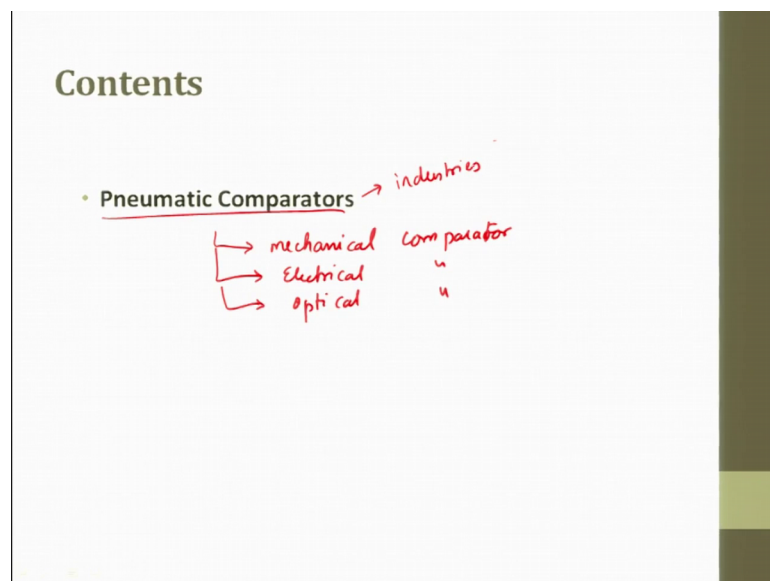**Engineering Metrology**
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Lecture - 19
Comparators (Part 2 of 2)

So, we will continue with the Comparator.

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So, in this lecture we will try to take up Pneumatic Comparator. So, till now what all have we seen? We have seen mechanical comparator, then we saw electrical comparator, optical comparator; optical is the most accurate one optical comparator. So, these are something which we saw. And the last part of the comparator is pneumatic comparator.

Of course hydraulic can be used, but the only problem is hydraulic if you pass through an orifice it is leaking and it will create lot of problem. So, pneumatic operator is the last one which is very important which is used in almost all industries. Industries for the regular application that means, to say at the top floor level. If you want to measure your diameter of a hole or a diameter of a barrel components, so then what they do is they quickly go for a pneumatic type and the pneumatic type is very easy, accurate and it is also sensitive.

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So, pneumatic comparator pneumatic means air, air is used for measuring. The basic principle involved is that the change so that that the changes in the calibrated flow respond to the changes in the part feature. For example, when there is a diametrical change then immediately what happens is there is a flow which happens this flow is restricted or it is changed because of that there is a back pressure that back pressure is known. This is achieved by using several methods and it is referred to as pneumatic gauging, air gauging or pneumatic petrology.

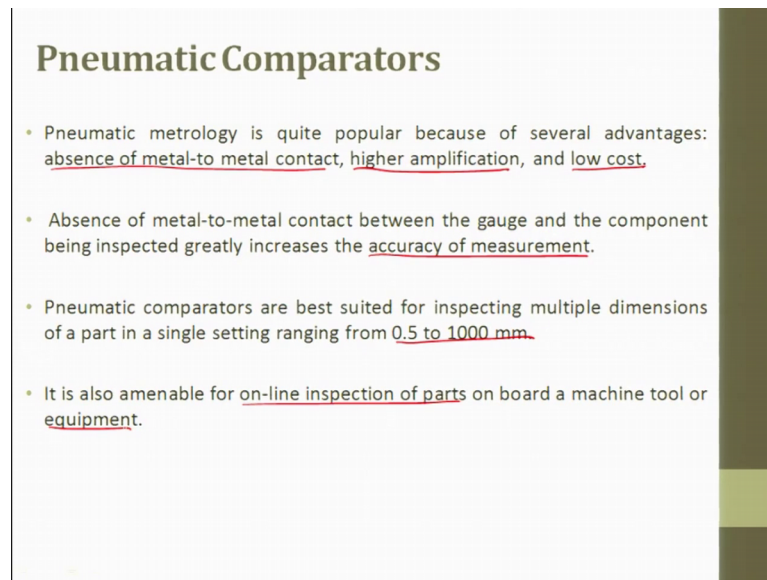Since pneumatic gauge lends itself to the gauging of several features at once, it has become an indispensable part of production inspection in the industries this is what I was trying to tell. So, more than mechanical pneumatic here pneumatic you do not have moving parts. So, moment the number of parts are reduced then the repeatability and reliability of the equipment goes very high, that is why today it is people always move to pneumatic, to people move to electrical because it is all non contact and people look for optical. Optical today they use exhaustively laser. The assignment what I gave to you to find out how do they find the distance from the earth to moon is by using a laser, ok.

