Fundamentals of Industrial Oil Hydraulics and Pneumatics
By Professor R. Maiti
Department of Mechanical Engineering
Indian Institute of Technology, Kharagpur
Lecture 36
Pneumatic Circuits

Welcome to today's lecture on pneumatic circuits.

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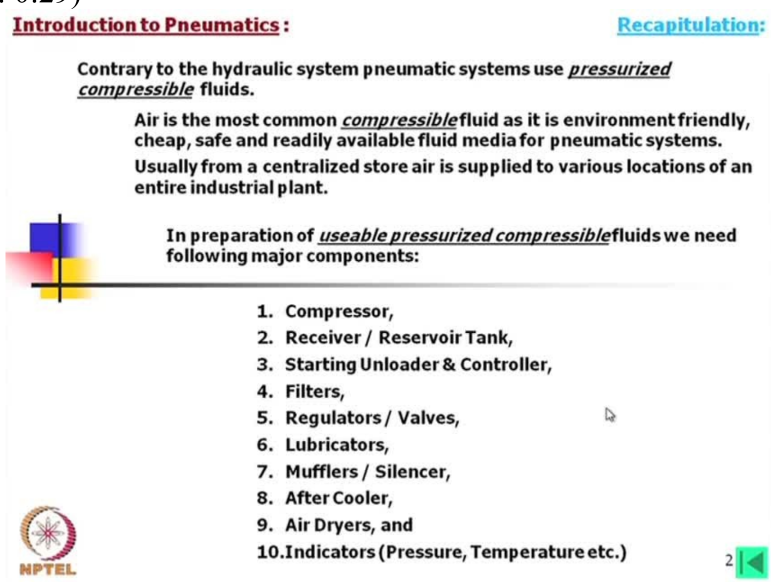

We have learned a little bit about the air preparation and components. Now contrary to the hydraulic system, pneumatic systems use pressurised compressible fluids. Air is the most common compressible fluid as you know, as it is environment friendly, cheap, safe, readily available fluid media for pneumatic systems. Usually from a centralised store air it is supplied to various locations of an entire industrial plant.

Now for the preparation of air, what we need? We need a compressor which in inlet, it accepts the air from the atmosphere which we call standard air and then at the inlet of the compressor, there is although a filter or strainer is there but actual filtration is done after it is compressed. Now that air only not only this compressed, it needs many other preparation process before it is allowed to enter into a pneumatic system.

Now 1st of all, this compressed air is stored which partially cleaned in a receiver or which is also simply receiver tank. Then in compressor, as you know that it cannot run for continuously or it is not desired that it would run continuously. What is there? There is a system by which the compressor is stopped when the compressed stored air reaches a certain upper level of pressure.

Now when it is stored, the compressor is stopped, then from the compressor end or compressor head to the receiver intake, the pressure, the air is trapped with a with the pressure at which we have stored it. Now that, we need to release before starting the compressor end, so for that the system which we have discussed earlier, it is called starting unloader and also that is a controller. If we need better control, nowadays the electronics control system with the maybe with the hydraulic circuit can be utilised for that.

Next, we need a filters. That means, when the compressed air being supplied to the machines, 1^{st} it is filtered, then we need to regulate. So there will be a regulator as well as, maybe the flow control valves. Then we need a lubricator. Now, why the lubricator is needed? That is needed to add some lubricant to the compressed air because it is, when it is being used in the pneumatic systems, there are moving components. And there are no other means to lubricate that components.

So lubricator is mixed with the air. Now we need also muffler or which is called also silencer. In case of oil or liquid, that is that returns to the tank and that is not that much noisy in comparison to the gases. When gas is released, then it is released to the atmosphere, air particularly. In that case, it makes a noise. So essentially, we need an silencer at the end. But as well we need a silencer even when it is entering to the system I mean utilisation end.

That silencer is usually called online silencer. Now we need a after cooler. This after cooler is not after the utilisations. In fact, before the utilisations because when the air is being compressed, a lot of heat is generated. So it needs to be cooled before being utilised for the further work. And also the air contains the water particles. So it needs to be dried. So we need a dryer.

And apart from that, different sort of indicators, pressure, temperature these are required.

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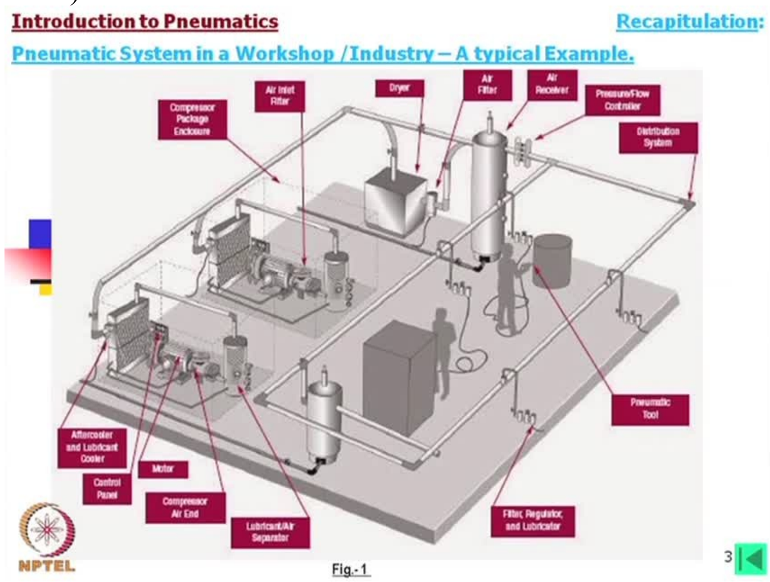

Now this is a typical schematic or artistic view for a plant. Here what we find? The compressor and usually this compressor, there will be another standby compressor also so that if one fails, another can be operated or intentionally, to reduce the load of the compressor particularly from heating, we may use two compressors instead of one large compressor.

But this compressor capacity by no means that this is of less capacity and pressure. Maybe volume capacity is less, the personal capacity is both should be same. But it can fill this tank say partially it is filled by this one, then can be filled by other one. So in that way, one can be of less capacity and other can be of higher capacity. But usually, both are kept of the same capacity because it will serve all the purposes. If one fails, it will work.

If we want to keep one standby, it will work. If we want to run, say this is A and this is B, A first B or B first, then A. Everything will be possible if these are of same capacity. Now as we see that this is after loader after cooler and lubricant cooler, these are cooling elements. Here is the compressor. Now this is Control Panel, this is motor, this is compressor air end, then lubricator or air separator. Maybe moisture separator or lubricator separator also.

I do not know exactly this why this separator also used for lubricating. This air, this water separator is definitely is used. Now this is the main tank and this is the dryer. One dryer we need, a single dryer is there. Then their pressure flow controller is there and this is usually you will find that each and every point the filter, regulator and lubricator, FRL, it is called short-term FRL, the 3 elements you will find. One is lubricator, one is filter, and another is regulator.

