Principles of Industrial Engineering
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Lecture 57
Quality Control: Control Charts

Hello, I welcome you all in this presentation related with the subject Principles of Industrial Engineering and you know, we are talking about the quality control. In the previous presentations we have seen that, therefore approaches which have been used for quality control.

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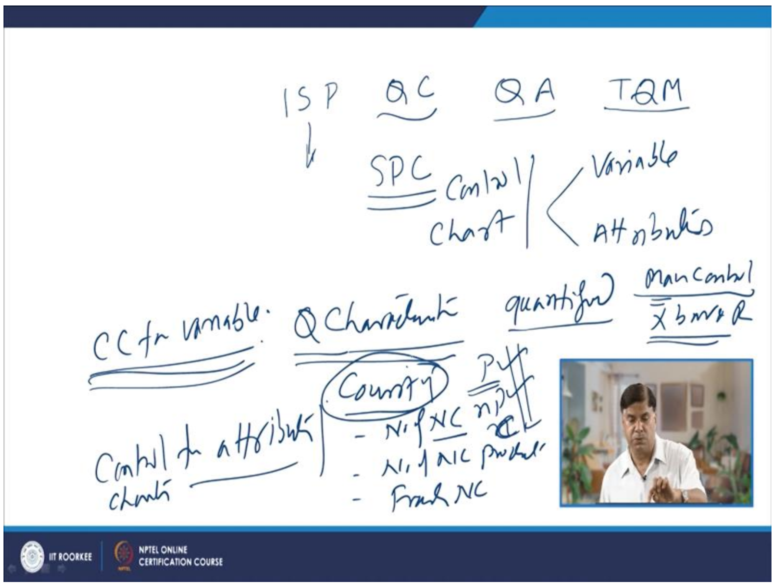

And these have been developed over a period of time which involved. Like inspection, then quality control, quality assurance and then total quality management. In case of the inspection approach up product which has been manufactured is inspected to see if it is of the acceptable quality or not and if it is not, then it is rejected.

So only the acceptable quality items are accepted rest are rejected or they are sent as a scrap or sent for reworking. In quality control approach this works on the controlling the process which is being used to manufacture the products, so if the process is in control, it is expected that whatever output is there from the process that will also be of the acceptable quality.

Well, in case of the quality assurance this is about documenting the things that we are doing and whatever we are doing that is documented. So that the assurance can be given to the stakeholders outside the organization to win the confidence of the stakeholders outside the organization and the quality assurance helps in.

So the ISO 14,000 ISO 9,000 and all those certifications are related with the quality assurance and a total quality management is based on the combined use of the human resource and the system, both are developed and integrated in such a way that that the quality products and services can be offered and it is based on the fact that even if the system is perfect means machines, procedures, everything is fine.

But if the human being or the operators and workers if they are not quality cautious, than even the good systems cannot help in producing the quality products and services. Therefore, it is important that human and the system both components are integrated well and they are developed in such a way that the quality products and services are produced. So SPC statistical process control was one of the ways by which the processes can be kept under control.

And what it assumes that if the processes under control, then the output of the process will also be acceptable. There are various tools under the SPC. So one of the tools is the control charts for quality control and in case of the control charts the two types of the control charts are developed. One is the control chart for variables and another is control charts for attributes. So the control charts for variables is developed when a particular quantitative value of the product feature is important for the success for acceptability for customer satisfaction.

Then the quality characteristic is selected in such a way that that when that particular quality characteristic is within the control within the acceptable limit, then the product will perform satisfactorily and it will be acceptable to the customers. So the choosing the quality characteristic choosing the quality characteristic is crucial in case of the quality control, control charts for variables.

Because there are many characteristics and all may not be equally important for the success of the performance of product or for making the customers happy or for the customer satisfaction. So choosing the relevant and important quality characteristic is crucial and only that is quantified. So the selected quality characteristic of the product is quantified and efforts are made to control to control the process in such a way that the products being manufactured are having those quality characteristics which are important for the product for the success of the product.

So the measurement of the those relevant important quality characteristics for which a control chart is to be developed is important. These maybe inform of like say number of kilometers a car goes in. So the data is in quantitative form or the height or width, weight, length, the dimensional feature, structural features so number of the characteristics which are measurable and can be expressed in quantitative terms.

So those characteristics are selected which are important than they are quantified and expressed in numerical terms and then for them control charts for variables is developed, then control charts for attribute. This is developed in differently, in this case, no precise measurement of the quality characteristic is done but here rather we count counting is done counting of number of nonconformities or number of defects in a product or the number of nonconforming products or units in a sample or the fraction of the nonconforming nonconformities in a given sample.

