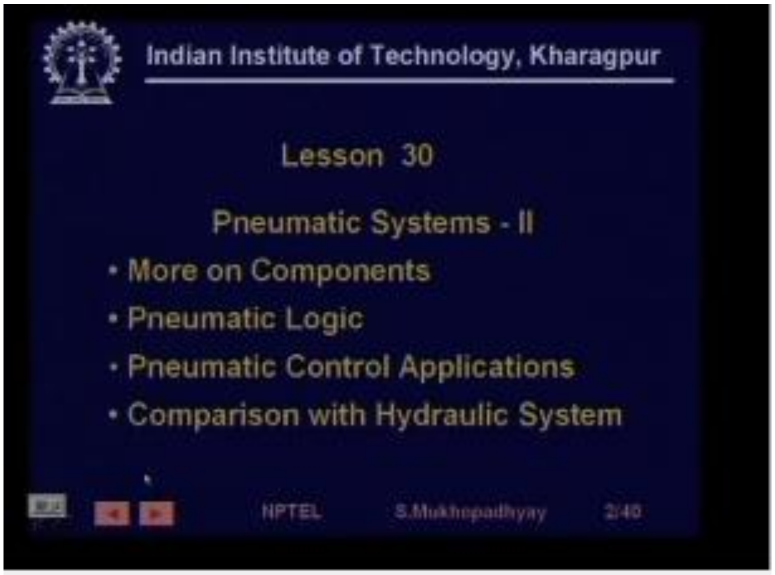
Welcome to lesson 30 of industrial automation control.

(Refer Slide Time: 00:28)

In this lesson we are going to look at, continue to look at pneumatic systems.

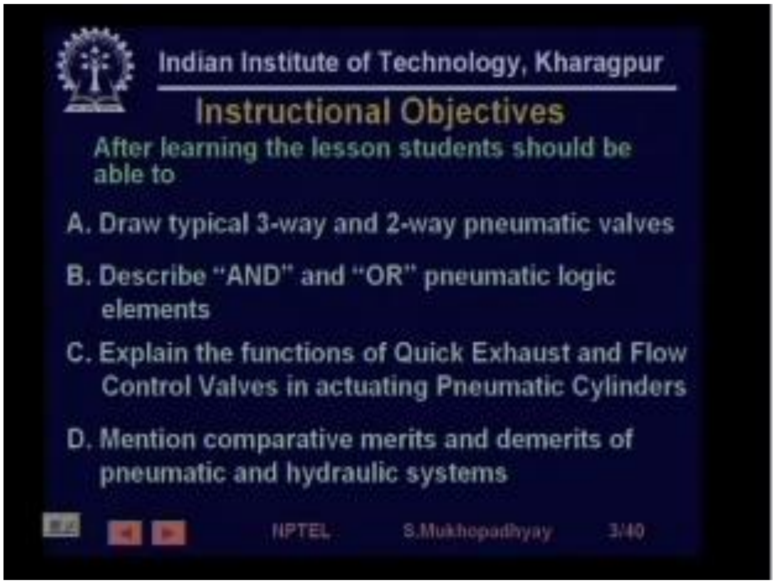
(Refer Slide Time: 00:36)

(Refer Slide Time: 00:41)