Each and every point usually such an element will be there. And these are 2 workstations where this power is being used. And this as we see that we can connect more.

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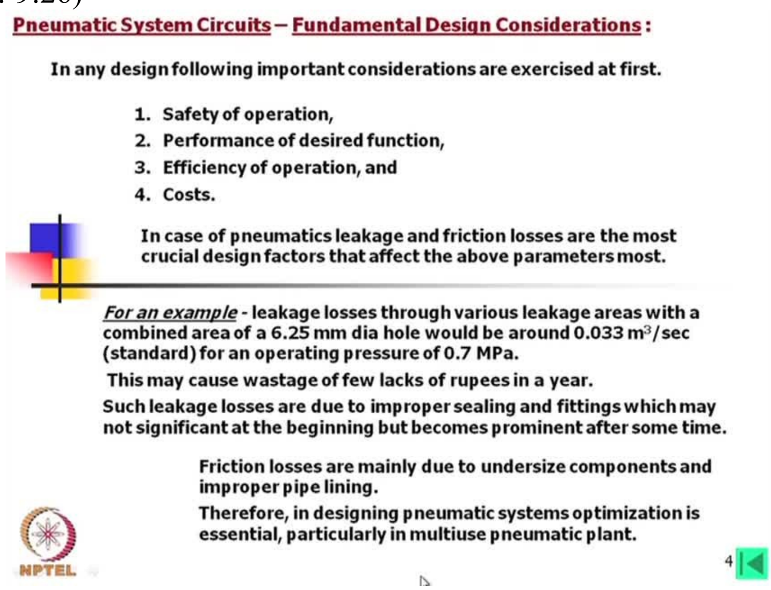

Okay, after such preparations, then these are used but for individual application, we need to develop separate circuits. This which we're talking about the air preparation, filter, et cetera, valves et cetera, that is for the common supply to the whole industry. But for any pneumatic system, we need a separate circuit. Now for designing such an circuit, 1st of all we should consider safety of operation, secondly, performance of desired functions, thirdly efficiency of operation and last, the cost.

All together, we have to think while we are going to design any system. Suppose one of that maybe not that essentials. Say for example, cost. Some sometimes the cost we can, of course we will not make it of exorbitant cost but the cost factors may not be that important. Other than, in every cases, the safety is 1st. So we have to think all sorts of safety protection. Now performance of desired function. It is very important.

Whatever may be the function we need, whether it is not very precision, still we need to design in such a way that we can achieve the best performance out of it. Now efficiency operation sometimes, it can be compensated means that we may not make the system very efficient. However if making any system considering the best performance, high efficiency and low cost, that should be the motto but it is not, each and every point is a minimum or the maximum efficiency maximum, cost minimum, this may not be possible so we use the term optimum design.

Anyway, that needs I will repeat, that needs maybe you can follow a mathematical model to optimise everything or else that mostly depends on the experience. In case of pneumatics, leakage and friction losses that affect the above parameters most. That means to minimise say for example, if I take even the cost factors, to minimise these cost factors, we have to make the system as much as possible, it is leakage free.

But in pneumatic systems, that although sealings are used, but still, there is a possibility of there will be leakage. Say for example a very simple example, when we drive the car. Let's consider the car of pneumatic tyre, in that case car, scooter, everything, that this is filled of to take the desired load but what happens on the process there will be some leakage or in these pipelines these pipelines usually in plant is very big.

There will be several joints, there will be several outlet points through which there is a whatever may be the amount, there will be very small leakages. That can be controlled by regular maintenance or initially selecting very good components. However, there is also friction loss. That friction loss, you can say the skin friction. We inside the conduit, even if it is a very good finish, but when the air is flowing, there will be friction between the air and the surface of the material and by no means we can neglect that that one.

Now for an example, leakage losses through various leakage areas with a combined area of 6.25 millimeter dia hole, that means we are considering that the orifice through which the leakage is being occur 6.25 millimeter dia. Now this is very rough estimation because this is all area summing up all area will millimeterdiaof 6.25. Again if we consider the coefficient of discharge through this orifice (())(14:40) whatever may be the leakage passage, it may be capillary.

Then these coefficients will be different. But roughly we can say this loss will be around 0.033 meter cube per second and this is of standard air for an operating pressure of 0.7 mega Pascal.

That is 0.7 means it is 100 psi. This may cause wastage of few lakhs of rupees in India if we calculate for pressurising air of that amount and this is per second. So if we consider the whole operating time for a plant this may be few lakhs of rupees in India. But anyway, we can minimise that, we cannot eliminate that. Such leakage losses are due to improper sealing and fittings which may not significant at the beginning but becomes prominent after some time.

Friction losses are mainly due to undersized components and improper pipelining. Now you see that while we are making this pipelining, and definitely we will select the optimum size. It should be minimum leakage loss as well it should not be of huge volume. Then you will feel, you will find that to fill that whole conduits, if the amount of air is too high and there will always be leakage losses. So we cannot control the leakage losses in other way. Therefore in designing pneumatic system, optimisation is essential particularly in multi use pneumatic plant.

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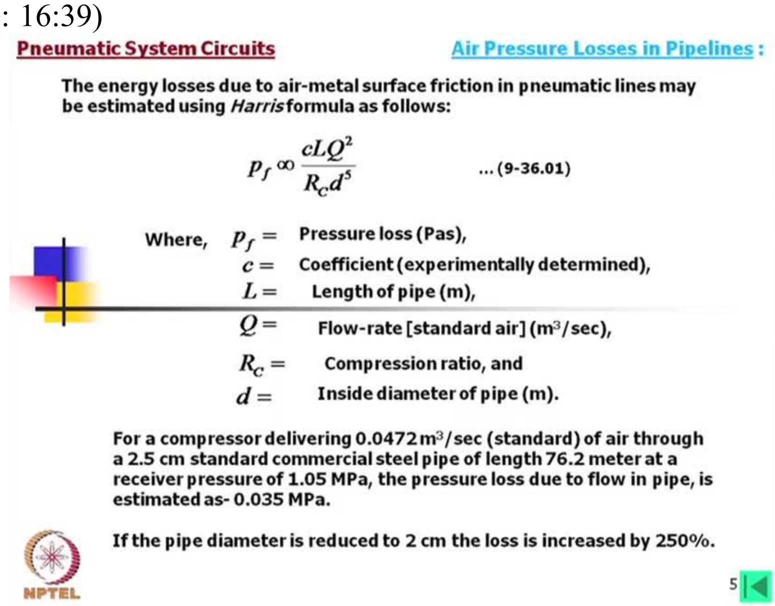

Now the energy loss due to air metal surface friction in pneumatic lines may be estimated using the Harris formula as follows, where this pressure loss I mean loss in terms of pressure is expressed in this form where PF is the pressure loss in pascals, C is coefficient which is to be determined experimentally. For this coefficient is for pipe losses. We are thinking of pipe losses. So where L is the length of the pipe, Q is the flow rate through that conduit in meter cube per second.

