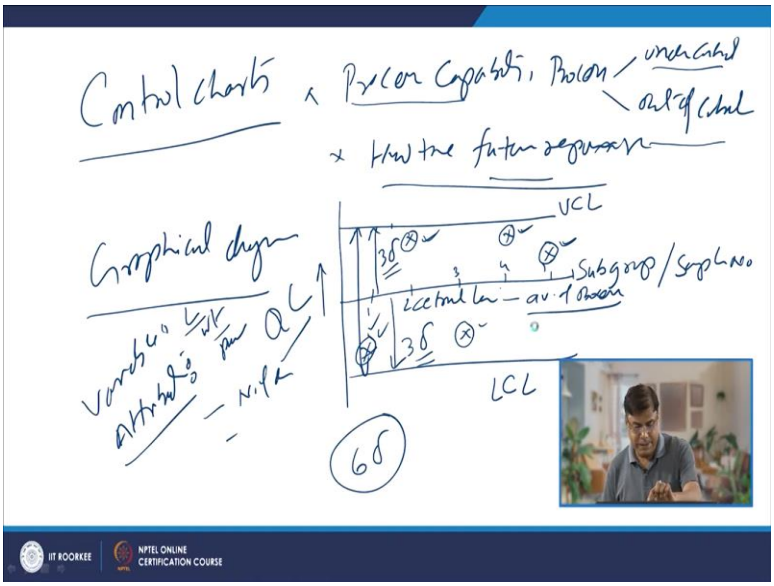
Principles of Industrial Engineering
Professor. D.K. Dwivedi
Department of Mechanical and Industrial Engineering
Indian Institute of Technology, Roorkee
Lecture 56
Quality Control: SPC II

Hello, I welcome you all in this presentation related to the Principles of Industrial Engineering. And we are talking about the quality control. In this presentation primarily I will be talking about the control charts, which is based on the statistical process control. So this is one of the tools which helps us to know about the status of the process.

(Refer Slide Time: 0:46)



So if we see the control charts when it is a developed, it helps to know about the process capability. It helps to know whether the process is under control process under control or out of control. Additionally, it helps to know, that how the process will behave in future? So how the future response will be of a particular process? A response of particular process. So it predicts the future, it predicts, it estimates, the process capability help an estimation of the capability and knowing the status of the processes under control or it is out of control.

So, under that is, identified through the, a typical graphical diagram. This diagram basically has one Y axis and one X axis. This X axis shows the like the subgroup or sample number, while the Y axis shows the quality characteristic of the importance. So the quality characteristic of the importance can be variable or attribute. So variable is the miserable quality characteristic while

attribute is the like, it is good or bad, acceptable or not acceptable and it is quantified directly in numbers.

So in the Y axis, basically we mentioned the quality characteristic of the importance. So the sample 1, 2, 3, 4, 5 like this it is mentioned and in the Y axis we have the quality characteristic of the importance, apart from this. So this line is called central line, which shows the average of the process with regard to that particular quality characteristic which is of importance. Apart from this center line, we have the two additional lines.

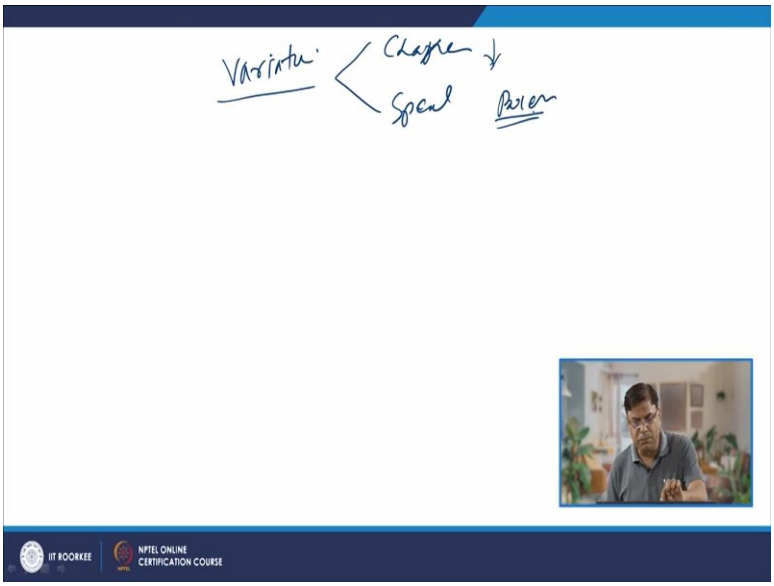
One is the upper control limit, UCL and another is the lower control limit, LCL. and whatever the data points are which are quantified to the measurement or through the numbers, these are plotted sample wise, like sample or subgroup wise. So whether 1, 2, 3, 4 these are kind of the subgroup or the sample number and the average value of the quality characteristic or the quality characteristic features are plotted on the Y axis.