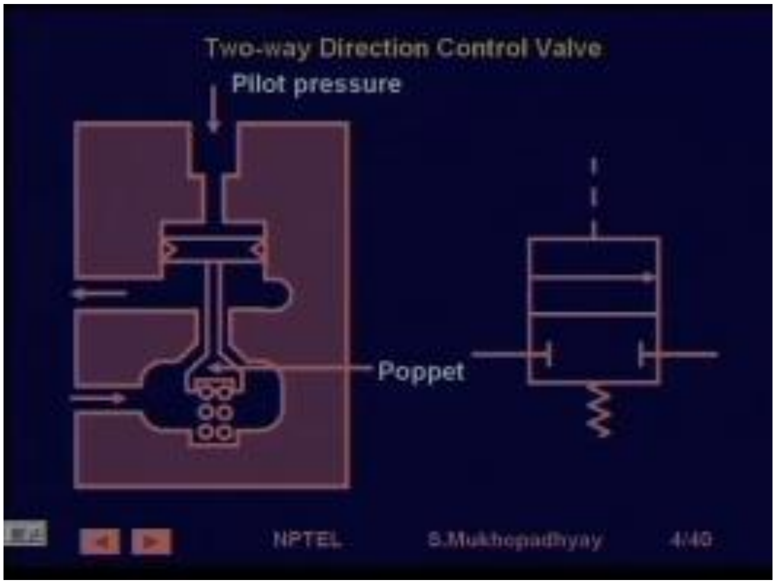
So in less than 30 we will look at more components pneumatic components we look at a kind of logic called pneumatic logic and we will see some control applications and finally we will see a comparison with hydraulic systems.

(Refer Slide Time: 01:03)



So and the instructional objectives are firstly to you know be able to draw some typical valve constructions described and are 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.

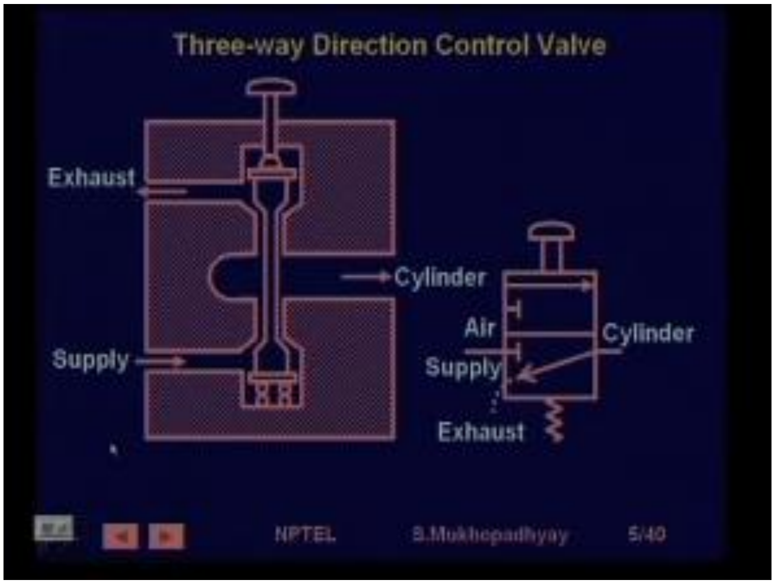
(Refer Slide Time: 01:03)



So we have already seen Direction control valves we have also seen them during hydraulics so there is nothing much new here so the valve is actually shown here there are so you can see the inlet and the outlet ports so you can see that this is the way when the pilot pressure is there this is as you can see that there is aspiring here let me choose a proper pen here so this is the pilot pressure.

So when the pilot pressure is not there is a spring right oh I see this is reckless eraser you have to choose a pen first and then choose this color so yeah so yeah so it is spring loaded so when there is no pilot pressure that this 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 it goes down so there is flow simple two-way valve.

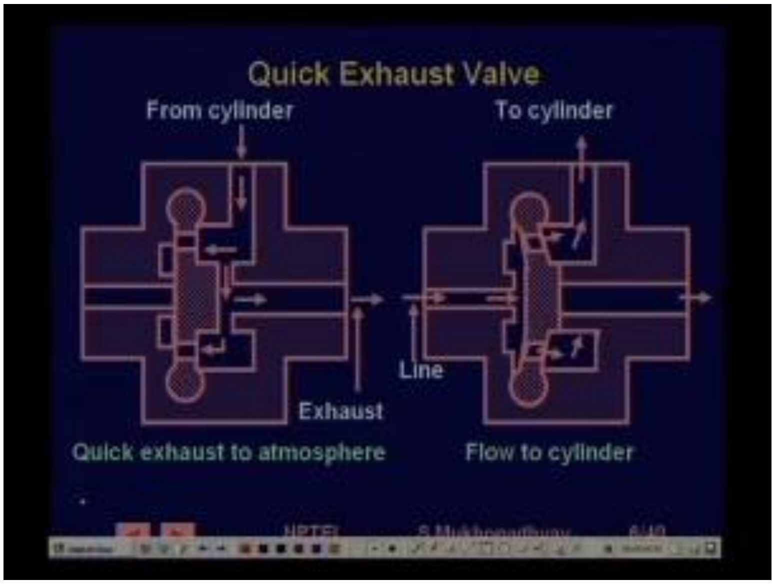
(Refer Slide Time: 03:03)



