Oil Hydraulics and Pneumatics
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Part 1: Introduction to pneumatic systems, Air tools, Basic design features of pneumatic circuits, Designations to be followed, Unique valves in pneumatic logic control-OR/AND/NOT function valves
Lecture - 74
Pneumatic Circuits: Design and Analysis

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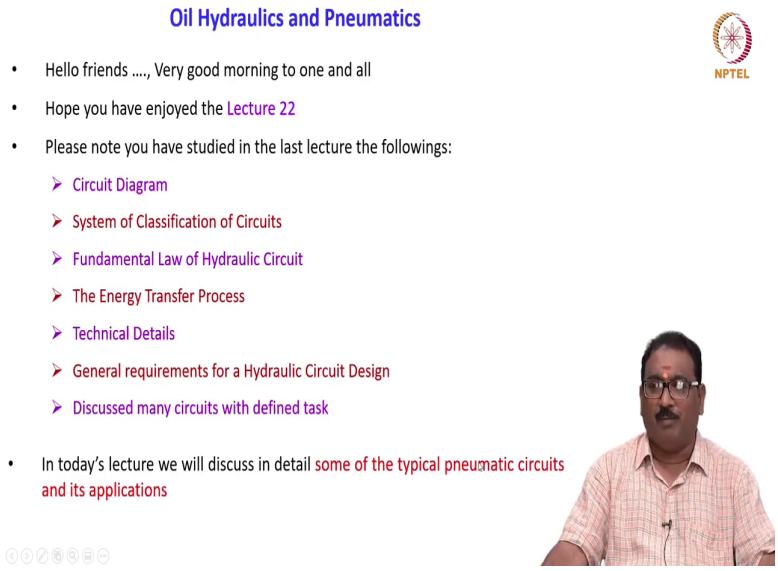

My name is Somashekhar, course faculty for this course. Hello friends, very good morning to one and all. Hope you have enjoyed the lecture 22nd. Please note you have studied in the last lecture the following contents; circuit diagram, system of classification of circuits, fundamental laws of hydraulic circuit, the energy transfer process, technical details of hydraulic circuits and components, general requirements for a hydraulic circuit design.

Also we have discussed the many circuit with a defined task and how to select the various components and how to arrange to meet the defined task. In today's lecture, we will discuss in detail some of the typical pneumatic circuits and its applications.

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Move on to the organization of presentation of a lecture 23rd, we will begin with pneumatic control system Recap – introduction, very quickly. Air tools; basic design features of pneumatic circuits; designations to be followed while designing the pneumatic circuit; breakdown of a control chain; hardware arrangement for signal flow in fluid power systems and electrical system, how the signal flow will takes place from the input to the output element.

Building-up the circuit diagram, which includes again from the signal input to the signal output, there are various elements how to select and how to arrange for the proper signal flow

from the input to the output. As I have told you, we will discuss the task based pneumatic circuits how to select the various components to meet the defined task. We will discuss some typical circuits of the pneumatics in the today's class.

Please understand friends, the circuits are very important in industry, you have to practice all the circuits by drawing the schematics on your papers. Finally, we will conclude the today's lecture.

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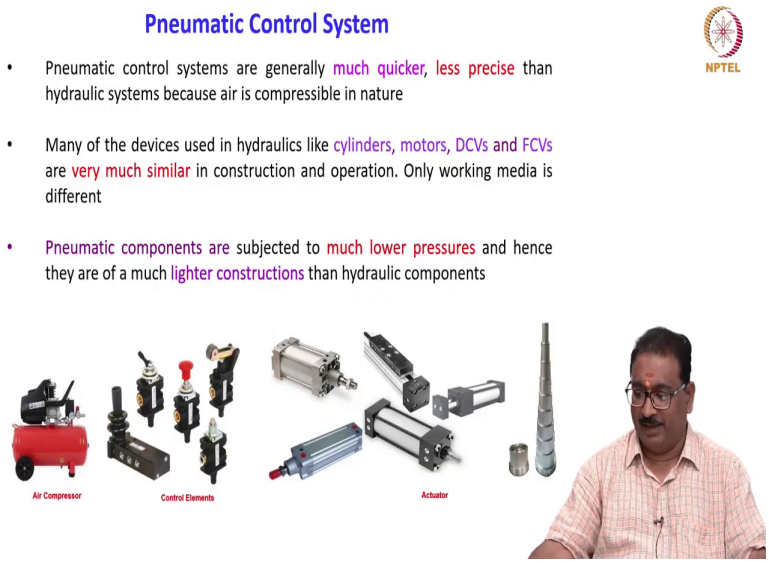

As we discussed in the previous class, details on pneumatic control system; how it differs from the hydraulic systems. The pneumatic control systems are generally much quicker less, precise than the hydraulic system; because as we already know that air is compressible in nature.