So basically, we try to count that number of the defects or the defectives or their proportions in a sample. And those are used for developing the control charts for attributes, which may be inform of control P chart that is the proportion of or NP chart or C charts. So these are the different types of the control charts for attributes. Similarly, the control charts for variable are of the two types, where the mean control charts drawn for X bar, R chart.

So the variable charts are drawn in form of X bar and R chart while the control charts for attributes are drawn in the form of P chart and P chart C chart or U chart. So in the second case, in case of the control charts for attributes we primarily do the counting of the number of defects or the number of defective products or the fraction of the nonconformities or the defective defects while in case of the control charts for variables we tried to quantify the characteristics which are important for success of the product and the process.

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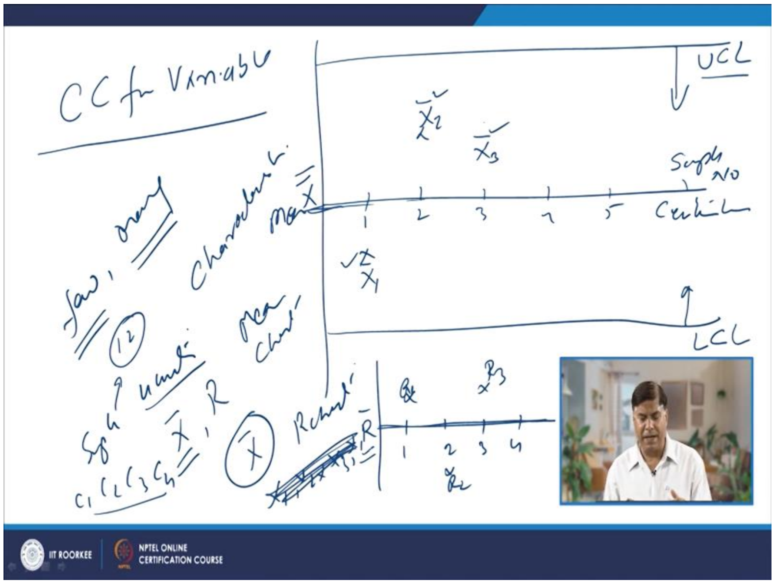

So accordingly, say control charts for variables we, to plot the control charts for variables. So what we do we in the Y axis basically we put the characteristic value and then in X axis we have the like sample number how many samples are being, how the data is about which and number of the sample. So like here, we put in the sample numbers and then accordingly same in a sample there are 4 units or 4 products.

So quality characteristic that a selected quality characteristic of the 4 units is quantified and then it is average is determined like this and it is a range is determined for each sample. And that is what is plotted here say here for sample 1, sample 2, 3, 4, 5 like this. So X bar value for sample one you will be plotted here say. Then for some for sample 2 X bar 2 is plotted here. So like this the values are plotted for the that average value of that quality characteristics which has been selected for developing the control charts and for the different samples it is plotted.

So basically this these are represents the average quality characteristic value being identified through the calculations from the items which have been selected in a sample in in a sample there can be 3 units, 4 units, 5 units, 6 or 10 products, depending upon the kind of control charts to be developed because it also affects the way by which control charts will be developed and its sensitivity.

So having very few or many units or many products in a sample will be affecting the kind of control charts which will be developed, so there has to be an up and more suitable number of the units which are selected in a sample, like say instead of 4, if we selected 10 or 12 number of a units in a sample then control charts will be very tight, it will be very sensitive and control limits upper and lower control limits where you will be very close to the mean value.

While on the other hand, so that will be that will be making the control charts very sensitive. So in addition to plotting these control these average values of the quality characteristics, we also plot the upper and lower control limits. So UCL and LCL upper and lower control limits. So when we have a large number of the units or products in a sample, these limits will be closer to the average, which will make the control chart very sensitive, for fluctuation or variation in the quality characteristics.

And that will be leading to the rejection or out of the control situation. Apart from this, making the control charts very sensitive, it will also increase the kind of efforts to be made for quantification of the quality characteristics for many items which have been selected in a sample.

On the other hand, there can be lot of variation, when the fewer samples are selected. So the control limits maybe very wide. And that may lead to a situation where, the things being produced may not be within the acceptable level. So this is about the control charts.

