INDIAN INSTITUTE OF TECHNOLOGY
KHARAGPUR

NPTEL
ONLINE CERTIFICATION COURSE

On Industrial Automation and Control

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

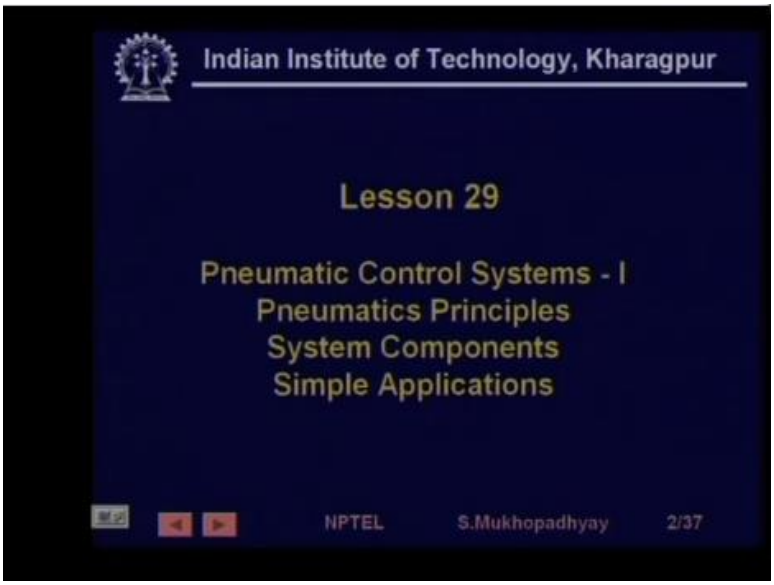
Topic Lecture – 40
Pneumatic Control Systems - I

Welcome to lesson 29 of industrial automation control.

(Refer Slide Time: 00:25)

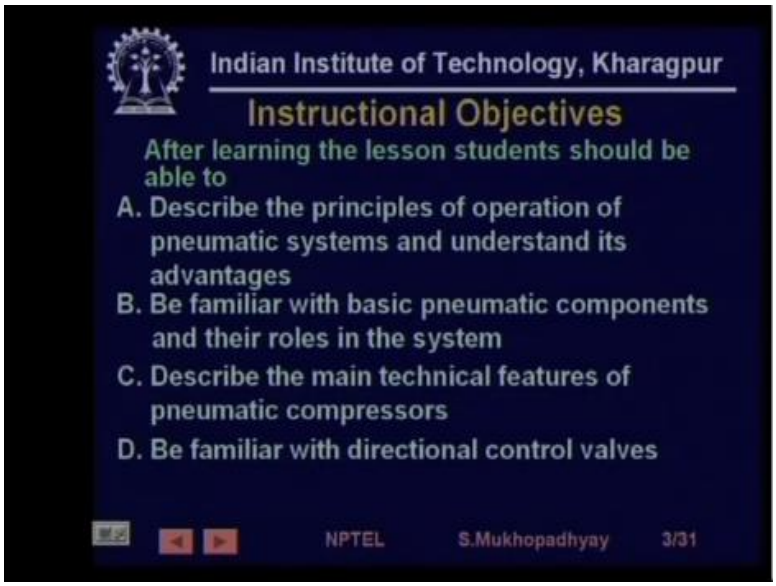
Today.

(Refer Slide Time: 00:26)



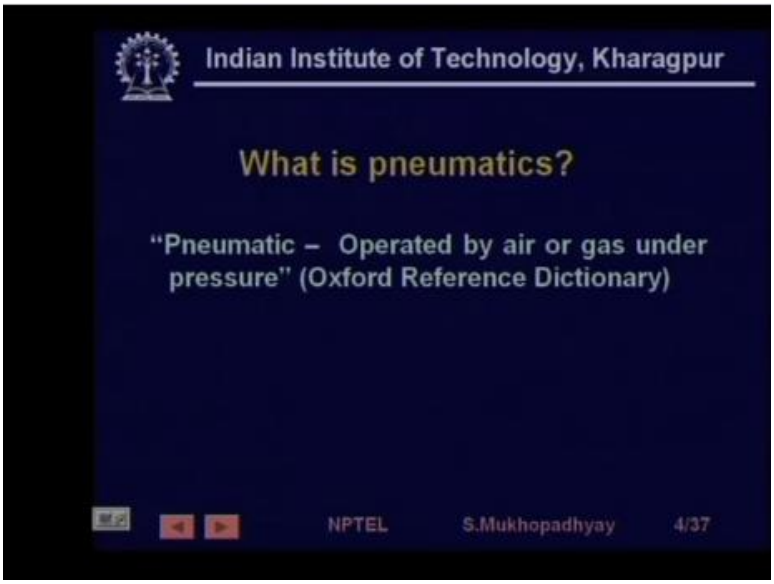
We will discuss start discussing pneumatic control systems and we will discuss the pneumatic principles the main pneumatic system components and some simple applications.

(Refer Slide Time: 00:42)



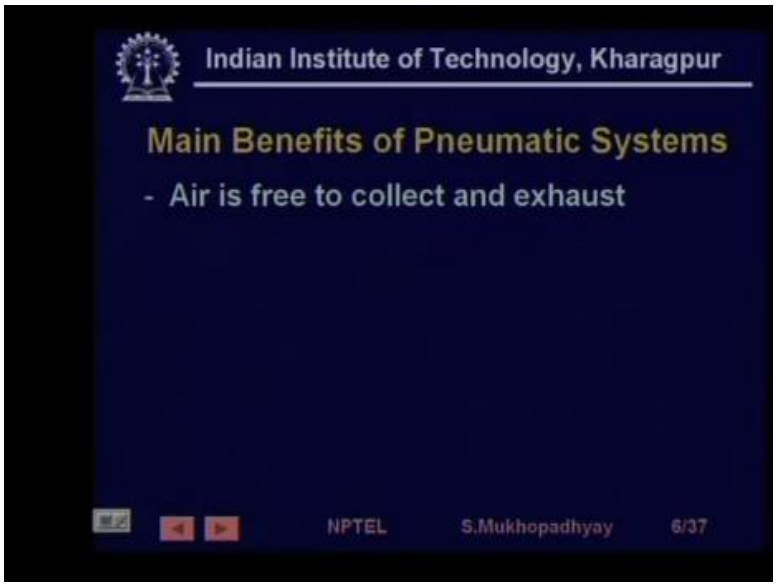
So coming on to the instructional objectives after learning the lesson the students should be able to describe the principles of operation of pneumatic systems and understand its advantages be familiar with basic pneumatic components and what roles they play in the overall system described the main technical features of pneumatic compressors and its accessories of course and be familiar with Direction control valves so that will give us the first a basic idea of a pneumatic control system.