Many of the devices used in hydraulic like cylinders, motors, DCVs, FCVs are very much similar in construction and operations. Only the working media is different. In hydraulics, air compressible fluids; in pneumatics, compressed gas is generally the air. Pneumatic components are subjected to much lower pressures and hence, they are of much lighter constructions than the hydraulic components.

Some of the typical components in the pneumatic systems are air compressor for the air production. Control elements which includes the direction control valves, pressure control valves and a flow control valves and actuator. Similar to the hydraulics, here also we are using the linear actuators, piston and cylinders and the rotary actuator, here we can call it as a air motors. Then, variants are there to do the different works like a telescopic cylinders are much more.

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Because of lower pressures used in pneumatic systems, a pneumatic cylinders have much lower force capability and hence, they are appropriate for the applications that requires the high speed and low forces and do not require a high degree of precision. Pneumatic cylinders are often used in automation equipment to assemble, sort, package etcetera and are used for clamps and low capacity presses, bending machines much more.

Other components such as quick exhaust valves, time delay valves, memory valves, pressure regulators, lubricators, dryers, filter regulator lubricator units briefly known as FRL units and air tools are unique to the pneumatics. Please understand this, these are specially you are seen in the pneumatic control systems.

Typical pictorial representations are air filters, air regulators, air lubricators, and FRL unit; filter regulator lubricator unit and air dryers and shuttle valves and much more, we will see in the today's class.

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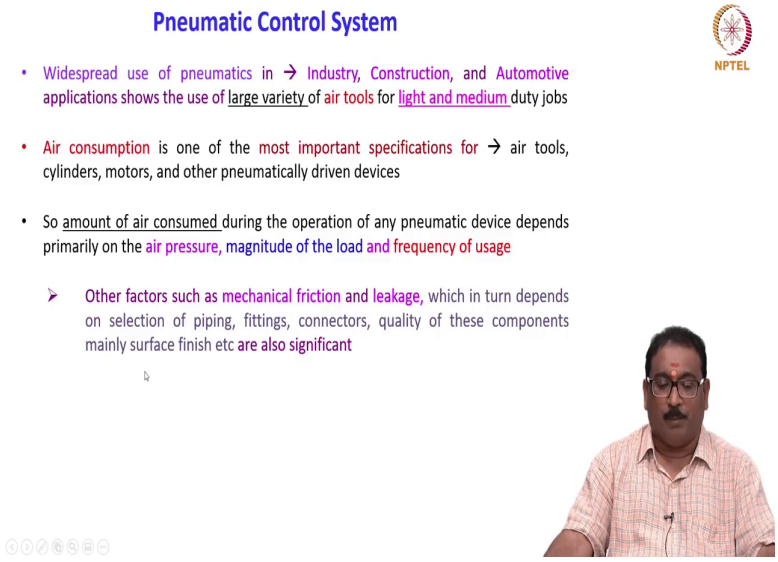

Widespread use of pneumatics in industry, construction, automotive applications shows the use of large variety of air tools for light and medium duty jobs. Air consumption is one of the most important specifications for air tools, cylinders, motors and other pneumatically driven devices.

So, amount of air consumed during the operation of any pneumatic device depends primarily on the air pressure, magnitude of the load and a frequency of usage. Other factors such as mechanical friction and a leakage which in turn depends on the selection of piping, fittings, connectors, quality of these components mainly the surface vanish etcetera are also significant.

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Quickly, we will see friends. Now, air tools also known as Air-powered hand tools.

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Typically, air powered hand tools are numerous use in industry. Some of them are I am listing here; they are the air grinders, air impact wrenches, air sanders, paint sprayers, air drills, air screw drivers, air riveting hammers, air hoists, air blow guns, air saws, air nail guns, air chippers, air staple guns, orbital sanders, jackhammers. The many tools are there, these are known as typical air-powered hand tools. They will use the compressed air for their operations.