Having the this line corresponds to the mean value, like X double bar, average of the average quality characteristics, identified from the different samples. So this line correspond this central line this central line corresponds to the X double bar value and a X bar that is the average of quality characteristics for each sample is plotted, like this apart from this like the average value of the quality characteristics range is also used.

So, when we are using the when we are using that the quality characteristic, average values, it is called mean chart for variable. And then R chart for variables when the range is used. So from each sample, like say in a sample, in a sample, we have got four products or four units. So the quality characteristic measured like say X1, X2, X3, X4 or we can say like, C1 quality characteristic of unit one, unit two, unit three, and unit four.

So what is the max difference of the maximum to the minimum? So that will give us the range of the quality characteristic in that particular sample. So, similarly here the for sample 1, sample 2, sample 3, sample 4 we have number of samples and the range of the quality characteristic in the sample 1 is plotted, say here R1, then R2, then R3 like this and we will keep on plotting the range. And then the central line in case of the R chart will correspond to the R bar.

R bar represents the average of all these range values like, R1 plus R2 plus R3 plus R4 likewise divided by 4 that will give us the average range value. This is how the control charts is a control charts for variables using the X bar and R chart is developed as part as that the inferences from the control charts for variable is concerned which will help us into to make the inference if the process is in control or it is out of control.

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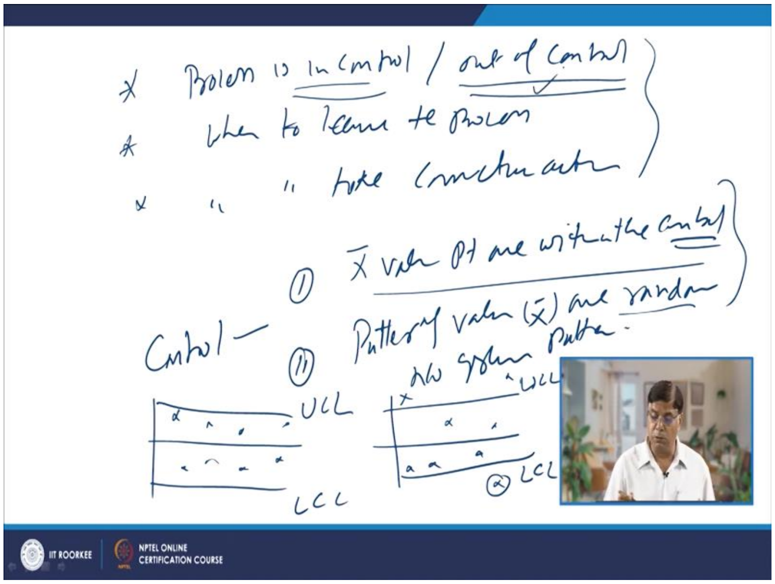

So the one inference, which we have to make from the control charts, which is being developed, is to see if the process is in under control or it is out of control. And based on that, it will suggest when to leave the process alone so that it can keep on producing the things of producing the products of the acceptable quality or when to take the corrective action. It also suggests the when the corrective action can be taken.

So as far as the inference about the, whether the process is in control or not. So the control situation that two things are seen in case of the control charts for variable like the average value, which has been plotted, for the quality characteristic from obtained from the different samples that points plotted in the control charts in form of the X-bar values.

The points are within the control limit. This is one thing which is seen. And so if the if there is a control chart with the upper control limit and lower control limit and central line. So if the all data values are falling within the control limits, this is one thing that is seen. And the second is the, the pattern of the values which have been plotted in a control charts of values which have been plotted in control charts in form of X bar.

They are, the values are random and there is no systematic pattern. So when these two aspects are present, we presume that the process is under control and it can be left alone for making the things which are being produced well either single or both of the things are not present in a control chart which has been developed.

Then we will make inference that the process is out of control and it needs the corrective action. It needs some kind of intervention so that it can be brought in under the control again, say this is the lower upper control limit, lower control limit and the X bar values are few X-bar values are falling out of the limits. So that will be inferred as the situation where process is out-of-control or the data values which have been plotted, are showing a non-random pattern.

If the rent pattern is random, it is a very acceptable situation indicating the process under control. But if the data values which have been plotted in control charts are falling are following a non-random pattern, then that will also be interpreted as out-of-control situation.