(Refer Slide Time: 01:25)



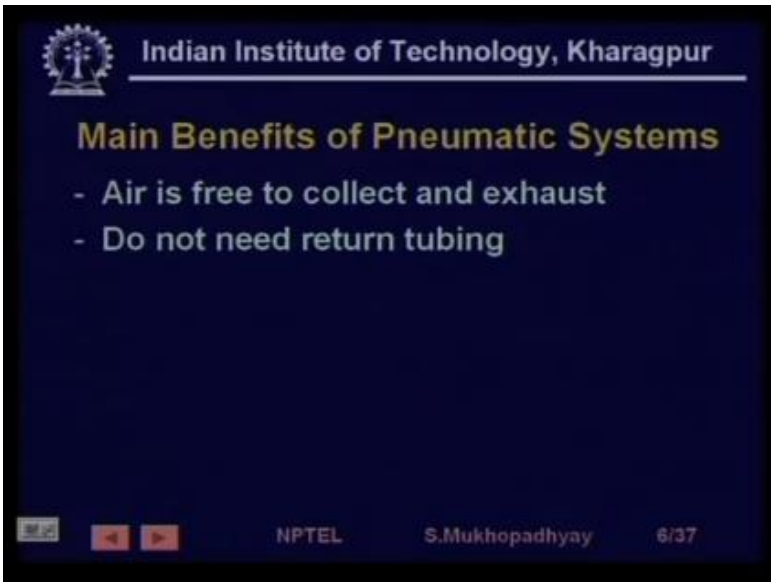
So what is pneumatics as I often do I checked up the Oxford reference dictionary and pneumatics means operated by air or gas under pressure so since we have already had some lectures on lessons on hydraulic controls in hydraulics controls they are both hydraulics and pneumatics of fluidic control systems where fluid under pressure is used to do work in hydraulics this fluid is oil and in pneumatics it is air it is compressed air so there are certain advantages and disadvantages as well of using compressed air.

(Refer Slide Time: 02:13)



So the main benefits of pneumatic systems is that air is free to collect and exhaust so you know it is simply connected you do not need to buy and therefore it is cheap and it can be exhausted into the atmosphere.

(Refer Slide Time: 02:31)



So you do not so you do not need return tubing so you see that for hydraulics you need one pipe or tube for carrying the fluid to the place of work namely the load and you need another pipe or tube to bring it back now this is not necessary for pneumatic since you are using when you are using air which is mostly the case because you can directly exhaust it to the atmosphere right at that at the place of work and therefore you save half the queuing costs so that is quite a lot there is another reason why pneumatics is generally turns out to be cheaper than you know electric actuator or hydraulic actuation.

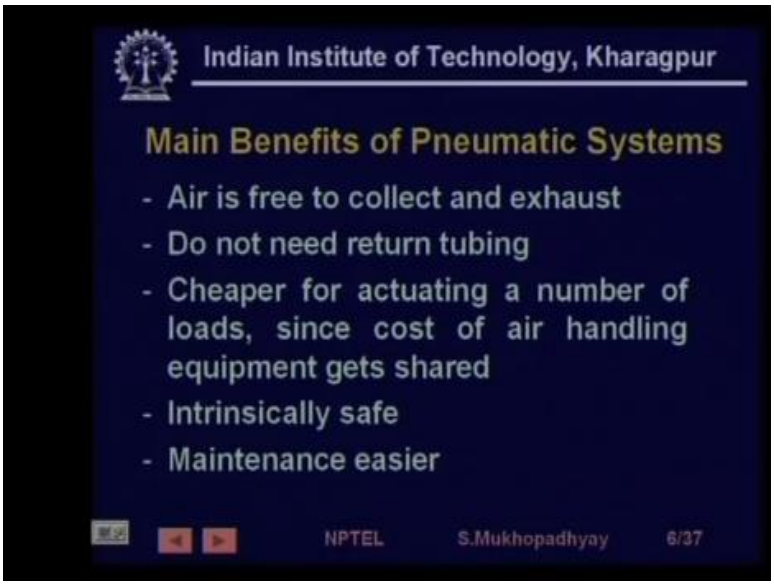
One of the reasons is that in pneumatics the cost of the comp the air handling equipment that is the compressor basically the compressor actually is shared among the application so suppose in a factory if you go to a let us say a factory like let say Telco if you go to the assembly plant of Telco then you will find that there are numerous places where pieces of you know let us say pieces of the engine are getting assembled so in each one of these places there you will find that there are various kinds of tools are to be used.

You know so like you know wrenches screwdrivers now to ensure a uniform degree of performance with these tools and also not to exhaust the exhaust the operator people use

pneumatic tools so you will find that every operator station actually has some compressed air supply and that compressed air supply so you so you are using compressed air to do work at numerous places but you possibly need only one big compressor and then run a line of compressed air through a different places so this so the cost of the compressor actually gives divided and this leads to you know cheaper a system compared to let us say electric where you would have needed to maybe put a motor a teach of these places right.