Again we call it standard air, that means standard air means it is some pressure, some temperature, et cetera mentioned. RC is the compression ratio of the system, d is inside diameter of the pipe. Now this C is to determined considering the type of pipes, type of conduits we are using. So usually, in case of pneumatic system, main pipeline is of metal. That is not flexible one.

So and metal means again it is steel. Nowadays stainless steel pipe is also being used because of the low-cost, production cost for the stainless steel. Otherwise previously, this was hardened steel was being steel, ordinary steel being used, it is medium carbon steel, not alloy steel. But again, the surface preparation of such pipes, even the material is same, maybe different. So there is some standard. Say in case of India, we call it Indian standard. Okay? According to that, this C is to be determined for a range of pipe.

And it was found that C also depends on this diameter, inside diameter d. That means, if we replace this C, we will find a factor is coming here, that numerical value something is coming here. And there will be something to be added with this power, subtracted or added with this power. It will become in this form. So this conversion I have not done but as far the calculations for a compressor delivering 0.0472 meter cube per second standard of air through 2.5 centimeters standard commercial steel pipe, this is this 1 inch pipe I have converted to like this. Length is 76.2 meter, that is around 250 feet at a receiver pressure of 1.05 mega Pascal, the pressure loss due to flow in pipe is estimated as 0.035 mega Pascal for this much of length.

Okay, this is all right, this 0.035 is not that a big figure but if we reduce this pipe size just from 2.5 centimeter to 2 centimeter, that means 20 millimeter. It was initially 25 millimeter and then if we reduce to 2 centimeter, 20 millimeter then the loss is increased by 250 percent. So therefore, determining the size is very important. Now I have not calculated but possibly, we have reduced the diameter by 0.5 millimeter. If we increase this by 0.5 millimeter, it will not be that it will be very efficient.

We will then we will find this loss is reduced but maybe only 20 percent is reduced. But for increase in 0.5 millimeter in the inside diameter, the quantity of air requirement will be huge. So just looking into this point that there will be frictional loss for smaller diameter, we will go for higher diameter. That should be not be the attitude. We have to properly calculate what might be the loss and then we have to select the pipelines.

That means, for a plant, while we are calculating the pipelines, it is impossible to calculate how much consumption will be everyday and other. So it is on the basis of average estimation and sometimes, it is found that this losses is not that optimum. You may need to change the whole pipelines which is expensive. But still, that means I just would like to mention, we should take a lot of care to select these pipelines.

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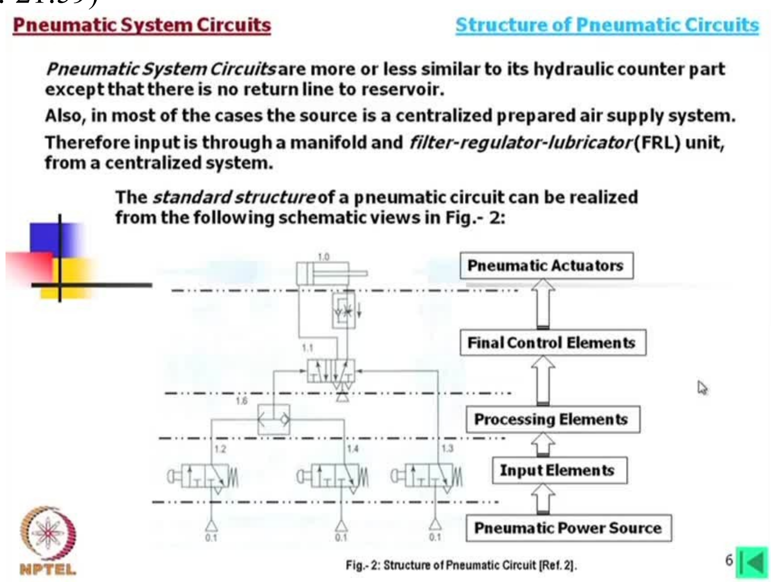

Okay now we shall come into that a circuit. So far what I have discussed that is mostly about the air preparation and what should be the line, distribution line, et cetera. But now let us come to the pneumatic circuits, what is used for the particular operational machines. Now, this is more or less similar to the hydraulic counterpart, except that there is no return line to reservoir because this is released to the air atmosphere. Also, in most of the cases, the source is a centralised prepared air supply system.

In there are some machines of course which is having special, even if in a plant, where you will find that they are using centralized pressure lines but you may find some machines which is having a special compressor attached to this machine, there is really some special air preparation is required. Otherwise, we will find normally there is a centralized system. So whatever circuit we have to think, we have to think that we are tapping a air source from a centralized system.

This means that we have to accept that at inlet, this pressure will be of a range. It may not be, we can have always the desired pressure. Therefore, input is through a manifold. Normally you will find, there are many manifolds are fitted at a certain distance and which is having filter, regulator and lubricator unit that which I have shown. It is very popularly known as FRL unit. Now we shall look into what should be the standard structure of a pneumatic circuit and that can be realised from the following schematic view as in this figure.

Now what we find that this is a pneumatic actuator, this is the application end okay? So we shall call an a actuator. Maybe an air motor also. Now next part, these 2, before entering into this actuator, we have some control units which is we should call final control elements. Now before that, there are processing elements. What is processing? Here only, as a processing elements, a shuttle valve is shown but it may not be shuttle valve.

It may be regulator, sorry pressure reducing valve, it might be a pressure control valve, it might be a flow control valve, et cetera and that flow control valve again for general, the any special control required for such operation will come here. And processing elements may have general some control valves and these are input elements. This means from the manifold, we need a regulator or valves, these are these elements.

And finally, this is our pneumatic power source okay? So broadly, any circuit, any system we can divide into few such elements. But if we think of this is the utilization and this is input end, that means from pneumatic power source, it comes to input element and then processing elements, then final control elements and then the actuator or motor, et cetera.