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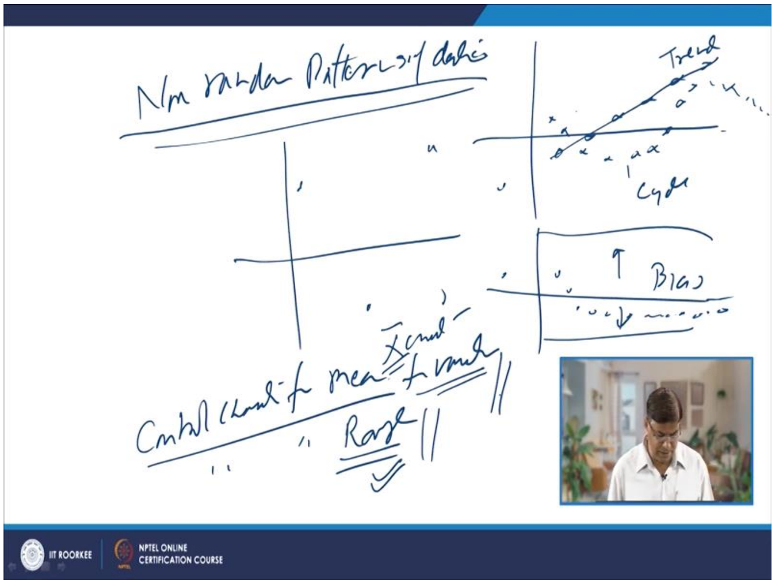

So that non random pattern non random patterns of the data values or the quality characteristics which have been plotted can be in the different forms. Like in a control charts, the data values are following in a particular are showing a particular kind of that trend. It is continuously increasing or decreasing. So that is a situation of trend. Then it is following a particular cyclic pattern like this.

So if the cyclic pattern is present, that also indicates the non-random pattern or distribution of the data values and they will be indicating the out of control situations. So this is the cyclic cycle and in case of the bias, like with respect to the central line and control limits, the data values are following particular side, only many values are falling just in one side.

So that is the case of bias and then mean shift like the process average is shifting from the central line towards either the higher side or the lower side or excessive dispersion is present, the data values are scattered too much one side or another or they are falling very close to the upper and lower control limits. So, excessive dispersion change in the mean or shift of the mean of the process, trend, cycle or bias.

All these will be indicating the non-random pattern in the data distribution when these are plotted on the control charts for variables. And these will be indicating that the process is going out of control and it needs some kind of intervention. There are two new ways to develop the control charts for a mean or we can say mean control charts for variables and then control charts are for range.

So these are the two types of the charts which are plotted is called X bar chart. There are two methods of plotting the X bar chart for variables. And then apart from that control charts for a range is also plotted and both charts are seen together to make any fruitful, useful and effective inference about if the process is under control.

So to have a process in control the both the range and the control X-bar control charts should indicate that the process is under control, means the all data points falling in X bar or R charts, they are showing the random distribution as well as the points are falling within the control limit, then it is assumed that the process is under control.

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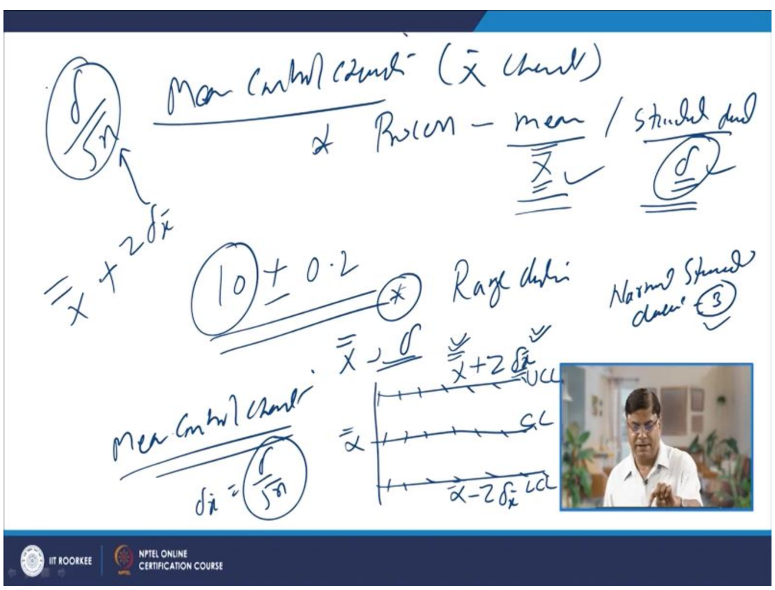

So plotting the mean control charts, basically this is the X bar chart. So there are two methods, one method uses where the process has been set. So accordingly the process has been set to produce the units of particular mean value. And what is its standard allowed is standard deviation. So the process mean there is a mean value for which process has been set in and what is the allowed the standard deviation for a given process.