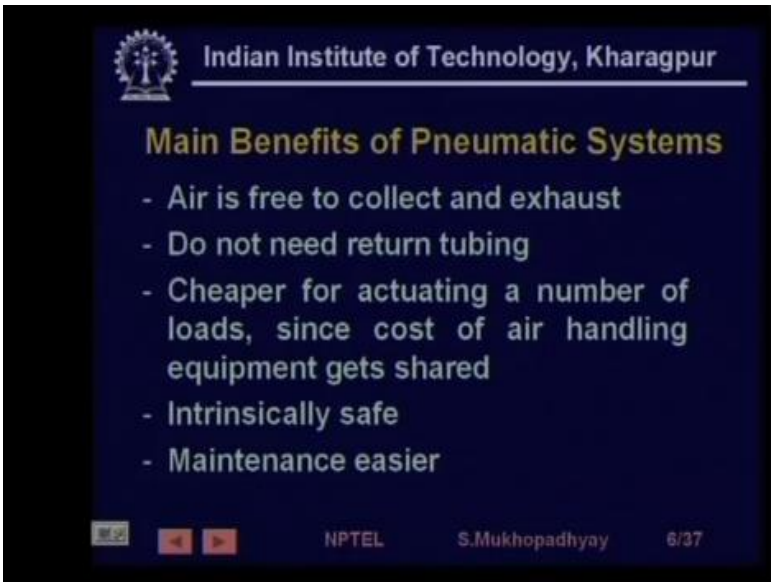
So therefore in such cases where the there are numerous applications spread over some area generally called the cost of pneumatic systems become cheaper now there are there is another important advantage of pneumatic systems is that while electric systems are you know prone to fire because of electric sparks and hydraulic oil is inflammable being from you know petroleum derivatives pneumatic systems are intrinsically safe and therefore often preferred in you know places like.

(Refer Slide Time: 05:31)



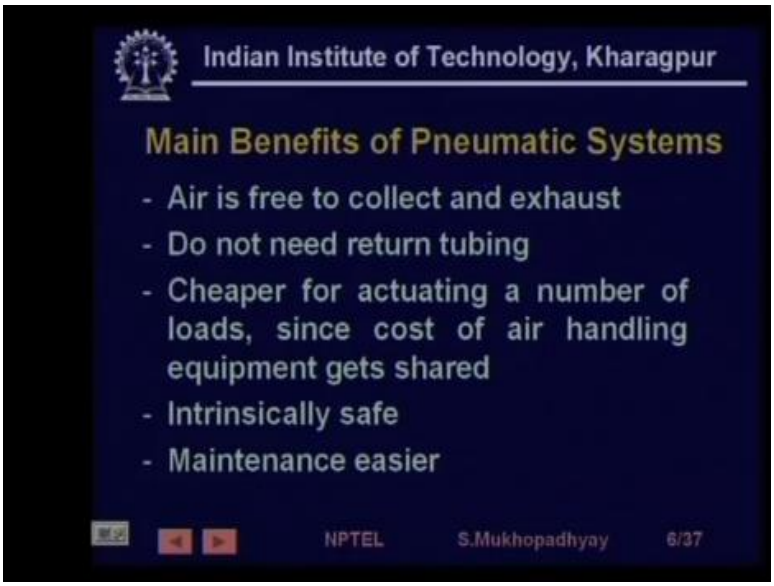
You know explosive environmental let us say a natural gas plant would prefer we would have a lot of application for pneumatic control systems to be free from the hazard of explosion similarly maintenance.

(Refer Slide Time: 05:48)



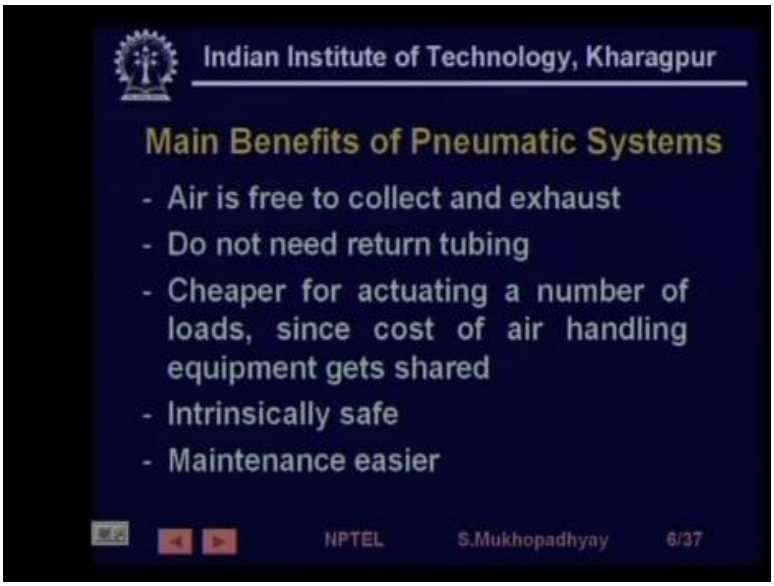
Is easier because of the fact that I mean in hydraulic systems if there is a leak in oil which is a major maintenance headache then first of all you are going to lose oil so that expensive secondly is going to you know create general environmental problem thirdly it is also inflammable but in pneumatics if you if there are you know small leaks here and there which are which are kind of inevitable then apart from the fact that a leak all is always going to cause a loss of pressure and therefore some loss of energy apart from that the consequences of that leak are minimal and therefore maintenance need not be so stringent so maintenance is generally a little easier.

(Refer Slide Time: 06:37)



On the other hand there are disadvantages of pneumatic systems as well for example firstly these systems are slower in performance compared to hydraulics their power handling ratings are also generally slower and compared to a min terms sophisticated controls they are inferior to electric controls.

(Refer Slide Time: 07:00)



So having said that let us so because of these there are quite a few users of compressed air in the industry.