So, it may be inform of like length or it may be weight or it may be any other parameter power, or it may be like the number of defects are the number of defective products or the proportion of defective products. So as per the type of chart suitable parameter is plotted on the Y axis. So in in a sample, in a control chart as per the sample number, these values are plotted, like this as per the kind of the value, being obtained, and this pattern is studied where these points are falling, which has been identified through the characteristic analysis measurement of the each sample in a subgroup are in a sample, a particular each part in a particular sample.

So based on the study and observation of these points, we make the inferences, whether the process is under control or out of control, in which way it will go, whether it will continue to behave like this or what we the process capability. These lines most of the time these upper and lower control limit lines are plotted at the distance or three sigma from the central line. So the plus minus 3 sigma is the kind of the is spread at which these control lines are plotted.

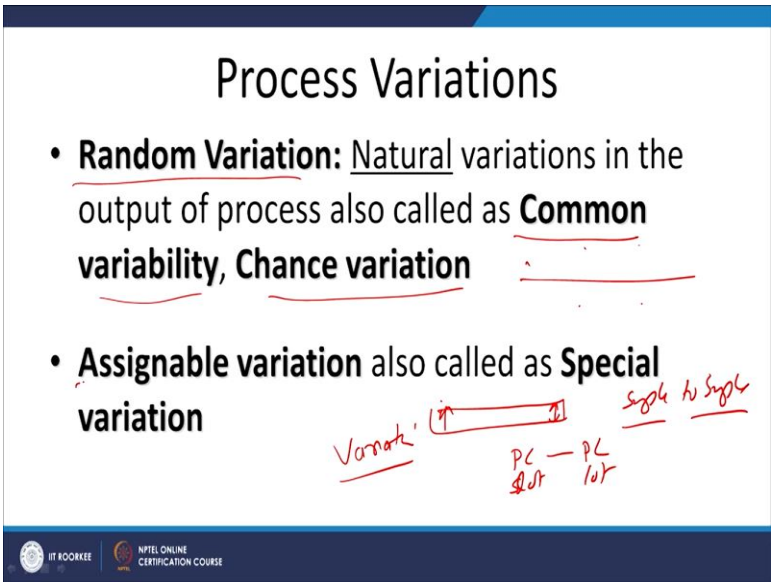
So in total it constitutes to the six sigma. So the spacing between the six sigma whether you got to the particular quality characteristic is of the six sigma and sigma is about the standard a deviation which is calculated through the values of these quality characteristics, which have been plotted for the different subgroups and the sample numbers.

(Refer Slide Time: 6:23)



So now we will see we will see how the inferences are made, how the quality, how the control charts are developed and how to make the inferences from those control charts. As I have said, the variation is a very normal thing. It is caused by the chance causes or the common causes and the especial or assignable causes, the special chance causes are controlled through the process improvement and especial causes and to avoid the special causes we need to bring the process in control. So the process control is needed.