If these values are known like the process is expected to produce the units of this mean value, for example if a process is expected to produce their units of a diameter having 10 plus minus 0.2 that is the kind of the tolerance which I guess, so the process will be set for producing the mean dimension of the 10. Then the allowed variation will be then as per the capability of the process the kind of the standard deviation that they are allowed standard deviation.

So if we know these two things, then we can set the control charts for that process. Another approach uses the range data arrange of the quality characteristic data of that particular product which is being produced by a process for developing the control charts. So as far as the mean control chart is concerned using the process average and the standard deviation related with the process that is used using that is developed using a simple equation like where is the process average, number one X double bar and what is the standard deviation?

So upper control limit will be set as X double bar plus Z process standard deviation allowed processes standard deviation and this is the center line and the lower control limits. So this is the upper control limit and of lower control limit will be set at X double bar minus Z sigma. So here the Z is the normal standard deviate that is normally considered 3, but if you want to set the closer or tighter control limits then it can be set at other values like 2 or 1.

So but normally the normal standard deviate is set at 3. So we know the process is standard deviation and process average, then using these two we can set the lower, upper and lower control limits and the center line is a set according to the process average where it has been set. So in order to determine the this process is standard deviation that is that like X bar sigma X bar, and a sigma X bar. So this sigma X bar is a obtain from the process is standard deviation divided by the square root of the number of samples in a process.

So here we know the X double bar where process has been set, then the sigma X bar into Z. So this sigma X bar is identified from the number of samples and the processes standard deviation processes standard deviation is sigma and a square root of the number of samples which have been drawn from drawn in a sample. This can be 2, 3, 4, 5, etc. So this is one way to develop a control charts using the process average and it is standard deviation.

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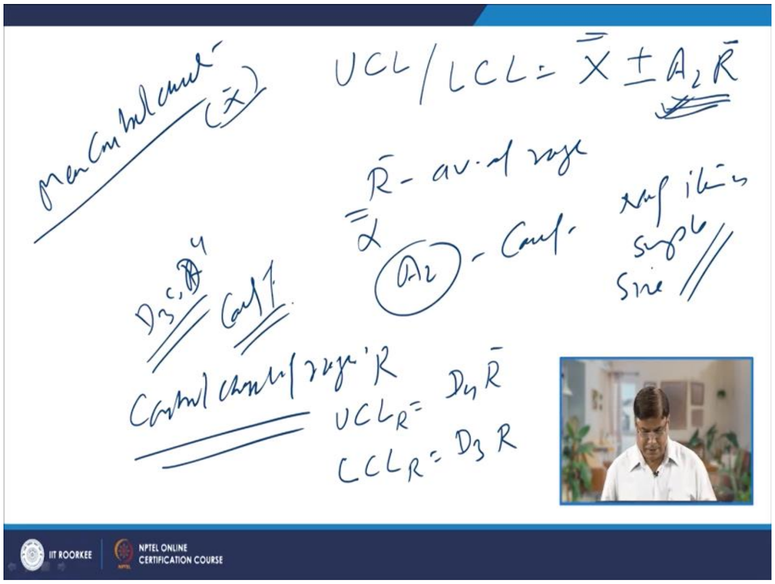

Then there is another where the range is used. So in that case, the range the upper control limit and lower control limit for mean control charts for variables like X bar chart, the lower control limit is a set using the X double bar plus minus A2 R bar. So R bar is basically the average of the range values identified from the different samples which have been taken from the lot and the X double bar is the average of the mean values identified from the different samples.

So the plus is used for the upper control limit and the minus sign is used for the lower control limit and A2 is coefficient which is identified using the number of the items in a sample. So that is basically simply termed it as sample size. So how many units or products are there in a ample based on that, we select the suitable value of the A2. So once we know the value of A2 using the R bar and X double bar, we can set the control a mean control charts for X bar.

Now the control charts for R control charts for range also has to be seen. So the control charts for the range will be will be established using the like upper control limit for R chart is a set using the D4 R bar and lower control limit for R chart is set at a D3 R bar. So basically these basically these values are the D3 and D4 are D3 and D4 are the coefficients which are determined based on the sample size.

Now, I will summarize this presentation in this presentation basically I have talked about the way by which the control charts for X bar and R chart are developed and how to make the inferences about the process if it is under control or out of control. Thank you for your attention.