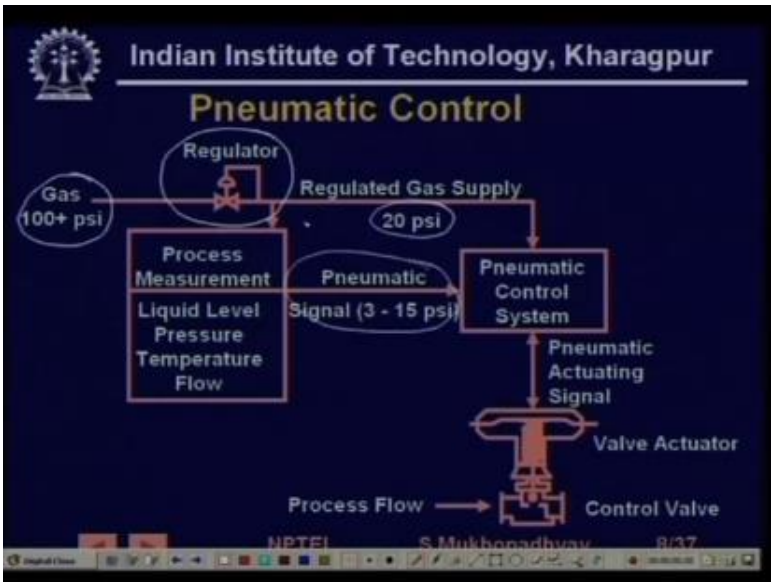
(Refer Slide Time: 07:06)

And some of them are you know pneumatic control valves so basically pneumatically actuated control valves that is what I mean so you know have big valves flow control valves which are operated pneumatically using air then there are.

(Refer Slide Time: 07:24)

Air cylinders for actuation then sometimes you need starting here for diesel and gas turbine engines diesel generators and gas turbine engines for that also you need compressed air you need tools so various types of tools for screw driving for drilling for paint spray and for clamping so for such operations people often use compressed air tools so there are lots of in applications of pneumatics in the industry.

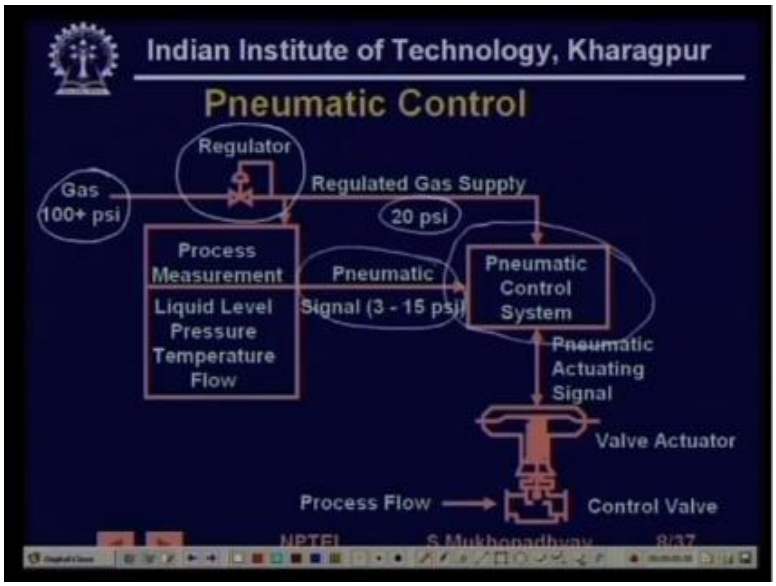
(Refer Slide Time: 08:03)



So typical pneumatic control systems block diagram wise would look like this so you have a source of air or gas which is at high pressure this source is generally coming from the compressor and then you have a regulator and this is actually a pressure regulator this is a pressure regulator after that you need you actually get the gas at the pressure that the your equipment will require similarly you can also have feedbacks you can have pneumatic signal feedbacks using you know things like.

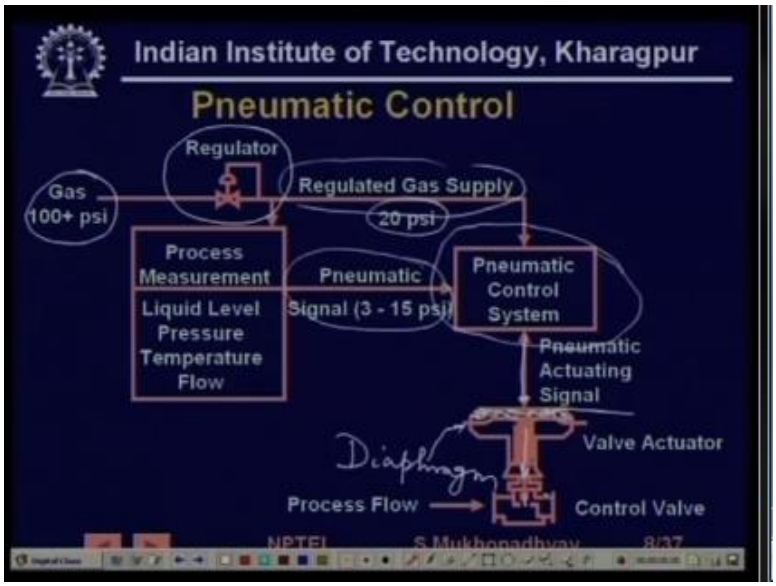
I to P converters current to pressure converters so you can have pneumatic feedbacks signals from.