(Refer Slide Time: 7:12)

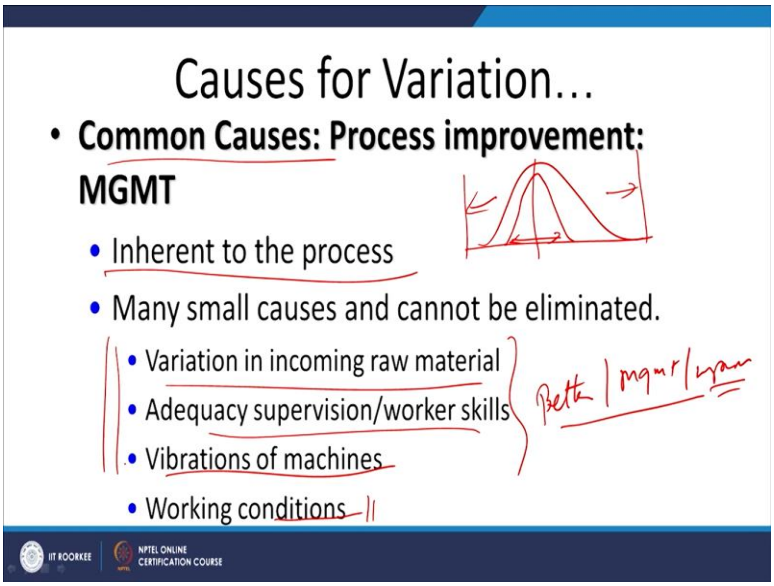


We will see little more details that related with these, the factors which are leading to the variations. As I have said, the variation is a very normal thing. Now this variation can be there in a piece itself. Variation within the piece, say thickness is here, one and the thickness here is another. So as per the location, the dimensional parameters or the quality characteristic may change variation piece to piece variation in a lot to lot variation in sample to sample. Like in a sample we have 5 pieces or 10 pieces.

So there will always be some kind of the variation in the products being made in one shift to another. So that variation there can be number of weighs which by which variation can be there. And these variations can be random means random means about the central or mean value. The points are falling randomly here and they are, there is no systematic trend or pattern. So when the random variation, when the random variation in the characteristic occur this is called natural variation which output of the process also called a common variability or the chance variation occurring due to the chance causes.

Means there is no specific reason behind occurrence of such kind of thing and needs proper improvement in the process. Like little variation in composition, little variation in the vibrations, little variation in the skill of the worker, little variation in the environmental conditions. On the other hand, the assignable variation, when the variation is too much, then there must be some special cause which is leading to such kind of the special variation.

(Refer Slide Time: 9:00)



So the common causes or the chance causes are very much part of the process. These are inherent to the process and many small causes chance causes are very large in number and these will always be there. These cannot be eliminated but their extent can be reduced. This can be the saw the chance causes or common causes may be present in form of variation, in little variation in the quality of the incoming raw material or inadequacy of the supervision or the workers is skilled, which is working in the shift to shift or vibrations of the machine with the changing condition of the machine or the working condition itself.

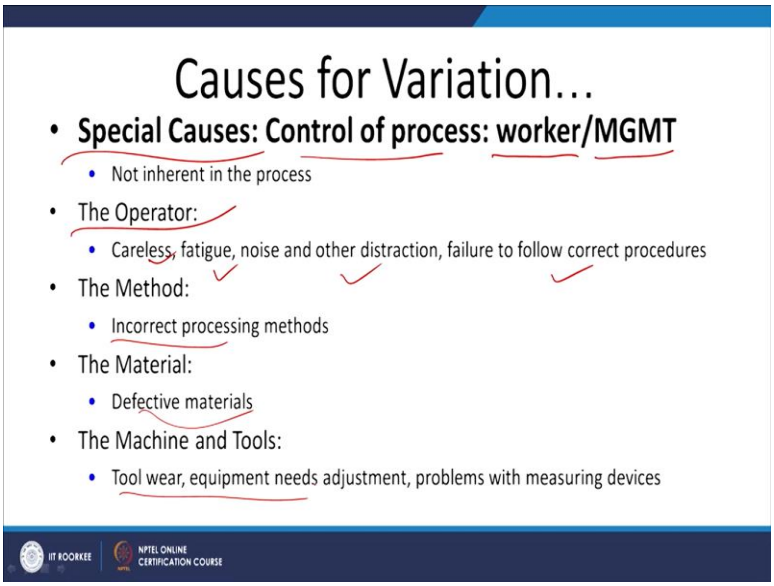
So little variation will always be there in these factors and that can lead to the minor variation in the spread or the quality of quality characteristic variation which may be of the importance, so control, better control or the management or the improvement of these things can help in reducing the variability.