So, optical, electrical, pneumatical becomes more usage as compared to that of mechanical because of their number of moving parts is less and they are very easily adaptable to the production environment.

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Pneumatic metrology is quite popular because of several advantages it has absence of metal to metal contact. So, there is no wear and tear high amplification can be done depending upon your circuit, pneumatic circuit what you develop and it is low cost reliable

Absence of metal to metal contact between the gauge and the components being inspected greatly increases the accuracy of measurement. If you go back and see in the dial gauge type we always said that the dial gauge there is a wear and tear which is happening at the tip. So, this wear and tear leads to an error when you try to measure it, ok. And the pneumatic gauges are best suited for inspecting multiple dimensions of a single part setting range from 0.5 millimeter to 1000 millimeter this is on the higher scale. But generally in a shaft floor automobile industry, hydraulic industry, infrastructure building, so we always go talk about 0.5 accuracy; millimeter accuracy. It is also amenable for online inspection of part on board a machine tool or an equipment this also can be done very easily with the pneumatic type comparator.
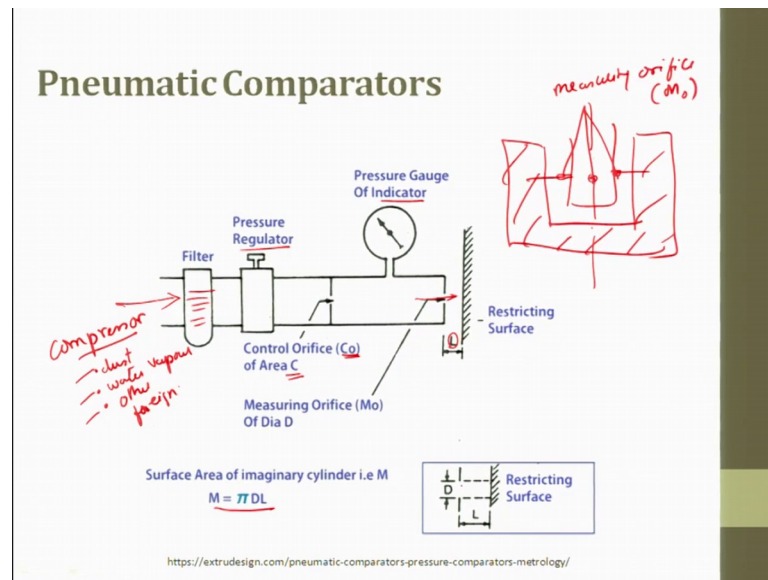
What happens in a numerical comparator or pneumatic comparator how does the circuit look like? Basically, what happens you try to take air from a compressor. So, whenever you try to take an air through a compressor what you do is you try to take free air, then you try to compress the air, when you try to compress a free air there is a possibility that you might have dust, you might have some amount of water vapor and you might have other foreign particles.
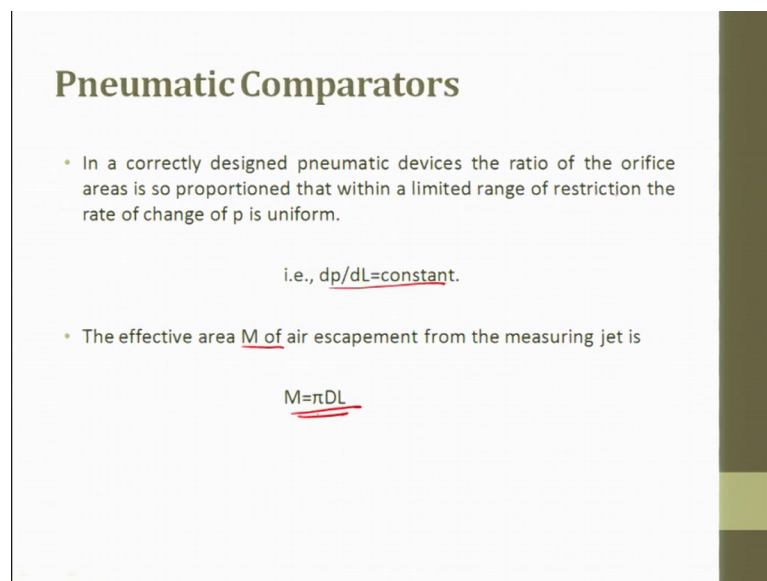
So, all these things from the compressor first thing it gets into a filter. So, this filter tries to filter all these things to a large extent, then the from the filter whatever you have filtered there is there is here you basically a filter will be you can have a paper filter through which the air pressurized to move it has orifice the dimensions of the orifice can be changed depending upon your requirement. Then this is allowed to go to a pressure regulator. So, in this pressure regulator you try to control what is the pressure you want to have such that you have a uniform flow.