(Refer Slide Time: 08:54)



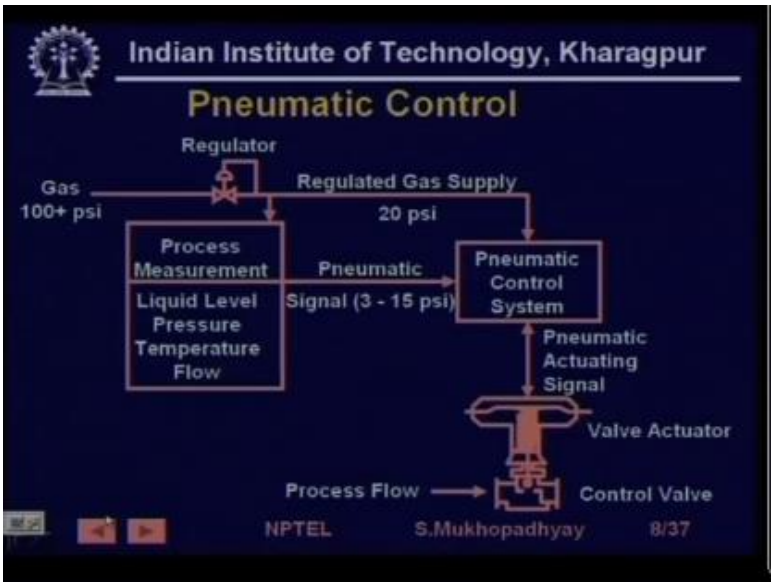
You know various sensors and then you can have a pneumatic control system so this control system will consist of you know various maybe Direction control valves and various pneumatic logic valves and or we will see them in the next lesson.

(Refer Slide Time: 09:15)

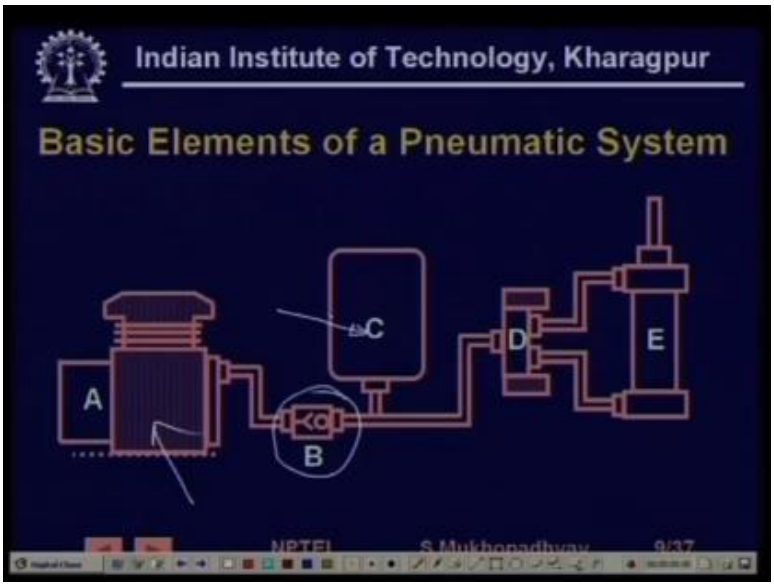


And finally this from the pneumatic control system and using this regulated gas supply the actuation signal is given in this case the application that we have shown is a valve actuator where the this valve is actually moved using pressure on this diaphragm so this is the diaphragm sousing this pressurized gas you actually apply pressure in this cavity so what will happen is that this diaphragm will under pressure it will come down and it will close the valve here so this typically is a kind of schematic that is used for pneumatic controls and various kinds of technologies are used so we are going to have a look at that.

(Refer Slide Time: 10:13)

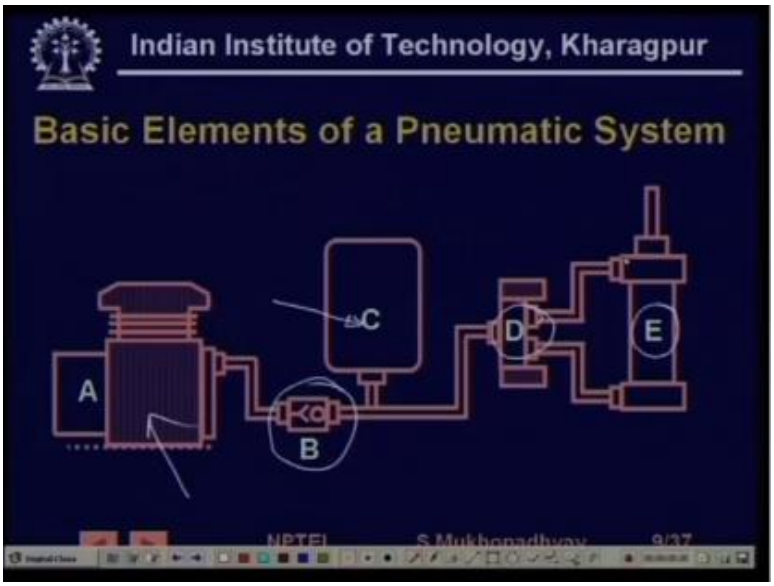


(Refer Slide Time: 10:15)



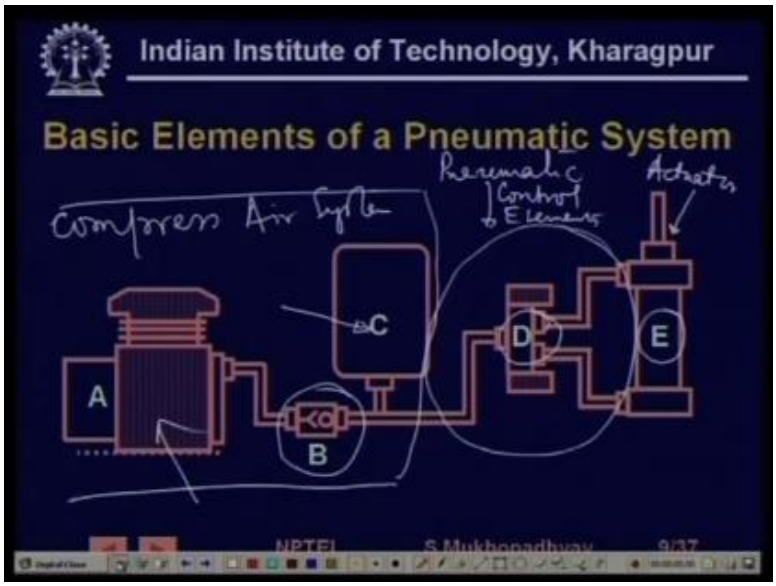
So let us look at the basic elements the basic equipment in a pneumatic system so we start with the compressor so this is the compressor A then after the compressor you have a sometimes of a check valve be then you have an accumulator or reservoir of compressed air this is very much necessary in pneumatic systems to improve response speed as we will.