Say initially the variability was like this, better control, better improvement of the quality of incoming materials, expertise of the worker, better, better quality of the machine leading to the reduced vibrations in close control or the working conditions may help in reducing the scatter or the variability.

So this variability is reduced like this, although earlier may also the things were being manufactured with the within the specifications and the products were acceptable, but the variability was large. So to improve the things further we need to control the common causes.

We need to work on the improvement of the process so that the common variability are very variability due to the common causes can be reduced.

(Refer Slide Time: 11:05)

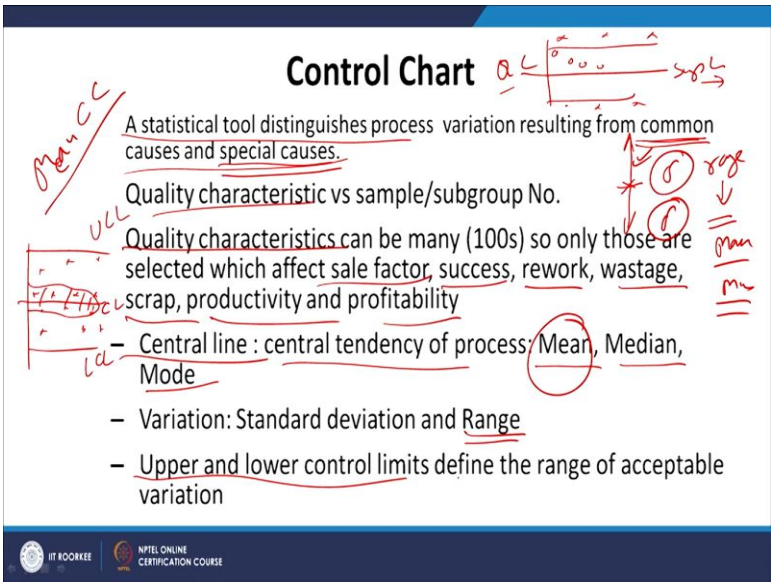


The special causes are really those special or unique things which have come into the procedurals aspects or the manufacturing steps which are leading to the excessive variation, variation, which is beyond the acceptable limit leading to the manufacturing of the poor quality product.

So it this needs the when the special causes are present it is required that both worker and management work together for bringing the process under control so that the products with the reduced variation can be produced of the acceptable quality. And this can be there, like operator is careless excessive fatigue, noise and leading to the destruction. The failure to follow the procedures correctly. Incorrect methodology is being adopted the defective material is being processed or the excessive tool wear, equipments need adjustments.

So there are some unique features which are present in during the manufacturing and a leading to the variation, which is beyond the acceptable limit.

(Refer Slide Time: 12:16)



As I have said the quality control chart is a statistical tool which helps in distinguishing when the common causes and when the special causes are present, how it is done? When we find that the data points as a function of the sample number and the quality characteristic also. Quality characteristic variation has a function of sample number when these points are going beyond the control limits like this or when they are showing a particular pattern.

So the variation distribution of variations should be normal, which means the variation should be equally on the higher side or in lower side and it should be within the limits. So no trend no pattern of the pattern in distribution of the quality characteristics when it is established through the sample to sample variation sample to sample measurements.

And the there is no trend so no specific trend and the quality characteristics are not falling beyond the expressive beyond the control limits. So when these two things are there, we have primarily the common causes and when the specific pattern is present in the distribution of the variation of particular quality characteristic or the quality characteristic points are falling beyond the control limits. Then we consider that special causes for variation is present and we need to do something to bring the process back in control. So the control charts primarily show the quality characteristics versus the sample or the subgroup number.

We know that there can be a hundreds of the quality characteristics related with a product or service. And if you want to control, then probably we need to make the hundreds of the control

charts. And measurement of n number of the characteristics or hundreds of the characteristics and their documentation, tabulation for preparing the control charts.

So it may not be feasible really. So the selection of the quality characteristic for developing a control chart is very crucial. And therefore, only those quality characteristics are selected for preparing the control chart, which are really important for success of the performance, success of the product, success of the surveys something which is important.