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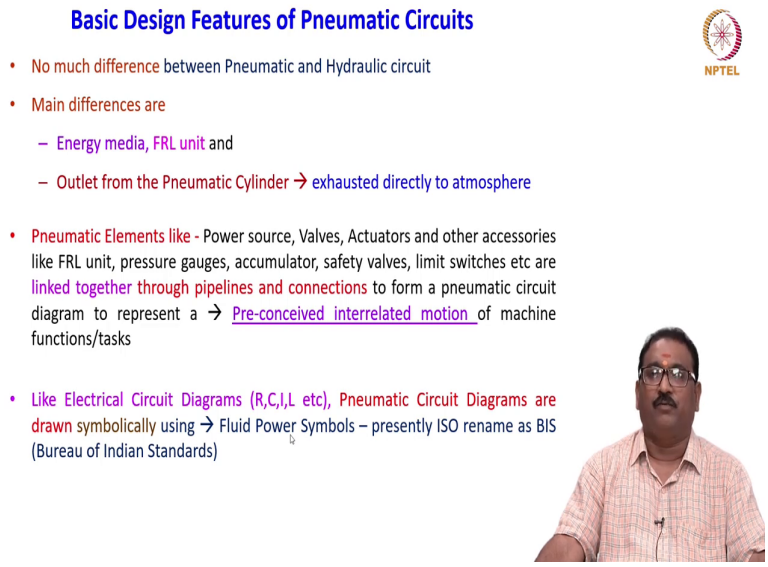

Now, quickly, we will move on to the basic design features of pneumatic circuits. Please remember friends no much difference between the pneumatic circuit and a hydraulic circuit. Main differences are energy media. As I have told you, here we are using the compressed air.

Then, FRL units, for the secondary air preparations. You have seen already in the previous class and outlet from the pneumatic cylinder exhausted directly to the atmosphere. But in the hydraulics, the exhaust oil, return oil will goes to the tank through the filters correct return line filter. But here, no; directly exhaust to the atmosphere.

So, pneumatic elements like power source, valves, actuators and other accessories like a FRL unit, pressure gauges, accumulator, safety valves, limit switches and much more linked

together through the pipelines and connections to form the pneumatic circuit diagram to represent a Pre-conceived interrelated motion of machine functions or a task.

Like a electrical circuit diagrams R, C, I, L elements, pneumatic circuit diagrams are drawn symbolically using the fluid power symbols. These things we have discussed in the beginning of the course.

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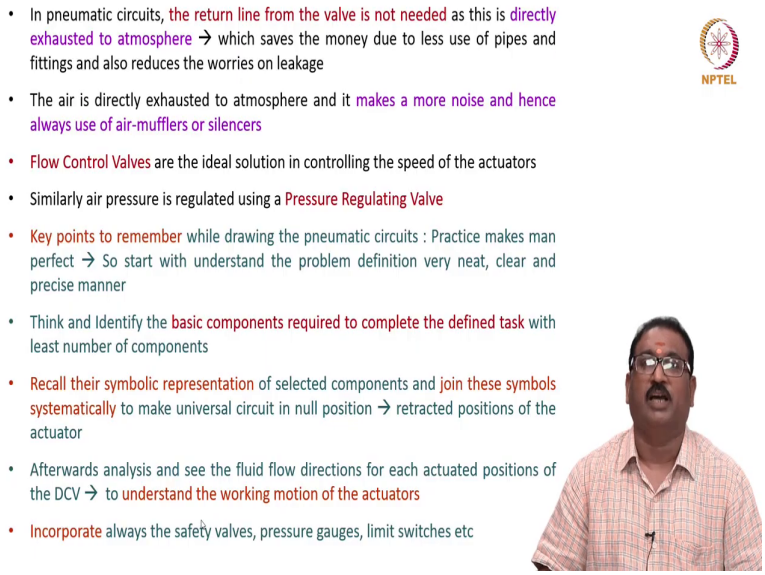

In pneumatic circuits, the return line from the valve is not needed, as this is directly exhaust to the atmosphere which saves the money due to the less use of pipes and fittings and also, reduces the worries of leakage. The air is directly exhaust to the atmosphere and it makes a more noise and hence, always use of air-mufflers or silencers are recommended in the pneumatics system.

Flow control valves are the ideal solution in controlling the speed of the actuator. Similarly, in the hydraulics. Similarly, air pressure is regulated using the pressure regulating valves. Key points to remember while drawing the pneumatic circuits; practice makes the man perfect that is why I am requesting all the student, practice the more circuits from the task dependent, how to select the various components and join to do the useful work.