Then we come to a three-way valve basically this is at here 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 whether 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 widget will get connected to exhaust so that is this rectangle these are standard you have also seen them during the hydraulics codes so we will go we are going little fast on this.

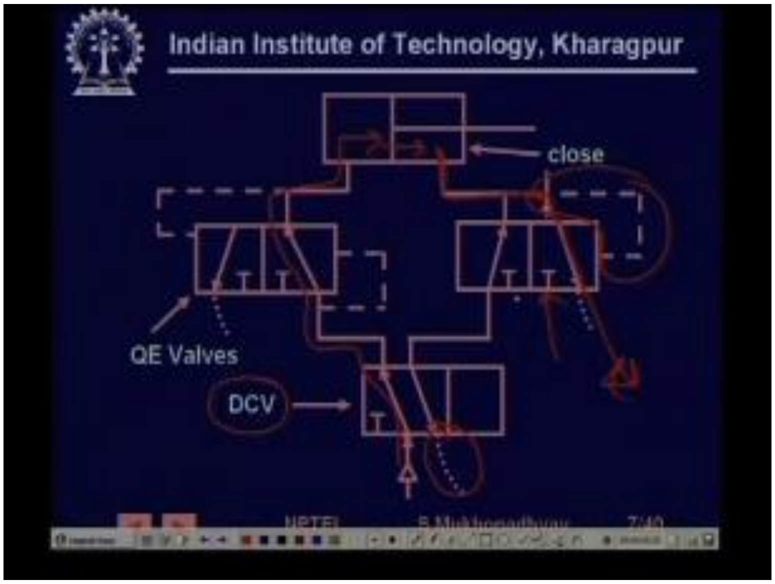
(Refer Slide Time: 04:11)



So then we have this is a special kind of valve which is called the quick exhaust valve 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 heir to the cubing and also the time response of the system will improve so therefore this 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 a quick exhaust valve.

So you can see a construction here where so when the when you are driving pressure into the cylinders the 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 DC v this is from DCV or direction control valve on the other hand wind is coming from the cylinder head is coming back from the cylinder then it does not need to go to the d and it is released see this is this will press it and therefore this this will close and the air will actually flow out into the atmosphere locally at the cylinder so it is quickly exhausted right.

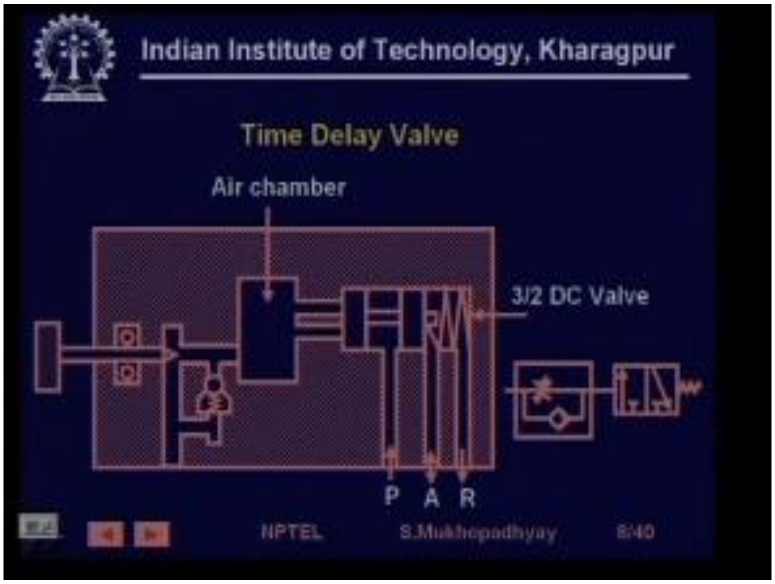
(Refer Slide Time: 05:54)