Quality characteristic which is important from the salability of the product point of view or productivity and economics point of view of the process as a whole. So only those quality characteristics are selected which are affecting the salability affecting the success and performance or affecting the productivity as a whole because a reworking and wastage scrap all those will be affecting the productivity and profitability.

Something which is important for economy of the organization, profitability and productivity. Productivity only those quality characteristics should be selected for development of the control charts related to the particular manufacturing process. So if those quality characteristics which have been selected and they are not being realized, then we need to work on the process to bring the quality characteristics a bit bring the process under control.

So that the products and the services within the acceptable quality characteristic level can be produced. So that the except the possibility for rejection under the rework wastages etc. can be in a reduced and the salability can we increased. So as I have set control charts shows a central line which indicates the, what is that central tendency of the data? Where the data is trying to accumulate? For example, here this is the center line and these are the upper and lower control limits UCL center line and LCL.

So if the if the day most of the data points are randomly distributed very close to the center line means the process is a centering close to the average value. Data is showing very high central tendency as far as the processes is concern and the limited variability. So basically where the data is falling that indicates the central tendency of the process. And this is indicated, this can be indicated through the mean, median, and mode.

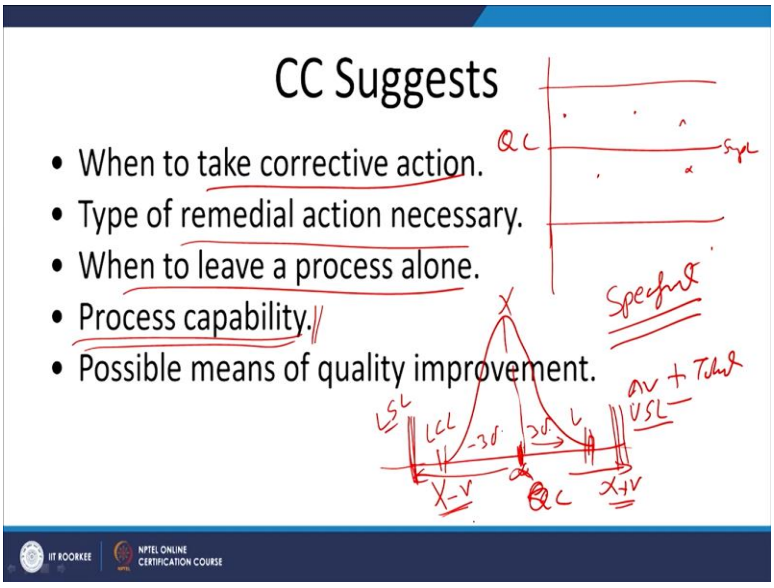
So, mean is the most commonly used central tendency parameter for developing the control charts. So in that case, like mean control chart otherwise it can be determined as a median or the

mode control chart also. So the extent of variation in the data which is falling about the center line that is a measured using the tool parameters.

So the variability in the data like about a particular target value what is the extent of variation that is quantified. So that variability is quantified using the two parameters. One is standard a deviation and another is range. So when the data points are many, then standard deviation is found to be more useful and when the data points are few, then the range is used. Range shows the kind of the complete range the kind of maximum variability which exist in the data because it is obtain from the difference of maximum to the minimum.

When the data points are many, then it is a good to calculate the standard deviation to show the variability or the variation in data as the range is used. So, as I have said the upper and lower control limits are a plot also plotted in the control charts and that will be indicating if the process is within the control or going beyond the control, so that the corrective action can be taken to bring the process back into the control chart.

(Refer Slide Time: 19:09)



So when the control chart is plotted, say any control chart is plotted with the different, points as a function of the sample number here and the quality characteristic on Y axis so, the and then the upper and lower control limits. So the study of these, the data points, which are they are in the control chart study of that or analysis of those data points help in making the inference when to take the corrective action to bring the process back.