So, to start understanding the problem definition very neat, clear and a precise manner. Think and identify the basic components required to complete the defined task with a least number of components. Recall their symbolic representations of the selected components and join these symbols systematically to make the universal circuit.

Always you have to draw in the null position; null position means all actuators are in the retracted position similar to the hydraulics, as I have told you in the previous class; retracted position as I have told you. Afterward analyze and see the fluid flow directions for each actuated positions of the DCV, to understand the working motion of the actuator, how they will operate. Incorporate always the safety valves, the pressure gauges and limit switches as much as possible as because we are moving towards the IOT concepts.

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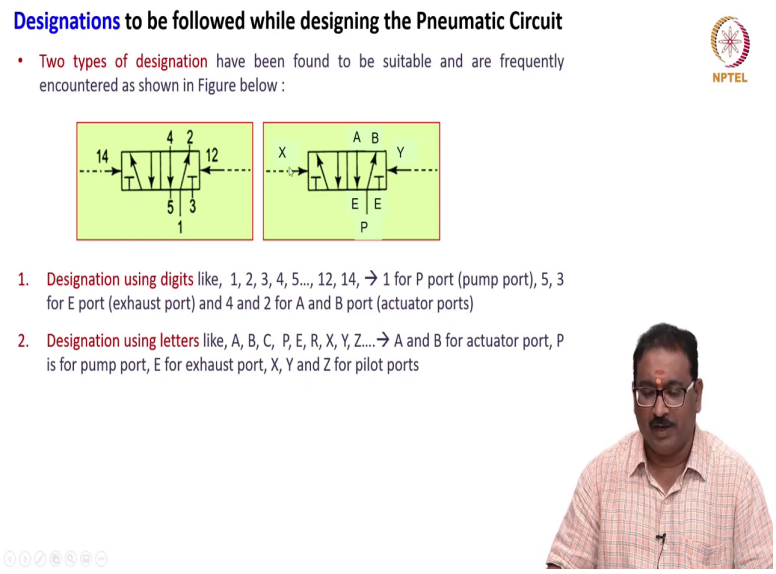

Then, quickly, we will see the designations to be followed, while designing the pneumatic circuits. Two types of designations have been found to be suitable and are frequently, encountered as shown in the figure below. You will see there are two types of designations for the valves, actuators all.

Here, I am showing you the direction control valves, how they will represent. As I have told you here, you will see designation using the digits like 1, 2, 3, 4, 5… 12, 14 like this. Here 1 is for the pump port and 5 and 3 for exhaust port. Correct, and 4 and 2 further your actuator port and 14 and 12 are the pilot signals.

You have to represent all the valves using the number systems or like a as usual how we are doing in the hydraulic control systems like a P port is P; exhaust port E, symbolically you

have to represent using the letters. A and B are the output ports or actuator ports and X and Y are the pilot signals. You have to represent like this or like this; both are allowed.

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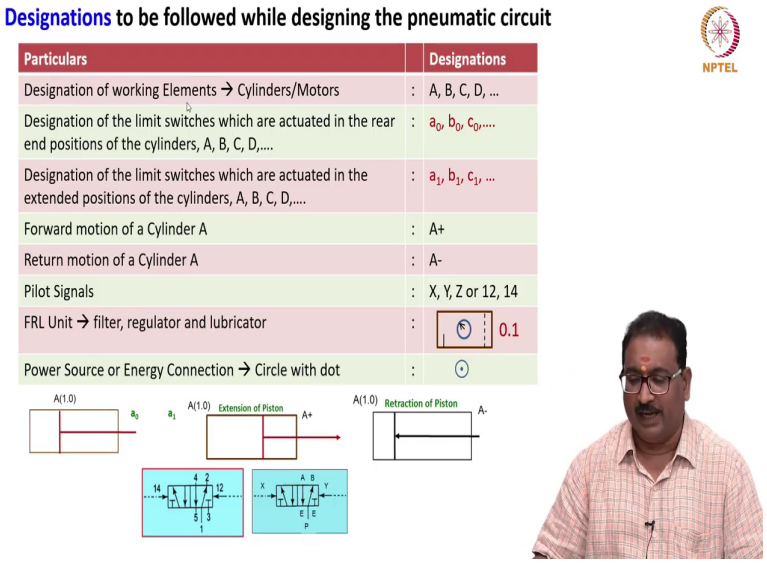

We will continue some of the designations. Here I am showing you here, many things here friends, you will understand this. Here I am showing you the cylinders, extended positions, retracted position and some valves. You will see here friends, designation of the working elements like a cylinders, motors; if many are there in the sequencing of the circuits or in the design of the multiple actuators, that time you have to represent each cylinders A, B, C, D like this.