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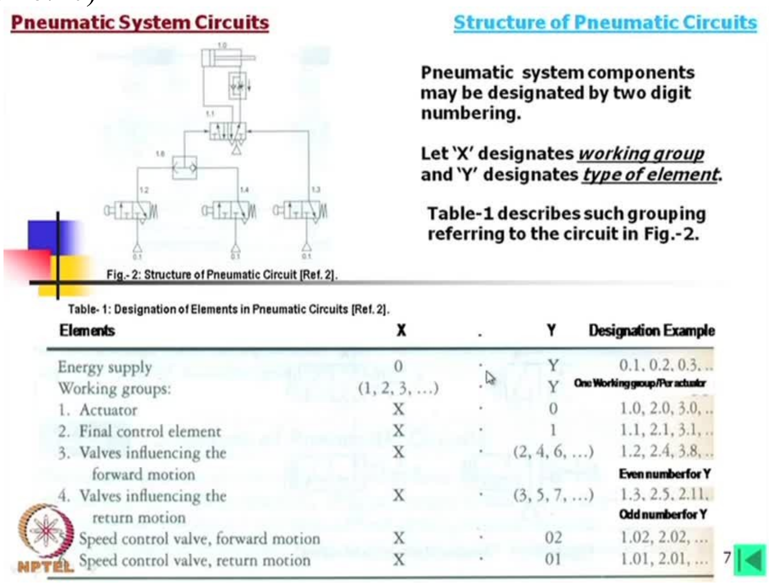

Elements	X	.	Y	Designation Example
Energy supply	0	.	Y	0.1, 0.2, 0.3, ..
Working groups:	(1, 2, 3, ...)	.	Y	One Working group/Per actuator
1. Actuator	X	.	0	1.0, 2.0, 3.0, ..
2. Final control element	X	.	1	1.1, 2.1, 3.1, ..
3. Valves influencing the forward motion	X	.	(2, 4, 6, ...)	1.2, 2.4, 3.8, .. Even number for Y
4. Valves influencing the return motion	X	.	(3, 5, 7, ...)	1.3, 2.5, 2.11, Odd number for Y
Speed control valve, forward motion	X	.	02	1.02, 2.02, ...
Speed control valve, return motion	X	.	01	1.01, 2.01, ...

Now what is this structure which I have discussed? Now what we can do? That we can designate these items by 2 numbers, here what we find, 2 numbers. In between that, one dot. This is 2 digit number, considering a dot. Now let us, 1st one is the X and 2nd one is the Y. Then X designates working group and Y designates type of element. Now in this table, what we find? Energy supply, that is in working group is 0 and designation example, Y might be 1, 2, 3, depending on different types.

So this working group, when the 1st supply we put 0. You can see, in place of X, we put 0 and this is 1 maybe for general supply, then 2 maybe another supply. Then working group may be 1, 2, 3 or et cetera, anything it can be. And one working group per actuator okay? It is then then we will come to the actuator. Let us come to the actuator. Actuator is 1.0. That means, working group is 1, 0 is the type of elements.

Now here, this type of element, 0 maybe single acting cylinder or 0 is given for say without spring, something is there. Then final control elements, say these are 1.1, so these designations. That, this is for again type of elements and this is for group. And here, it is given 1, that means what we find, except the supply, this here we find this is in working group 1. All such components for a typical type of work which is in the group 1, so we have used group 1.

And then as such the element, say actuator of this type, this designator 0, this control elements is 1, then this element is 6 and this is 4, this is 3, this is 2, et cetera. So this is just to give you an idea how these components are designated. Now again, what I feel? There is not must standardisations about these. These are we should call a company standard. A company, they can designate such components for their machineries what they are manufacturing.

Again such this designation is not possible if you buy a machine and in your plant where the general pneumatic system is there and utilising these components. This is to give an idea and that is how these are components are differentiated.

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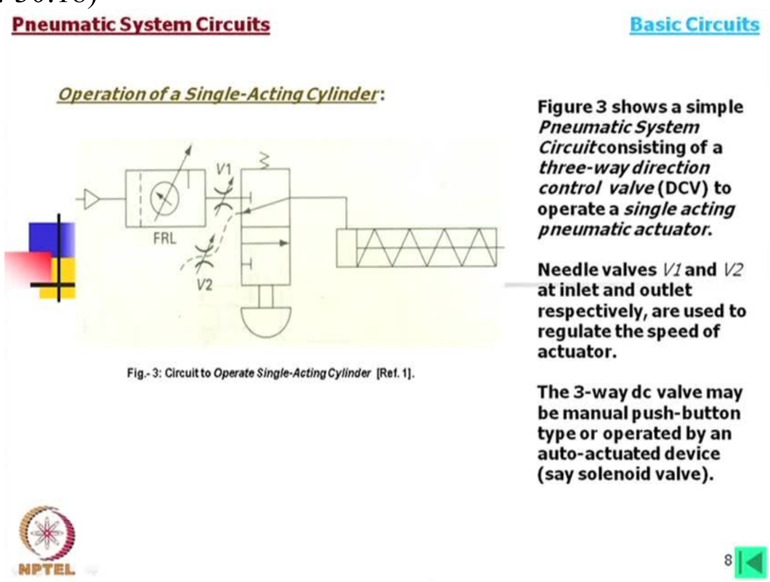

Now we shall come to the basic circuit. Now this is a operation of a single acting cylinder. Now, from looking in this figure, you can see, this is the you have to recognise such components. See this is the cylinder. What type of cylinder it is? It is a single acting and what these lines means, these triangles? This is nothing but a spring. That means, in case of single acting, you have to think of how it is returning.

If it is a vertical one, then due to self-weight, it can come down. But normally, there is no guarantee that we can use the such a cylinder always in vertical position even if it might be in the downward directions okay? So looking into this, all such single acting cylinders are mostly with a return spring and that spring is just to overcome the friction, minimum friction inside. If there is any pressure is trapped this side, then this will not return.

We have to release this air completely and then due to the spring action, spring release, it will return to its original position okay? So this is an cylinder. And from there, this is if we know about the symbols, what we find? How many ports are there? We find the 3 ports. So that we should call there is a three-way okay? And what it is? It is a looking like a button.

It is really a pushbutton. And these are usually manually operated and there, what we find? There is a spring. What does it mean? This spring always bring this pushbutton valve to a position. What position it is? It will remain in this position normally okay? Now this is FRL unit and this is, this indicates that this is from the common source. Now what happens?

This is a simple pneumatic system circuit consisting of three-way and 2 position, this is called direction control valve. In hydraulics, normally we use word, DC. And both D and C small usually. There is no harm, you can use capital D and C. But in case of pneumatic normally, it is called DCV. We do not want, we should not call DCV valve, we call DCV, the direction control valve.

Now this direction control valve, normally remains in this position. That means, the air from this piston end is going to the atmosphere okay? Now again what we find? That there are 2 valves. It is the name is needle valves. Basically, this is a throttle valve which is controlling, needle means there it is a small needles and orifice which is controlling the area and this is usually screw type, not pushbutton type. You can just simply rotate it just to reduce the orifice size and in turns, it gives the flow control.

Obviously, there will be pressure drop but flow control will be there. Now we can control this flow at in at the entrance, that mean entrance means, you see when it is coming to his position, simply what we can do, the whole valve we can push it here. That means, when the air is entering, there is a control of the flow. It is possible to control the flow. Even the we can also control the flow when the air is going out.