(Refer Slide Time: 10:49)



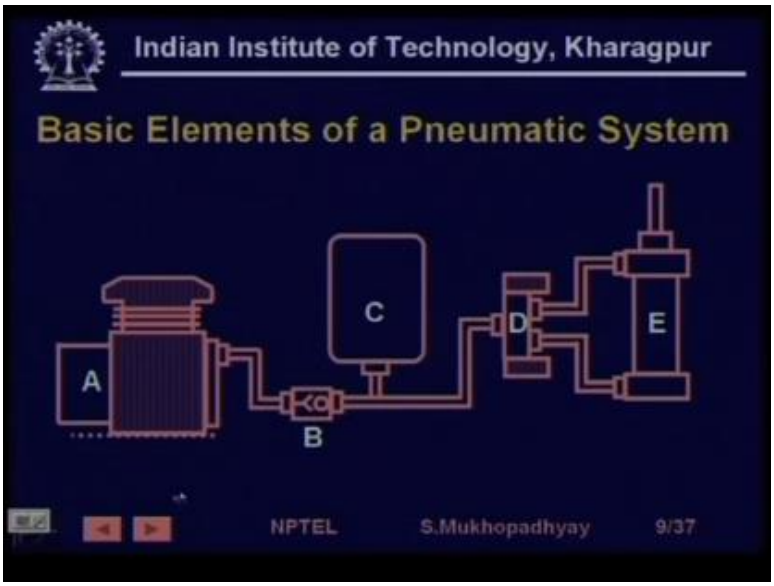
Discuss after that you have you can have a kind of various kinds of equipment for example in this case we have only shown a direction control valve which is trying to drive a and air cylinder so but this is a there is a very typical and simple system but in general you can have various other pieces of equipment like you can have.

(Refer Slide Time: 11:16)

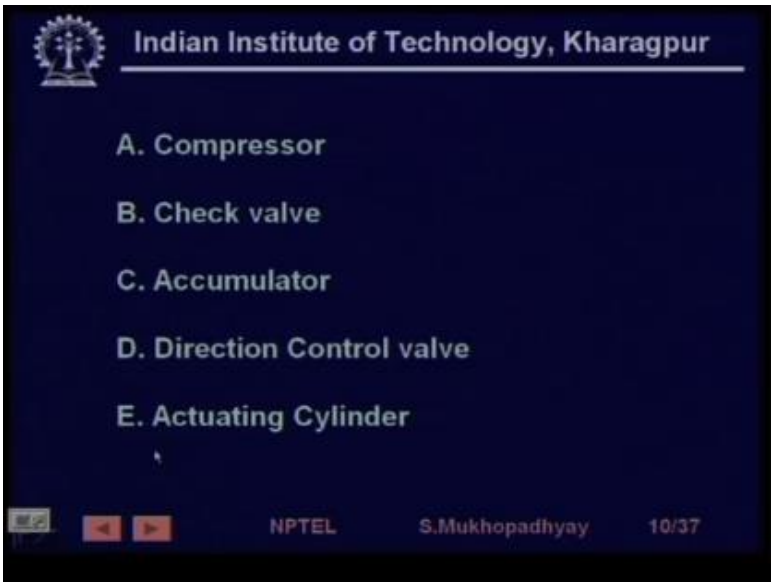


You can have pressure regulators you can have flow control valve various kinds of valves apart from this simple direction control valve so you have your actual you know control system elements here this up to this is generally the gas compressed air system this is the pneumatic control system pneumatic control elements and then finally the actuator finally the actuator so these are the three types of equipment which are typically used in pneumatic controls.

(Refer Slide Time: 12:08)



(Refer Slide Time: 12:09)



So A compressor B check valve C accumulator D Direction control valve and finally E is actually cylinder or actuator.

(Refer Slide Time: 12:19)

Now in system components compressor is the pressure source sometimes you can have you can have a linear air cylinder or sometimes you can also have a pneumatic motor reservoir or accumulator reservoir accumulator is very much necessary because of the fact that pneumatic system responds tends to suffer because suppose you want to move a cylinder then you have to create the pressure on it now creating pressure actually take some time because the air will have to flow into the cylinder chamber and then get compressed enough.

So and then the pressure inside the cylinder will build up and the cylinder will move so what happens is that if you want to move the cylinder quickly after you know let us say giving a control signal in terms of opening a direction control valve then you want that quickly a lot of air can be supplied to the quickly a lot of air can be supplied to the cylinder chamber so that is quickly the pressure builds up and the cylinder starts to move now supplying this a lot of pressurized air quickly is.

The basic problem because compressors are devices which can which can create a steady source of compressed air but a very you know instant supply of large volume of air cannot be supplied from this from the compressor itself so in that situation the accumulator comes into play and in

such situation the large volume of air can directly come from the accumulator and then the accumulator can get slowly filled up by the compressor again so this improves system response a lot therefore in pneumatic control systems accumulators are very much necessary.

(Refer Slide Time: 14:06)

More than in hydraulic controls there we have the direction control valves and actuator as we have already said and we naturally need correcting tubing and accessories like filters.