And designation of the limit switches which are actuated in the rear end position of the cylinders A, B, C, D, you have to represent like this a naught b naught c naught; small all

small letters. Similarly, designation of the limit switches which are actuated in the extended position of the cylinders, how to represent? Small a 1, b 1, c 1.

Here, I have shown you, here you will see here I am shown here for the cylinder a naught, it is a retracted position of the limit switch. Here extended position where the cylinder will extend the limit switch a 1. Here, you will see next, forward motion of the cylinder. When the cylinder will extend, it is represented A plus, you will see here A plus is going run now.

Then, you will see return motion of the cylinder, here you will see return motion of the cylinder is represented using A minus. Similarly, for the B cylinder, C cylinder, D cylinders. Then, you will see pilot signals X, Y, Z or number systems like a 12 and 14. Here, you will see 12 and 14 or X and Y or the pilot signals.

Also, we will remember friends, FRL units very very important it is. In the pneumatic system, filter, regulator, lubricator unit, it is represented rectangle with the circle with arrow, then one line and dotted line and 0.1. Power source or energy connections, the circle with dot you have to show. These are the some of the designations to be followed in the designing of the pneumatic circuit.

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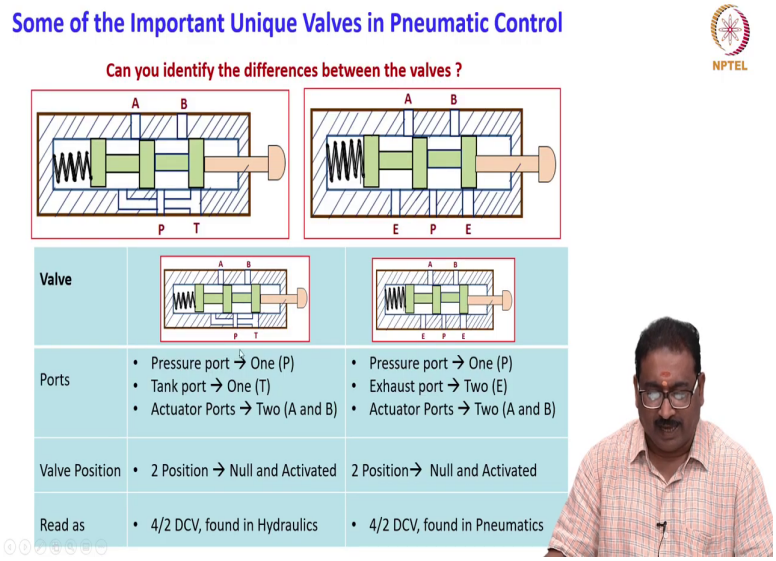

Now, we will see some of the important unique valves in the pneumatic control systems. We already we discussed in the previous classes; but these are very essentials to understand the pneumatic circuits, I am listing here now. Can you identify the difference between the valves? As I have told you this is a spool, this is a push button, the valve body and these are the ports. Same here. Correct, this is a stiff spring to make the valve connections; correct.

As we have seen, now we will see the both are different or both are same. Here valve it is, I have shown you here; now, identify the ports first. Here you will see the pressure port, one port is there; tank port, one tank port is there; actuator ports A and B, two are there. Here also the pressure port one, exhaust port two are there, two E meaning exhausting the air; then, actuator ports A and B.

The valve position as I have told you the one is in the null position or one more is in the actuator position. 2 valve position; here also 2 valve position. Read as this you can read as please understand, 4 by 2 directional control valve, found in hydraulics. You will see this 4 by 2 DCV, it is found in pneumatics because you will see friends exhaust is direct to the atmosphere, no cutting of the in the valve body.

2 exhaust ports, the purpose is same. That is why even though it is having the 5 port, it can be treated in the pneumatics as 4 by 2 DCV. Please understand this.