Why we need to control the flow while it is going out? So that it does not returns suddenly. Say it is pushing something but it is also being released very slowly. If there is no harm that it can return very fast, we do not need this valve at all. The three-way DC valve may be manual pushbutton, most of the case it will find pushbutton type for a single machine we are operating but in a sophisticated machine, or we need very quick operations, then we can use the auto actuated devices.

Say for example, solenoid valve. That means, here, this actuation is through an solenoid okay? So this is a very simple single acting cylinder operation.

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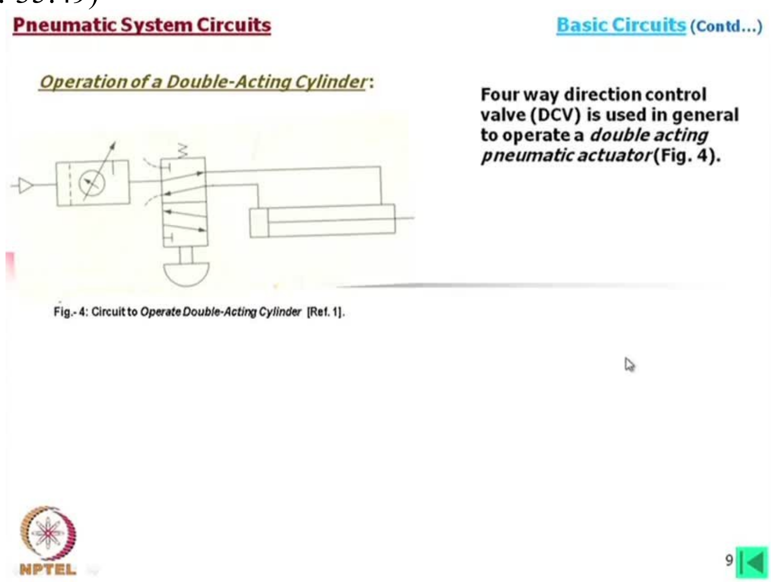

Now if we consider the double acting cylinder, in that case what we find? These are actually there are 5 ports. Sometimes we can consider, this is a, these 2 are common because both are exhaust but in many cases, this there might have to exhaust from a valve. So basically, we should call it 4 way, not 5 way because these 2 are exhaust. How to count how many ways are there? This is simply count the port in a single icon, in a single block.

There are 5 ports, so we may call it is a 5 way valve. And how many positions? 1 position and 2 position. Now in this case, that means this is a simply we can call in terms of hydraulics, we call it 4 way. In that case, that both sides are actuated by the airflow okay? Again, this might be pushbutton and this spring and this figure indicates, normally it is in this position. That means it is in normal condition it is in retracted positions.

But if you push it, this will be in the other side okay? So double acting operations is similar, more or less similar. Only thing, this is through a control valve.

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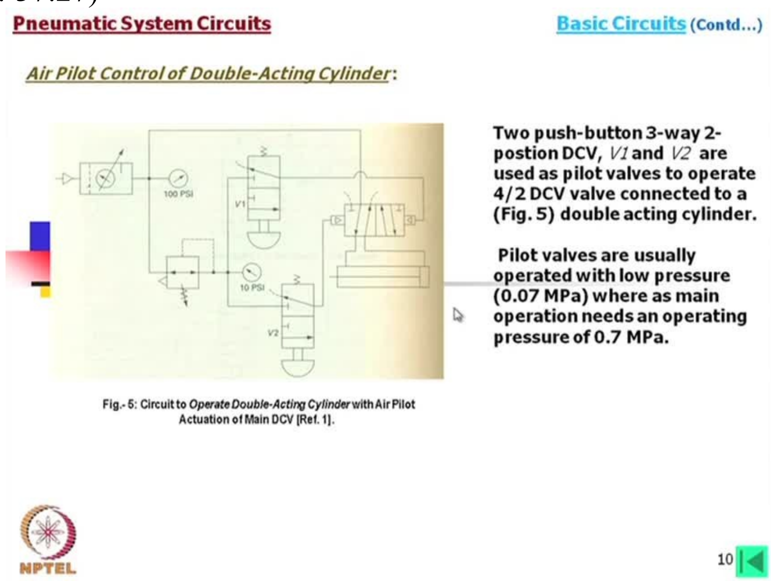

Now air pilot control of double acting cylinder. The same double acting cylinders and we have the same valve but instead of pushbutton, what we find? This is actuated by the air and that is called pilot operated. Now this pilot valve is named as V1 and V2 and in this pilot valve, what we find? This is again 3 by 2 directional control valve. But if we think of the pressure, this main system is working with one pressure and this system is working with an another pressure.

So we need to have a different, sorry this is pressure regulated valve. That means main source is 100 psi. Whereas from the main source, it is utilising for this pilot operations, there is only we are using 10 psi, that is 0.07 mega Pascals whereas this is 0.7 mega Pascals. Now the operation as you see, V1 and V2 are used as pilot valves to operate 4 by 2 DCV again I have made a mistake, DCV valve. I could have write, it is DCV only.

Pilot valves are usually operated with low-pressure, 0.07 mega Pascal whereas main operation needs an operating pressure of 0.7 mega Pascal.

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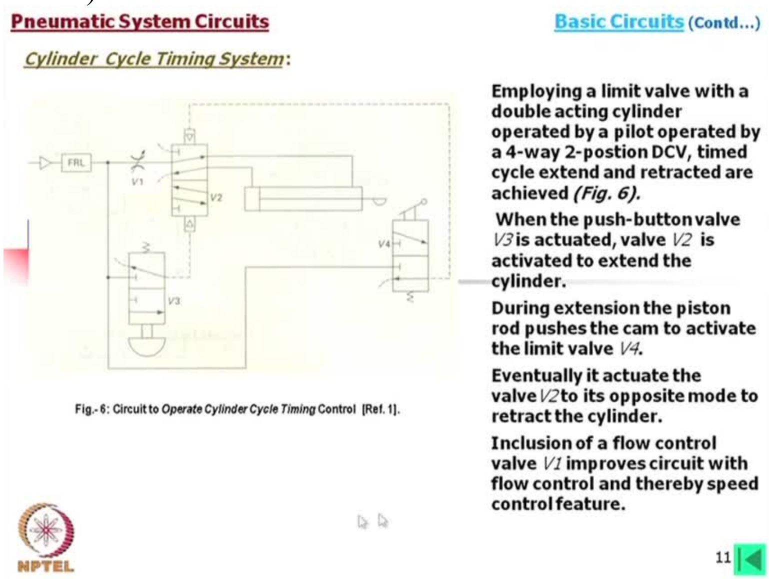

Now we are coming to a cylinder cycle timing systems. In many cases, we need not only the velocity control but there is some timing is there. That means, after doing, say it is like that at certain portion with one velocity and maybe with another velocity or next operation should start after some time. In that case, what is done? If we 1st of all look into the system, this part is same as it is and then what we find?