So that was the idea so you can see this that so this is an actuator which is being driven so what happens is that the air flows this is the DCV so the earth the air flows into this goes through this and rise the actuator so the actually moves when it moves it actually expels the air so you know it actually expels the year so because this is a you 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 exhaust 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 the quick exhaust valve.

(Refer Slide Time: 06:57)



You can have similarly you know you sometimes you want that for in a synchronization purposes you would like that after you put an actuator there are three valves will actually move one after the others so if you have to realize this concept of one after the other then you have to create gradually increasing time delays after which this valve should be executed will be shifted.

So that is done this is a you know this is a 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 there on its path then sometime 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.

(Refer Slide Time: 08:02)

So you see that yeah 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 the spool and that will shift the valve so this is the this is a basic mechanism by which a time delay is created.

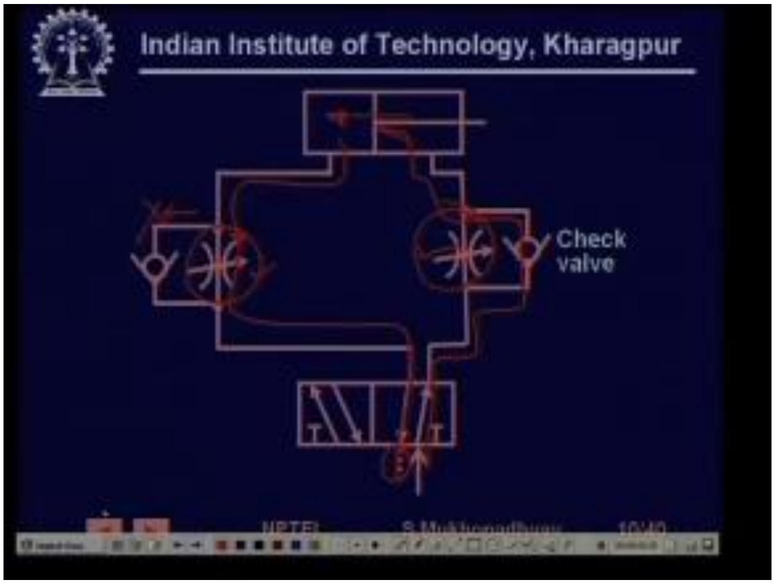
(Refer Slide Time: 08:36)

Similarly, you have you have flow control valves so in flow control valves are mainly used to have a controlled speed of the of the actuator especially when it is driving 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 maybe at one speed towards the end of the journey it may be a slower speed basically because of the fact that the load typically tends to have an inertia and if you push the load too fast then then a lot of kinetic energy can accumulate in the load and it can go and heat 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 you can you can put this flow control valve either in the path of the incoming air or in the path of the outgoing expelling the layer which is being expelled from the other half of the cylinder right now it turns out that generally there is at here is a benefit of you know these two these two cases are called meter in flow control and meter out flow control so meter in is when you put the flow control valve on the incoming air flow and meter out is when you put it at the outgoing air flow.