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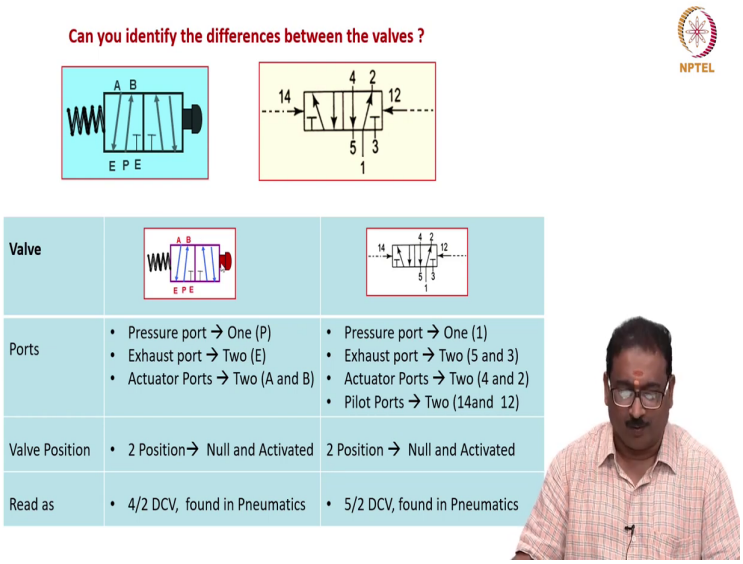

Next, we will move on to the one more valve, can you please identify the difference between these two, as I already shown you in the previous slide. Quickly, we will see the number of

ports, all these thing. Number of ports, the pressure port is there; correct friends? Exhaust port, 2 exhaust port and actuator ports A and B.

Immediately how to tell? This is a 4 by 2 the spring centered push button actuated directional control valve; correct friend? 2 valve positions; null position, actuated position. This is always the null positions; all the numbers are written. Please understand this. When you will push this button, always it will goes to the right side actuation.

Then, here also you will see friends, the pressure port is one, number system it is one is always a pressure port. Odd numbers are there know, you will see here exhaust ports are odd number 3, 5. Even number 2 and 4 for the actuator ports. The pilot ports are 14 and 12. Understand this. The valve is 2 position as I have told you. How to read this? This is a 4 by 2 DCV found in pneumatics.

This is also you can call it as a 5 by 2 DCV because these 12 and 14 serve as a pilot signal, that is why I am treating as a 1. Similarly, exhaust port know that is why you will call it as a 5 by 2 DCV, found in pneumatics or you will call it as like this the 4 by 2 DCV similar to here, but pilot operated; both are same. But better to we will call 5 by 2 DCV, found in pneumatics.

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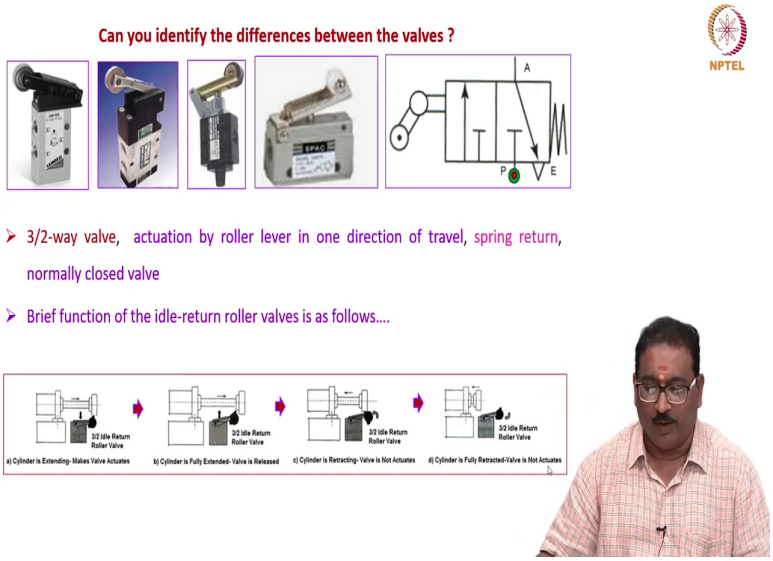

Can you please identify the difference between these valves? You have seen already this. Correct here, you are seen already in the directional control valve chapter, what is this can you please how many ports are there? P port is there, A port is there, E port is there. In the null position, P port is blocked; meaning, it is a 3 by 2 directional control valve.

The spring centered; pressure port is blocked. What is this? Can you please tell me here? Only in one direction, valve is get actuated; in the return direction, it will not.

How we are placing this? This is very important. What is this? 3 by 2 way valve it is, actuation by roller lever in one direction of travel, spring return, normally closed. Please understand, normally closed; pressure port is blocked. Brief functioning of the idle return roller valve is already explained in the previous chapter.