There is a flow control valve, needle valve and then there is a direction control valve and which is pilot operated okay? Now in these operations, we find here one pushbutton is there. Let us see how it is being operated. Employing a limit valve with a double acting cylinder operated by a pilot operated 2 by and a timed cycle extend and retracted are achieved. Now when the pushbutton valve V3 is actuated, this is actuated momentarily to extend the cylinder during extension, now this is operated to extend the cylinder.

That means, in normal condition it is like that. Now when we push, this is connected to that. Then this air is allowed to come over here and this is operated. This operation means then this is being extended. Air is going to this side, extended, and this is being actuated. Now this is our limit valve. This valve is V4 is limit valve. During extension, the piston rod pushes the cam to activate this limiter valve.

So when it is extend after so position of this valve or rather to say this cam and this piston, is important. So this is an with an proper fittings, it is done. Eventually, it actuates the valve V2. So when it is pushed then it operates valve V2 to its opposite mode retract the cylinder. That means we are pushing it, so operation, some operation is being done. But when it touches, is automatically it retracts.

Now during retraction, we can control this as well. This means that if we operate this valve,V1 then this will return at a controlled speed. Inclusion of flow control valve V1 improves circuit with flow control and thereby speed control features okay?

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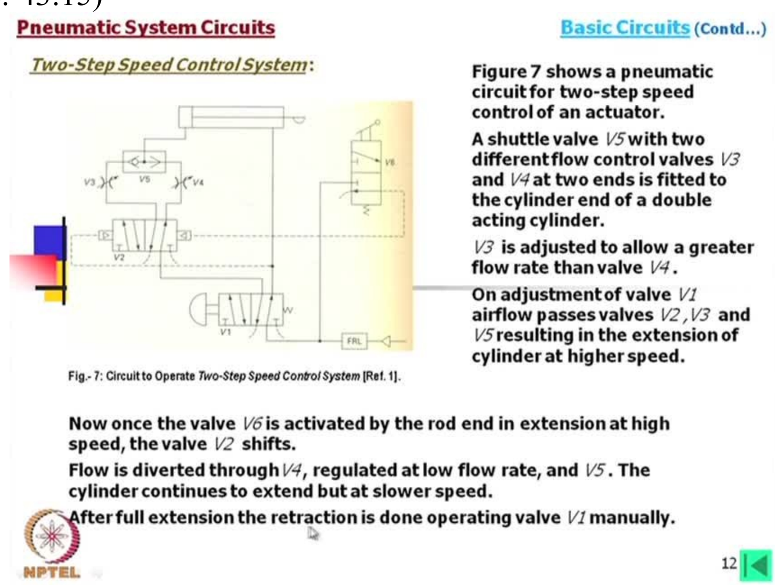

Similarly there is, we can think of the another circuit which is two step speed control system. In this case what we find that there is also an limit switch is there and this is the cylinder and at this stage, we find, 1 shuttle valve with 2 needle valves or throttle valve or so-called flow control valve. And here what we find, that the result direction control valve which is pilot operated and this one side is through a pushbutton, other side is from a limit switch.

A shuttle valve, this is called shuttle valve. Shuttle valve means, if the air is going from this side, it cannot go through this, it will go here whereas when the air is coming from this side, it can, it will go through this, it will not come back to this side. This means that this in many cases, these operations is depends on the pressure at these 2 lines okay? A shuttle valve V5 with 2 different flow control valves V3 and V4 at two ends is fitted to the cylinder end of a double acting cylinder.

Okay. Then V3 is adjusted to allow a greater flow rate than valve V4. So V3 is having greater flow rate than V4. That means, this has more resistance, this has less resistance. On adjustment of valve V1, air flow passes valves V2, V3 and V5 okay? Shuttle valves, in the extension of cylinder at high speed. Now once the valve V6 is activated by the rod end in extension at high speed, the valve V2 shifts.

Because a signal is coming from here, pilot and then this shifts. And then, flow is diverted through V4, through this. Regulated at low flowrate and then V5, the cylinder continues to extend but at slower speeds. That means, when it reaches here, then this is actuated and after this position, this will move at slow speeds.

So this means say for example you can have some operations that for some portion, you need less force, high-speed and then more force, low speed. So you can, this might be position of this with respect to this one, possibly, you can adjust. By adjusting this, you can make this operation of the cylinder at 2 speeds and it might be the half the stroke length, it might be this one third high-speed and two third slow speed, et cetera et cetera.

After full extension, the retraction is done operating valve V1 manually okay. So this means that we just maybe this pushbutton if we release, it will come back to this position and then it will be retracted okay? Now it might be also as I told, pushbutton type or we can a lever type. That whenever we can fix the position, either of this.

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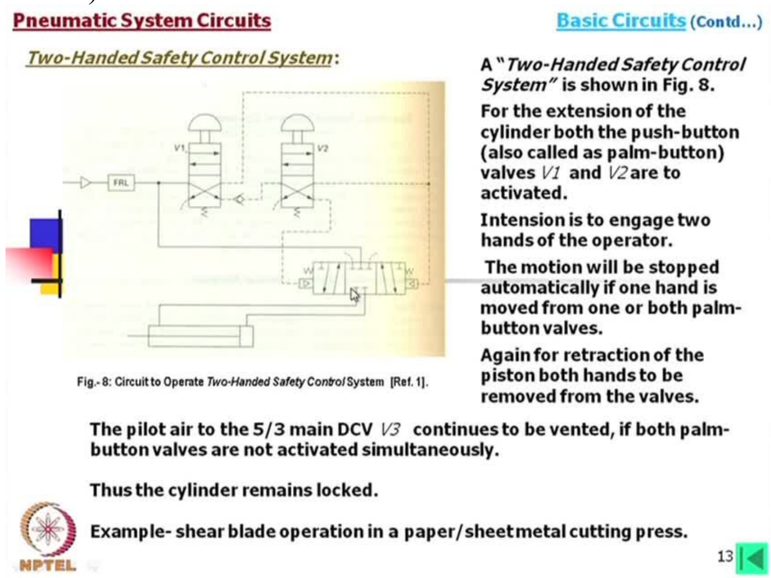

Now another very important operation, this is usually with the pneumatic. Can be with hydraulic also. See, this is called two-handed safety control system. In this, a two-handed safety control valve system, what we find? We have a double acting cylinder. Here, how many ports? We have 5 ports and 3 positions. This is the neutral position. So this we should call 5 by 3 DCV and these are 4 by 2 pushbutton type valve and this is the main supply source.

Now for the extension of the cylinder, both the pushbutton also called as palm button. Palm button means these are usually you will find very big size. You can simply push it like this, are to be pushed. That means suppose you are pushing this one, this pushing this one means the air is going like this. So this is going here and it is coming over here and it is trying to actuate this one. But this one you have not pushed.