Then what we do is it this after this the pneumatic or the air compressed air is passed through a controlled orifice Co of a cross check of an area of C, control orifice C naught of area C, then it passes through a pressure gauge of indicator. Here it is a regulator here it is an indicator, look at the difference here it regulates here it only shows then afterwards it is just then passed through here measuring orifice M naught of diameter D.

So, this is controlled orifice this is the measuring orifice. Once I say measuring orifice through which the air exits the setup, and then you have a restriction surface whatever is the restricted surface. It can be when you try to do a hole suppose this is the gates and then you have hole which is there and then you will have a components.

These are the orifices these are nothing but the measuring orifice M naught, and this is the restricted surface. So, schematically we have put, but in real time you can have it. So, if it is a cylindrical component then it can be component can rotate or it can be through here it is a blind one which I have drawn, this is the restricted surface. So, the distance between the measuring orifice of the dia and the restriction orifice is called L. So, the surface area of imaginary cylinder that is M which is nothing but this and here the orifice diameter is D and this is the length. So, this is the zoomed to figure of it this is the D whatever is given here.
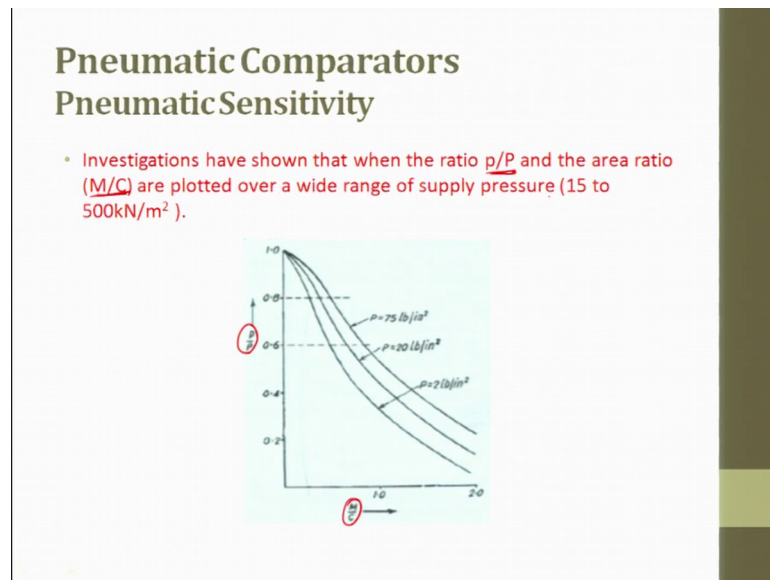
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So, in correctly designed a pneumatic device the ratio of the orifice area is so proportioned that within your limited range of restrictions the rate of change of p is uniform. So, dp by dL we will try to maintain it as constant. So, the effective area M of the air escaping from the measuring jet is this M nothing but pi into D into L.

So, the sensitivity of a pneumatic gage can be brought like this. So, this is dp by p and this is M by C. So, there is a ratio. So, we try to put these two in ratios and then we try to take a linear range whichever is there and try to operate our device within that linear range.

Investigations have shown that when the ratio p by p and the area ratio M by C are plotted over a wide range of supply pressures from 15 to 500 kilo Newton per meter square.
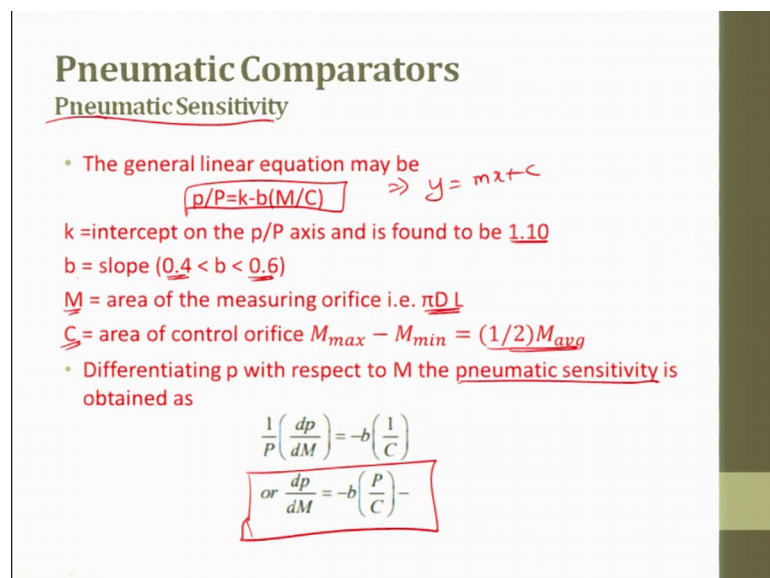
The general linear equation may be written in this form linear equation, this is nothing but basic linear equation of y equal to M max plus C. So, what we are trying to do is we are trying to take this linear equation bring it here. Why linear because linear is a place where we can try to dictate or demand what the output we want, where here k is the intercept of p by p axis. So, if you go back p by p axis, k. And axis and it is found to be 1.10, go back to the figure 1.10 and b is the slope which varies from 0.4 to 0.6. M is the area which is given pi dL and C is the area of controlled orifice which is M max minus M min which is half M average. So, differentiating p with respect to M what we get is the sensitivity of the pneumatic system we get. So, this is nothing but this.