Very quickly, I will show you when the cylinder is extending makes the valve actuates, you will see it actuates at standard position. Then, cylinder is fully extended, valve is released; only it will, when it will completely extend identify only one, afterward it will release, see here.

Then, when returning, what happens? Cylinder is retracting, valve is not actuates; slides over it, it will slides over it, it will not actuates. Then, cylinder is fully retracted valve is not actuates; meaning, in only one direction, momentarily when it will fully extends, it will actuate, then it will release.

If you will place it in the retracted position also possible, where you are placing this 3 by 2 idle return roller valve matters. These are very very important in the sequencing of the circuits because when the cylinder A extend, then B will extend. How to determine this? Using 3 by 2 idle return roller valves.

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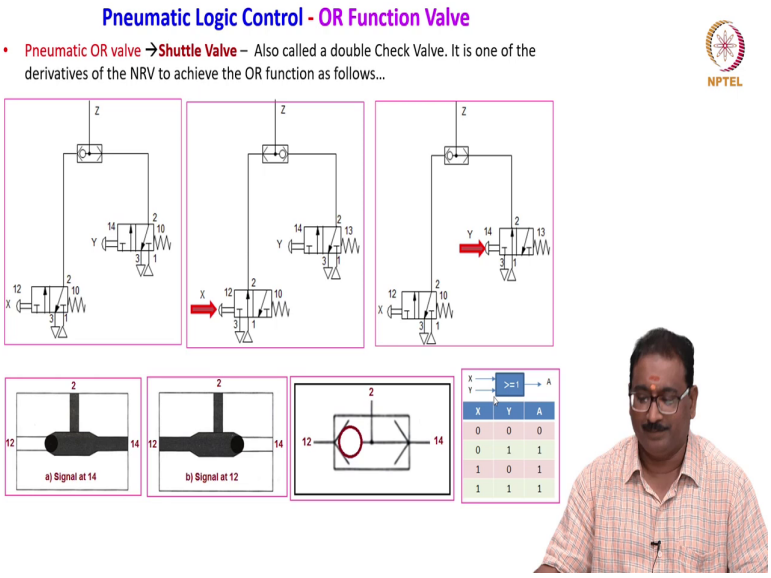

Then, I will show you some more valves. Pneumatic logic control, we are using the OR function valve. You already studied this OR gates in the digital electronics; same way here, the pneumatic valves are there. The pneumatic OR valve, it is known as a shuttle valve, also called a double check valve.

It is one of the derivative of the NRV to achieve the OR function as follows. You will see here friends, this one is a shuttle valve. The Z is an output whatever you will call; it will receives the signal. These are the 2 pilots whatever you will call, 2 valves are there, 3 by 2 valves are there. Here, one 3 by 2 valve, here one more 3 by 2 valve. What happens here friends? When the Z will receives the flow either here for here which one you will actuate? You will see now. When you will actuate this, what happen?

The pneumatic energy will come, push the ball here, Z will receiving the flow from here. or when you will press this, what happen? Ball will slides and close this, Z will receives the flow from this valves; 3 by 2 way valve. This is the OR function; with this is a shuttle valve, very very important.

Here, I am showing you the how it works. Here you will see the signal 14 is there, ball will slide and close here. 2 is receiving the flow from 14. Similarly, when the signal is at the 12, what happen? Ball will close the 14 block, 2 will receives the flow from 12. How to represent this the double check valve? 2 will receives either from 12 or a 14 whichever is at the highest pressure.

Now, we will see here logic table, where X and Y, these are the signals 12 and 14. When they are 0 0, no actuations here; then, output is 0. Whenever any one of the signal, you will press this or this, the output will be on or when you will press the both button, the ball will slide to the middle, then it will receives the flow ok.

The meaning here the X and Y are the inputs; A is an output, here it is a Z whatever it may be ok. X is greater than or equal to 1, output is there; similarly, Y is greater than or equal to 1, output is from the Y. Very very simple friends it is.