So in that case, what is happening? That this is not activated, this is still in this position. So you will find that this is not being actuated. Only if we push both, then this will be actuated. Intention is to engage two hands of the operator. The motion will be stopped automatically if one hand is moved, one or both Palm button valves, from one or both Palm button valves. Again for retraction of the piston, both hands to be removed from the valves.

You can study this valves very careful. Then you will find that to operate this one, that is for this movement from this side, we need to push this one. And again for moving in the opposite directions also, we need to remove both the hand okay?

Now an example, good example is that before that I would like to say, this is a 5 by 3 main DCV, V3 continues to be vented if both palms, Palm button valves are not activated simultaneously. That means, in neutral positions the air is being vented. Now thus the cylinder remains locked. In this position, you will find that the air is coming and this is being vented and it remains locked in this position. This indicates that the no passage is allowed in this position. No air is allowed to through this passage when this is in this position.

Example is that shear blade operation in a paper or sheet metal cutting press. Usually if you look into the cutting press, the cutter is like that, then paper is placed, this paper is placed like this and we find what where is the line. For that, you will find a separate lever is there, usually handles by which you can bring down the shear to this line just to have line. In some cases, you will find that there is a the lighting arrangement, very thin line is coming on the paper by which you can see that whether you have placed this one properly.

After that, you need to shear it. Now, you may keep your hand and try to operate this one, then your hand will cut, this your fingers will cut so that this arrangement is that these switches are at the 2 ends, not even at a close place. You cannot push these two by the single Palm. These 2 ends, you have to push this one, you have to remove your hand, push this one. So it will come down and it will shear, shear the papers.

Now to release it, you have to move both hands. So it will be released and then it will become in the locked position.

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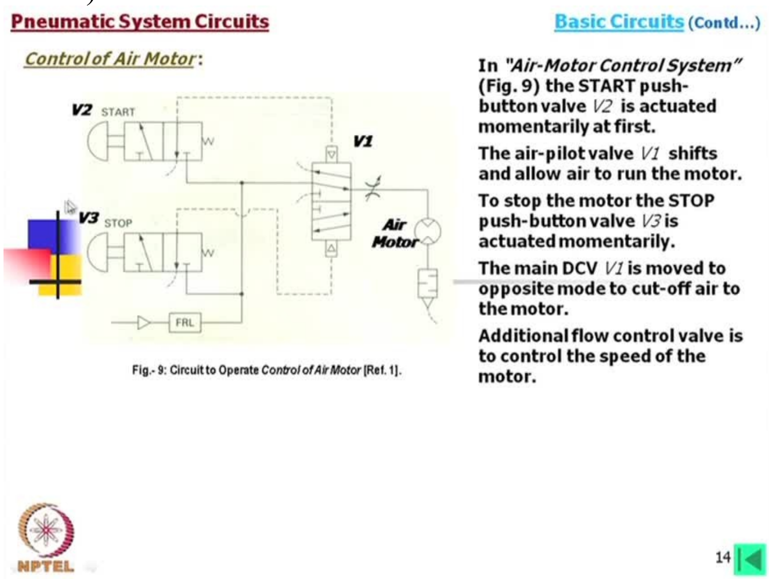

Now control of air motor. This instead of actuator, if we use an motor and this one is the silencer, usually with the cylinders, there may have silencer or the silencer is not that very I would say very sophisticated but in case of air motor where the continuous flow is being exhausted, you need a good quality of muffler or silences. So that is this one. And this, in this air motor, what we find? This valve again we find that we have the 4 by 3 DCV is there and then there is one start and one stop pushbutton type 3 by 2 valve is there.

Now in air motor control system, the start pushbutton valve V2 is actuated momentarily at 1st. So we push this one. Once we push this one, we get this position. That means this path is being connected okay? That means this path is being connected. Then the air pilot valve V1 shifts and allow air to run this motor okay. To stop the motor, the stop pushbutton valve V3 is actuated momentarily. Then what happens?

The main DCV here is moved to opposite mode. It moves to this mode to cut off air from the motor and in this way this running and say it is what we could do? That we could have only this valve with some pushbutton actuation by the from the main source but using these two switch, what we do? If we put the start and then we leave it, this motor will continue to run. Okay? In case of using one single valve with a pushbutton, we have to keep it closed and then it will run.

But with this system, what we do? Simply like a switch as if a on switch, we do it and then motor is running. Until we move this one, this will not be stopped.

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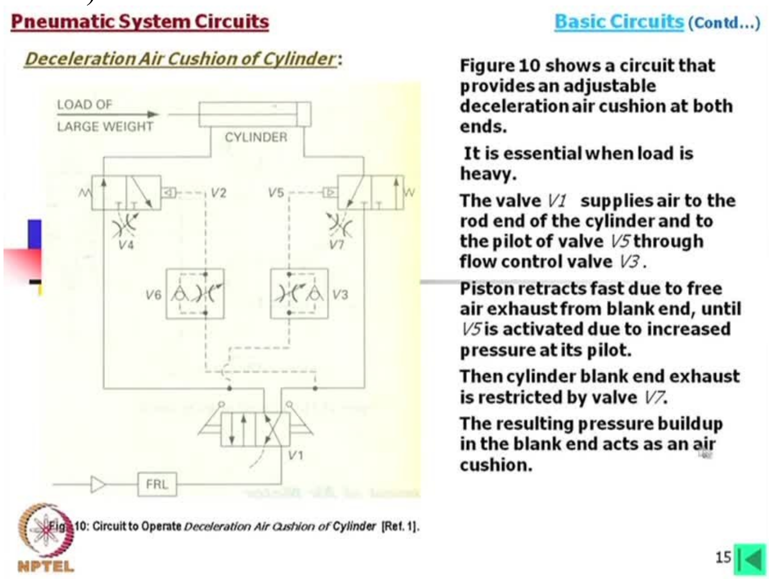

Sorry, there was an additional flow control valve which was being used to control the flow rate. That means you can control the speed of the motor by controlling the flow rate. Now this shows a circuit that provides an adjustable deceleration air cushion at both ends. In many cases, particularly where the heavy load is there, we need a cushioning effect at the end of the cylinders.

The cushioning effect is also used in case of hydraulic cylinder. In that case, the system is like that, when the cylinder is reaching towards the end of the stroke, then the outlet port through which the oil is going out, that port is controlled. The area of that port is controlled and there a cushioning effect. In case of air, how it is done let us see, pneumatic systems. The valve V1 supplies air to the rod end of the cylinder and to the pilot of valves V5 through the flow control valve V3.