So, now what are we trying to talk about? We are trying to talk about the sensitivity how much accure or what is the resolution, how do you improve the resolution is nothing but the sensitivity.

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So, with this we will try to take this equation further. However, it must be remembered that M is dependent upon C. If you go back to the previous figure you see that M this is M naught and this is C naught. So, M is depended on C.

See since if we work with a range of 0.6 to 0.8 then the average value of M corresponds to p by p is 0.7. If you go back and look into the figure p by p 0.6 to 0.8 and this is somewhere here. So, we are trying to take this portion, 0.7, p by p is 0.7. So, p by p is 0.7, 1.1. So, we put back into the equation. We try to get the value for C. So, this is the

ratio for b C, then substituting back into the equation ignoring the negative terms. So, dp by dM is nothing, but point four times p divided by M average. So, this is nothing but the sensitivity.

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Now, if we want to look at the overall magnification, the overall magnification is the rate of change of output with respect to input that is magnification. The output variable in the pressure gauge or water column reading today it is only pressure gauge and the input variable is surface displace is a surface displacement.

The three factors combined to produce the overall magnification are pneumatic sensitivity, indicator sensitivity and measuring head sensitivity. So, that is nothing but dp by dM place one role, then dG by dp that is nothing, but the output gauge magnification where G is the gage reading and p is the pressure, and the measuring head sensitivity that is the rate of change of M with respect to the displacement of the restricting surface dM by dL. So, this one plus this one plus this one are the three major factors when it is combined try to overall effect the magnification of a pneumatic device.

So, the overall magnification is nothing but dG by dL is equal to dp by dM into dG by dp into dM by dL. So, where M is given by this and dM by dL is given by pi d. So, L max minus L min is equal to half. So, in the linear scale of R, of the length R provides reading of p over the range of 0 to p then dp by dG is nothing but R by P and this is dG by dL which is the gauge. You have combined and we have got dG by dL is 0.4 times R by L average. And what is L? This is your L, this is your L. So, keep that in mind this is your L, this is D, when we said pi dL this is what is D and L, ok.

So, the in the linear scale of length R which provides the reading of p over the range of 0 to p then dG by dp equal to R by P. So, after this magnification this is what we try to get in this equations.

So, to recap what all we saw in this particular chapter where in which we studied about comparators. We first saw what are the functional requirement for comparator, then we saw classification of comparator. We saw mechanical type that is dial gauge, Johnsson Mikrokator, then we saw sigma micro comparator, then we saw a mechanical optical comparator, then LVDT linear variable differential transformer, where in which there was a primary coil, secondary coil, and then inducing. Then we saw electrical comparator, finally, we saw what is pneumatic comparator.

So, these are all the different kinds of comparators which are available in the market which is used for measurements. And again I repeat comparators are only used for comparing the date the standard with respect to the achieved here. We do not talk about the basic size, we talk about the tolerance alone which is there for example, 40 plus or minus 0.1. So, we try to talk about a range for this and we do not talk are the basic size measurement we do not do. We just take only the tolerance range and try to find out whether the component falls within this tolerance, ok.

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So, task two for students. So, I would like you to list down, list down 10 different components which components slash feature features which can be measured only by pneumatic comparator. Please write list down the 10 components. These assignments are very useful you do not have to submit it to me, but these assignments are very useful from the examination point of view, so, 10 different comparators or features. You can take a single component make 10 features in a single component and say these are the components which can be made which can be measured only by pneumatic and not by anything else.

The next one is lists down 5 different applications, 5 different applications where LVDT is used. We have talked about measurement, you can also think any or look for any other things where LVDT is exhaustively used for applications.

The last one is profile projector is used in tool makers in tool room or in tool room application. Why? Is the first question, and the next question is - draw different components for this profile projector usage, for this instrument usage, ok. So, these are all just you have the refer some website or refer some books and start writing it down because there can be an application based questions in your end semester, with that.

Thank you very much.