So generally people sometimes prefer putting it in the outgoing flow because that creates aback pressure which you know kind of stabilizes the motion of the valve you know motion of the cylinder

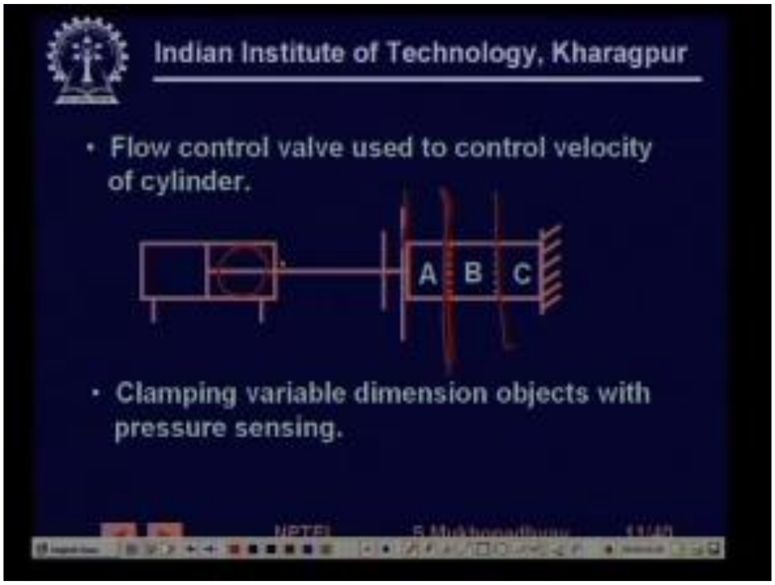
(Refer Slide Time: 10:22)



So the moment the cylinder tends to move faster immediately the flow control valve developed some pressure which tends to decelerate the cylinder this so it says 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 also discussed in the in the case of hydraulics that while the fluids flowing it is flowing through this spot so there is a check valve which is puts it bypasses flow control valve so it will go to 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 XP expelled so this flow control valve is used to used so that the when the cylinder is moving this way there is a certain there is certain speed that maximum speed that it can it will generally achieve you can you can have different flow control valves settings here in this two valve so that you on two sides you can have different speeds of the cylinder.

(Refer Slide Time: 11:47)



So okay so this is you know the same concept you know sometimes what happens is that you can start oops 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 ascertain amount of clamping force so certain fix decided amount of clamping force so you can see that depending on the object dimensions the stroke required after which the required clamping force should be obtained depends on the dimension of the object.

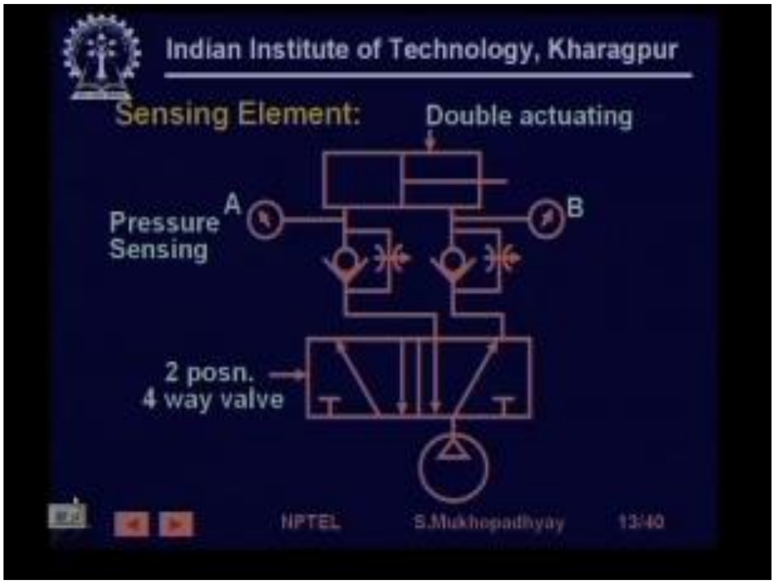
So if the object is A then at this point only that then at this point only the clamping force will be realized if it is of the of the size B then at this point the clamping force will be realized if it has C so how much the cylinder will move and where it will stop has to be determined based on the pressure developed in the chamber so the pressure will develop the I mean the backpressure will be developed in the chamber when this cannot move again so you see that that there will be this will this will actually then this will actually resist the movement so therefore a certain pressure difference will arise right.

So normally this pressure difference will not arise the cylinder will freed will be free to move so yeah so actually we can have this 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 the same thing 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.