(Refer Slide Time: 14:23)

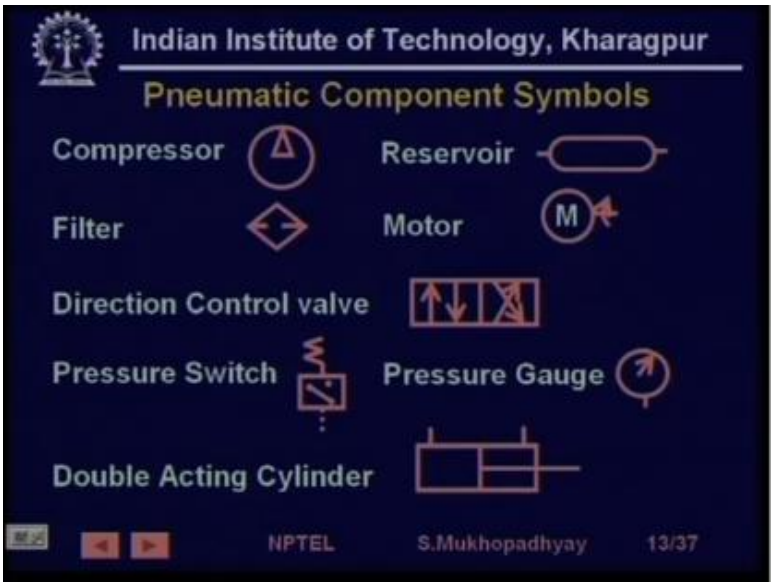
There are just like in hydraulics there are various types of control devices which are also used here so you have pressure control devices like pressure regulators you have check valves which control flow that is allows flow in a certain direction and does not allow flow in the other direction then there are flow control valves flow control valves in this case they are not they are you mainly used to control the speed of motion so sometimes you know you need that you I mean for example in the case of hydraulics we have seen that when you are driving the load typically you need slow motion.

And when you are returning without load you need you can have fast motion to save time so in such a case in such cases flow control valves.

(Refer Slide Time: 15:09)

Can are used much as very similarly as to what you use in hydraulics then there are you know various kinds of if you have feedback control then you can have various kinds of feedback elements like pressure switches you kind of pushbuttons for operator commands and of course you have various kinds of you know electrical interface devices like you have I to P converters so two for interfacing between electrical systems and hydraulic systems.

(Refer Slide Time: 15:46)



Symbols are very similar to the ones we use hydraulic so compressor is like this only note that the triangle is hollow in the case of hydraulics the triangle was solid because it was oil then you have reservoir you have filter motor hydraulic motor the same as electric motor or rather this is pneumatic motor then Direction control valve pressure switch and pressure gauge the pressure gauges are used at various points in pneumatics to either to feedback pressure values or to read them and of course thus seen in this so these symbols are fairly common.

(Refer Slide Time: 16:40)

And very similar to hydraulics then we look at compressors are the machines which are designed to compress gases.

(Refer Slide Time: 16:48)

From an inlet pressure which is generally atmospheric so it takes air from the atmosphere filters it and then compresses it to a high pressure and there are this mechanism can be of generally of two types one is positive displacement where each time a certain given volume of air is converted from the atmospheric pressure too high pressure so every cycle of movement of the compressor is very site whether its rotational or translational converts a certain amount of gas from low pressure to high pressure.

(Refer Slide Time: 17:30)

Then when you and the earlier and the other kind is non positive displacement which is basically you know centrifugal type basically fans essentially types of fans and blowers which are typically used when you need large volumes affair but not at such high pressure so typically for high pressures positive displacement type compressors are used.

(Refer Slide Time: 17:58)

If you if you want to convert to a very high pressure something like you know 600 700 800 1000PSI then you some often need to do it in multiple stages so you so a compressor we can have various stages.

(Refer Slide Time: 18:15)

Single or multiple and it needs to be driven right so because it compresses the air so therefore it needs to be driven by a prime mover that there are various types of prime movers possible it can be the prime mover can be an electric motor or it can be an it can be an IC engine or it can be even sometimes it can be a you know something like a turbine with which this the compressor will be coupled so in places where you have.

(Refer Slide Time: 18:48)

You know such turbines then you can actually use that energy for running the compressor.

(Refer Slide Time: 18:54)

So positive displacement could have involver linear motion or could involve circular motion so you can have either reciprocating piston type or you can have rotating vein types or totally impeller so either you have routed rotational designs or you have translational designs but in each case one cycle of rotation or one cycle of to and fro motion will take a certain given volume of air and push it take it to the low pressure inlet port and push it into the outlet port so in the reciprocating.

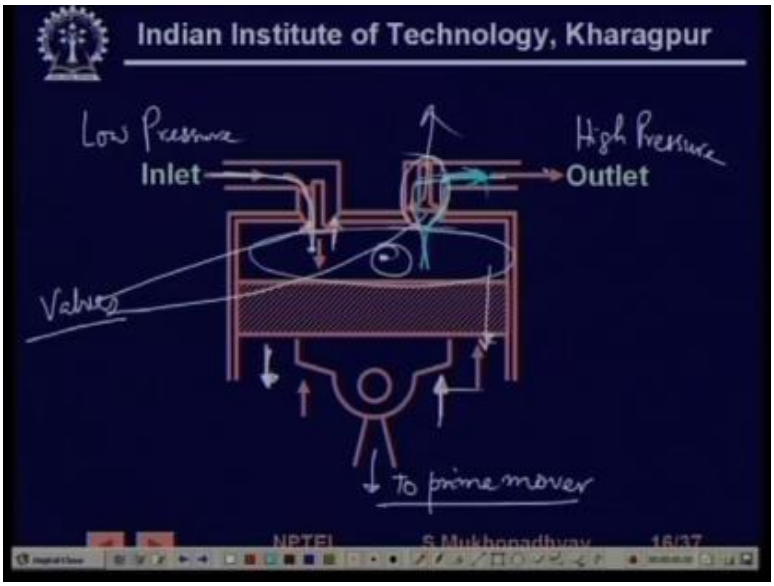
(Refer Slide Time: 19:34)

Piston type you have a piston you have cylinder and you have some valves right and there are two strokes so one stroke is called suction and the and the other stroke is called compression so in the suction stroke you are taking in air from the low pressure side which is typically atmospheric.

(Refer Slide Time: 19:53)

And in the compression stroke that volume of air you are pushing on to a high pressure port and this sucking and compressing is actually guided by the set of Valve's as we will see.