So the valve V1 supplies air to the rod end side, as well it supplies to the pilot side of this okay? Piston retracts fast due to free air exhaust from this end until V5 is activated, until this one is activated due to increased pressure at its pilot okay? Then cylinder blank end exhaust is restricted, this side is restricted by valve V7. The resulting pressure built up in the blank ends acts as an air cushion okay?

So operation is like that. The valve V1 supplies air to the rod end, this side okay? And to the pilot side of this valve, V5 through a flow control valve, V3. Piston retracts fast, it is retracting very fast from blank end until V5 is activated due to the increased pressure. This pressure increases. Due to this restrictions and due to this increase in pressure when this activates, then V7 become activated and due to that, the airflow will be restricted and there will be cushioning effect.

And the similar is achieved when it is moving from the other side also. So I suggest that you should study this valve to understand how this operation is being done. It is, it will not be difficult to understand but you have to keep in mind that it is moving towards the end, automatically there is a, pressure is being increased to operate this one. Possibly we can adjust this.

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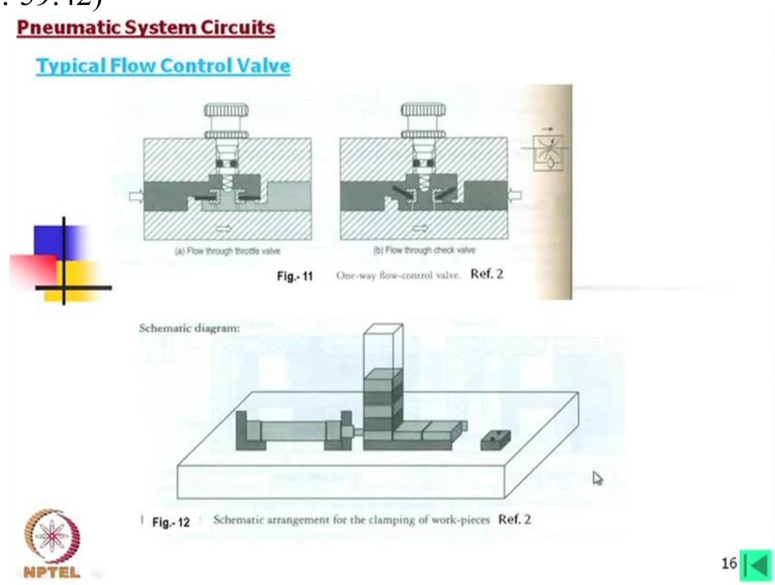

Now say if we look into the valves, these are, we have not studied the valves in detail, so this is a typical flow control valve and practically, this is a throttle type of things. When we rotate this one, gradually this passage is decreased. That means, the angular space is decreased and in that way, the pressure flow rate is controlled. Say such applications, application of such valve it seems say for example, this is an schematic arrangement for the clamping of workspace.

Say this, this is air is flowing and we are notif we completely trap suppose if we try to hold something, we are trapping the fluid, you will find that after some time, the pressure is reduced and the clamp is not working. So usually what is done? The flow is always there with a pressure drop. That means, inside the cylinder which is clamping, there is always the pressure with a constant pressure but the flow is maintained. That means, it is always keeping the, this cylinder filled with required volume and the clamping is done in that way.

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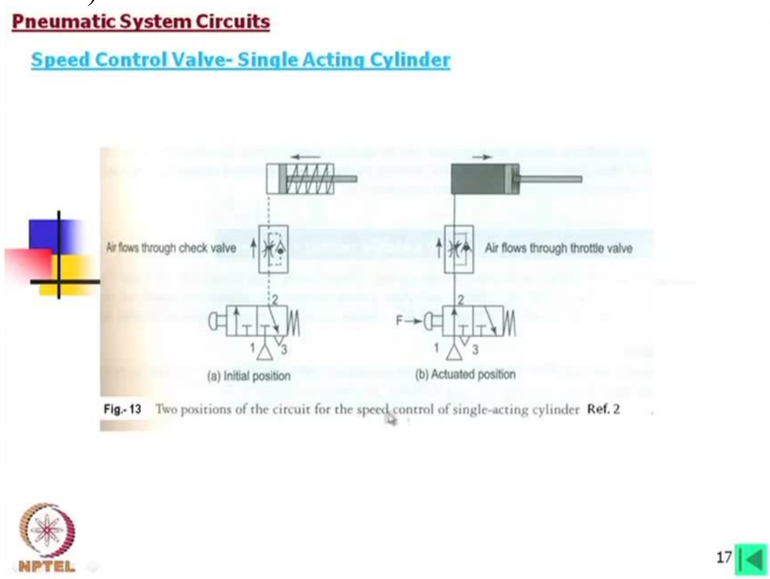

Now this is a true position of the circuit of speed control of a single acting cylinder. This is already, we have discussed, this is again shown in this form how the 2 different positions are there and then if we look into such operations, we have to always keep in mind that has particularly this is a compressible fluid at the beginning and at the ends, this is not, neither the constant speed is possible, not the full pressure is achieved.

Or in other words, this is not the desired pressure. So it might be the actual operating range from here to here, say for example, we are using this air for some cutting operations or something like that. Say we are cutting a plastic, finishing a plastic sort of things, very soft material with the pneumatic, not hydraulic, in that case, say when the tool is moving, we need a constant force, that operating range to bewithin this range.

So this knowing such pressure and speed characteristics is important for such circuit. In case of hydraulics, this zone is very small.

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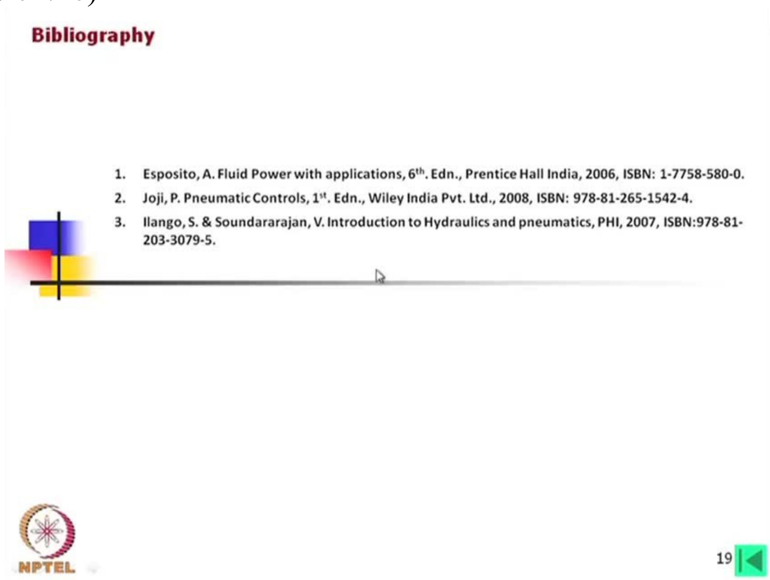

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