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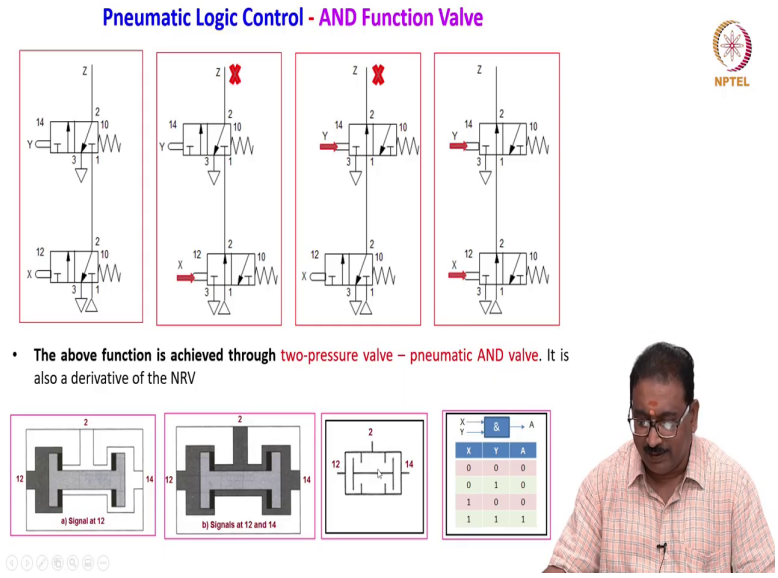

Now, we will move on to the pneumatic logic control the AND function valves. You will see here how it will work. The Z is an output whatever it is, now always you have to draw the signal in the outlet positions correct. When I will get the Z, when you will press this, what happen? Here it will come, but again it is locked position.

You will see here, when I will press this, what happen? This is activated correct. It will jump to the activated position; from the null, here it will jump. But again, it is closed here, you will see. When I will receives the flow Z here, when you will press only if you will press only this what happen here? It is the null position; it will not correct.

Only it will receives the flow, when you will press both 3 by 2 DCV; you have to press both 3 by 2 DCV, only Z will receives the flow, otherwise no; meaning, it is a AND function, please remember. What is this? AND functions valve. How it is? I will show you here. The above

function is achieved through two-pressure valve, the pneumatic AND valve, it is also the derivative of the NRV.

You will see here, when the signal at 12, two will not receive any flow. Then, signal at 12 and 14, that time only it will receives. How to represent this? You will see friends; symbolically, it is represented like this. It is a AND function valve. Here I am showing you here the truth table X and Y, A. How it is? Only when both signals are present, A will receives the flow; otherwise, no opening of the valve for the Z or A, whatever it is.

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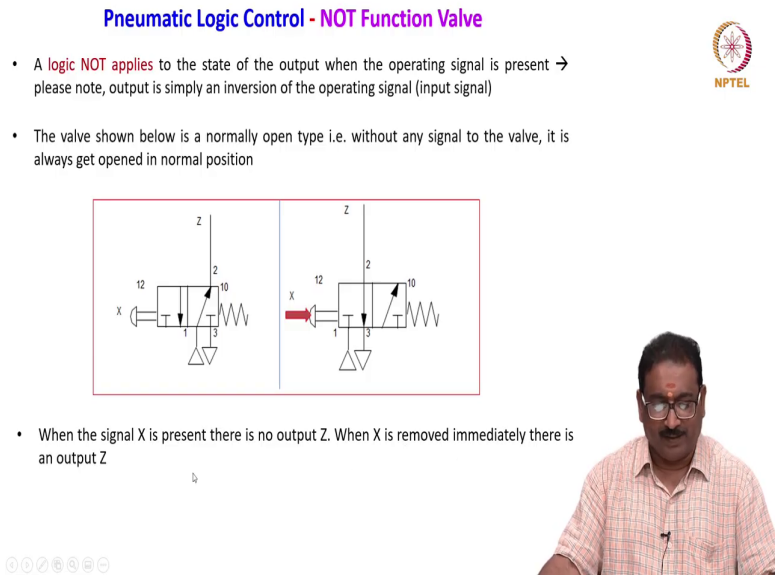

Move on to the pneumatic logic control, here NOT function valve. A logic NOT applies to the state of the output when the operating signal is present. Please note the output is simply an inversion of the operating signal that is a input signal, it is an inversion. The valve shown

below is normally open type that is without any signal to the valve, it is always get opened in the normal position.

You will see here the whatever the valve I am showing you here, again 3 by 2 a valve it is. It is a open type, Z will receives the signal in the null position. When you will press this, the Z will not receives. The other way around also is possible. In the null position, Z will not receives the flow.

When you will press the button, NO correct, it will receives the flow. See here, this is a very very important. Z is receiving the signal when there is NO here; when you will press this, what happen? Z will not receives. Always it is a inversion of the input signal. When the signal X is present, there is no output. When the x is removed, immediately there is an output.