(Refer Slide Time: 20:08)

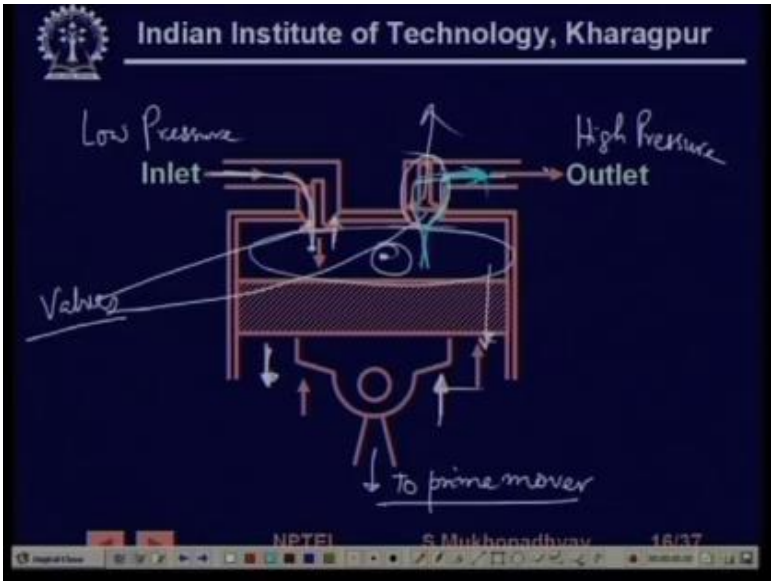


This can also be single or multiple stages so here is a diagram so typically you know see this is the low pressure inlet port and this is the high pressure outfield outlet port so and these are the two valves you know which actually control the motion and this is coupled to the prime mover so maybe it is a cam operated mechanism so in the in the suction stroke this cylinder moves this way as shown here and then this valve is going to open because the pressure here is going to fall so this valve will open and air will flow in from the inlet on the other hand this is not exactly I mean this is only schematically shown.

So since this is suction so therefore this will seal this outlet so no air will be sucked from the outlet right now after this is come to the lowest position a certain given volume of air is going to be residing inside and that is at the at the low-flow inlet pressure after that this alternating motion this cylinder will start going up the moment it starts going up it creates a high pressure here it actually compresses the air here so what happens is that this valve is now pressed up so it will be so it will be closed while this valve will also go up and then that will open the that will actually open that.

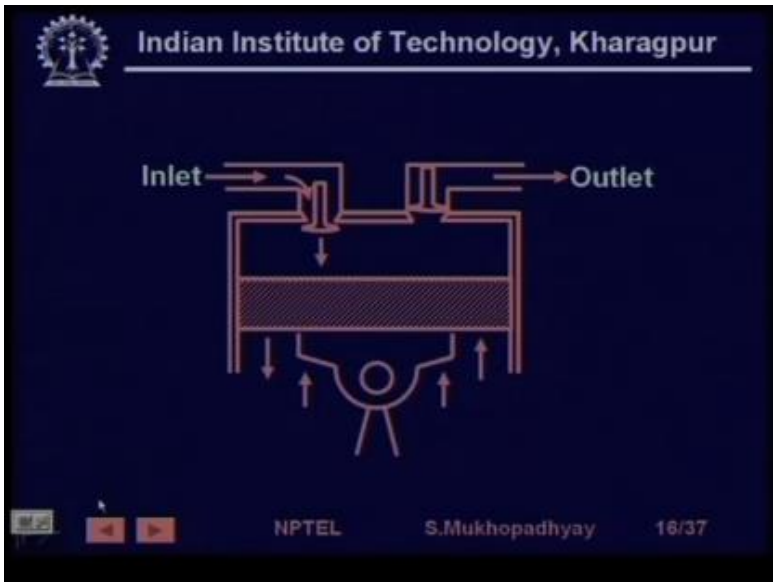
So the air will flow out so the air will flow out during that time through this bath and this is so this is what is happening so every stroke it is bring it is sucking a given volume of air from the low pressure atmospheric side and it is pushing the air back into the high-pressure outlet.

(Refer Slide Time: 22:20)

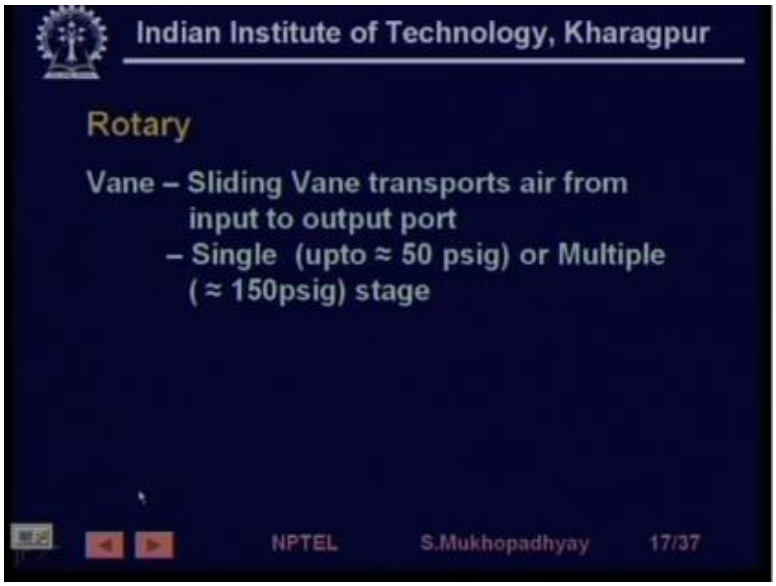


So this is a reciprocating type compressor mechanism.

(Refer Slide Time: 22:28)



(Refer Slide Time: 22:30)



For rotary compressors there either you know when type where as we have seen in the case of hydraulics also we have seen 10 type pumps where the rotational motion of the of the vein inside a cavity will just when the wind smooth air is sucked in from the inlet and that air is transferred back to the outlet at high pressure.