(Refer Slide Time: 14:35)

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

(Refer Slide Time: 15:13)

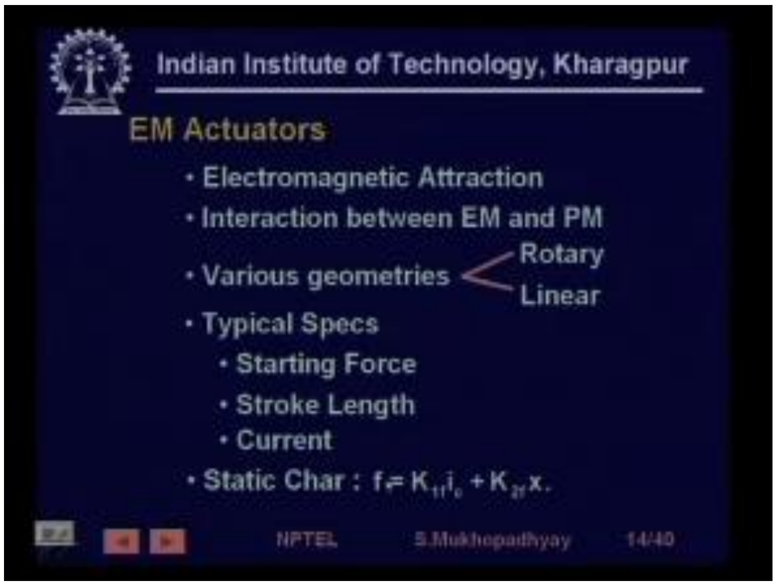


So yeah so exactly that is shown so you see that you are sensing to this pressure A and pressure B and then you have to use an appropriate logic to actually drive this valve so that a certain amount of pressure is force is developed. Now so this is about valves now the valves this valves are can be actuated as we have seen that we can have various kinds of logic for actuated valves and not only that we have after so 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 they can on the other side then when the valve should move it should provide the necessary power for the main valve to shift so there are two things which are necessary so the make an electromechanical actuators can actually so this providing power this can be done in various ways for example it can be a directly solenoid driven valve that there were some current is driven into a coil and it pulls this move on.

On the other hand as we have seen in the case of hydraulics also that it can be directly pilot pressure driven generally 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 and there will be some sort of an electric two pneumatic converter that is also possible so there are various ways general electric two pneumatic controller what other use 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 of safety or for the purpose of higher power etcetera.

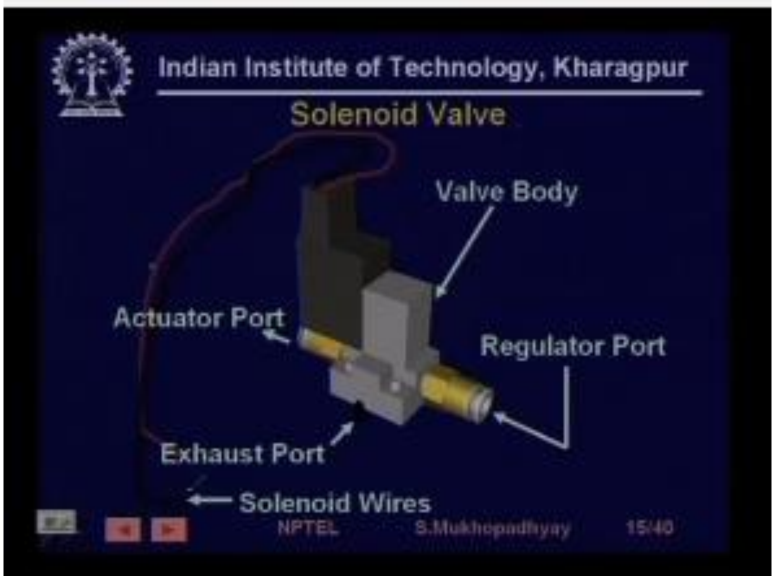
(Refer Slide Time: 17:44)



So in so we often very often we have electro mechanical actuators so electromagnetic actuator so basically it works by electromagnetic attraction between a prop between a permanent magnet an electromagnet so even if you when you drive or sometimes between an electromagnet and an iron spool both are possible so there could be various Gmail geometries the actuator can maybe wrote earlier linear and typically the specifications involved starting force stroke length by how much it can move and the current requirements.

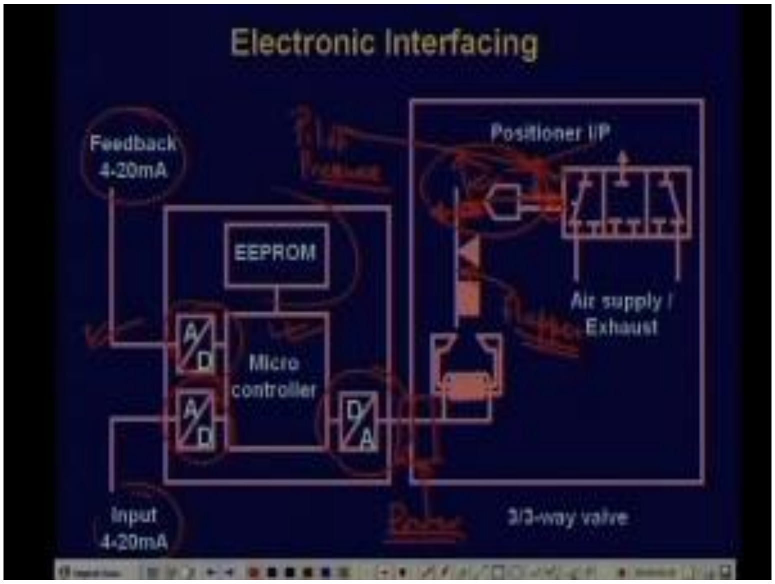
So the typically the force varies depending on depending on the current as well as the displacement because you know basically it's by flux so the flux actually depends the flux actually depends on the current because the current decides the magneto motive force and it also depends on the reluctance of the of the flux path which depends on the gap which keeps changing during motions so the force characteristics depend on current as well as the position.

(Refer Slide Time: 18:52)



For example, this is this this is you know a typical solidities valve so you directly can drive current into a into a solenoid valve which will pull the spool.

(Refer Slide Time: 19:07)



Similarly you can have electronic interfacing so this is a this is a slightly more elaborate configuration so you have electric feedback of signals maybe either displacement so you can have position sensors or you can have pressure sensing as you have as we have discussed so this this electric feedbacks come from sensors using some transmission technology in this case we have just mentioned 4 to 20 mille ampere it may be something else also and then they are taken in acquired this signals are acquired in a in a digital controller so the so finally the DJ controller computes the necessary force that must be applied for control to the valve.

So that is output through a D2A converter these are A2D converters because these signals are analog so they have to be converted to buy A2D this is the we have just for example we have shown sort of a shown just to indicate that it is also possible to use a detail well let us say a microprocessor to you know all these so this is the microprocessor CPU and this is the memory so the microprocessor finally gives a gives a digital command which is converted to an analog command in general actually there will be up there will be a power amplifier because a microprocessor generally cannot drive it cannot drive a coil.

So typically one can use one cause relays or one can use power amplifiers so this is the so finally the model a current is driven once the current is driven using this is using this attraction principle this is you know what is called a this is this is the I2P converter and often referred to as a flapper nozzle system so what happens is that if the if this current flows then then this will touch start to move this is the flapper this is 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 well if this nozzles very far away then this pilot pressure is going to drop out and go through the go to the atmosphere right here at the nozzle.

So therefore this position this pressure which will there which will develop here is going to be somewhere here you have excess pressure here you have pilot pressure so the pressure here is you know somewhere in between now as you bring this closer and closer you are 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 have been 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 then the pressure would have fallen close to the exhaust pressure so as it more 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 valve can shift so you know such interfaces are possible for activating the valves.