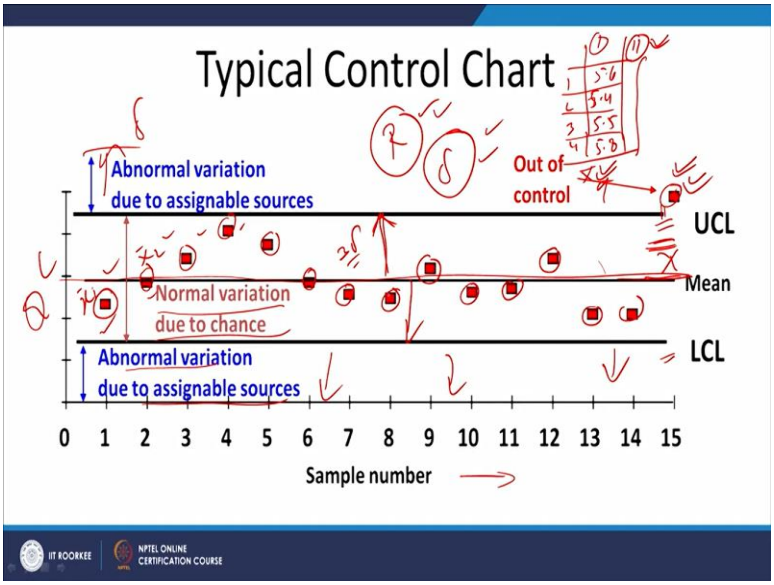
And which type of the remedial action is needed. If the process is going out of control, either the points are falling beyond acceptable control limits or the points are the or the data points are showing a particular kind of trend in the distribution of the variation. And when we can leave the process alone means when the process is under control, then it can be left alone to do the same thing.

Whatever is being done so that we can continue to manufacture whatever is being done. It also helps to show the kind of the process capability. Most of the time what we see that the specification of the product, which shows that the average value and then the plus minus some kind of that tolerance that is allowed. So if the specification, in the Y axis let us like say this is the, quality characteristic and the upper, the lower and, upper acceptable limits according to the specification means the lower specification limit is say, the X minus, this, V and X is this.

And, the X plus the variation is this for the upper specification limit and the lower specification limit. And this is the average of the quality characteristic, which is in target. We would like to see that the process is centered at the X and the variability of the process is within the acceptable limit. So the process average is at the center of the quality characteristic which is desired. And the variability is also very well within the specification limits, that lower specification limit and the higher specification, limit upper specification limit.

And if we see the, the distribution of the data points, then we will see, this is the, upper control limit. It is a 3 sigma on the highest side. And, the lower control limit 3 sigma on the lower side. So, the control limits, are within the specification limits. If that is the case, what a given process, then we assume that the process is capable to manufacture such kind of the product. So basically, the control charts also help in determining the capability of the process. And, it also suggests like the, what can be done for improving the quality characteristic.

(Refer Slide Time: 22:35)



This shows that typical control chart, where in the distribution. So, let us start here is the quality characteristic and the X axis shows the sample variation. And this is the mean, value of the quality characteristic and the higher value of the quality upper control limit under the lower control limit. And, the samples are taken during the manufacturing randomly, their quality characteristics are characterized. And then like, say in sample one, there are four items 1, 2, 3, 4. So, the quality characteristic of four items is measured like 5.6, 5, 5.4, 5.5 and 5.8.

So now we, these are the individual quality characteristics of the four pieces in a sample 1 will determine the average of these 4 samples. Average quality characteristic of one sample is a measured, and that is what is a plotted here for sample 1. Sample 1 having 4 pieces, their quality characteristics are measured. And then it is plotted. Likewise for sample 2, again, the four samples are taken. It just an examples some number of pieces in a sample, maybe, maybe a different and that is also, established properly so that we have the more reasonable quality, control chart.

So not too less, not too many, pieces in a sample that is called a sample size are taken while developing the control charts because it has other implications. I will talk later about like how to choose the sample size. So likewise, the sample to, the quality characteristics of the various samples in a sample 2 are characterized. And then average value is plotted. So like this, the different samples are taken and their values are plotted on the control.

Average values are plotted on the control chart, and the central line shows the average of all these averages value, so basically this is the X double bar. So X, these values are basically X bar for sample 1s, X bar for sample 2 like this. So, basically, average values are plotted on the control charts. And at the center line shows the average of the averages, of these data points which have been plotted, statistically we tried to establish these control limits at the 3 sigma level.

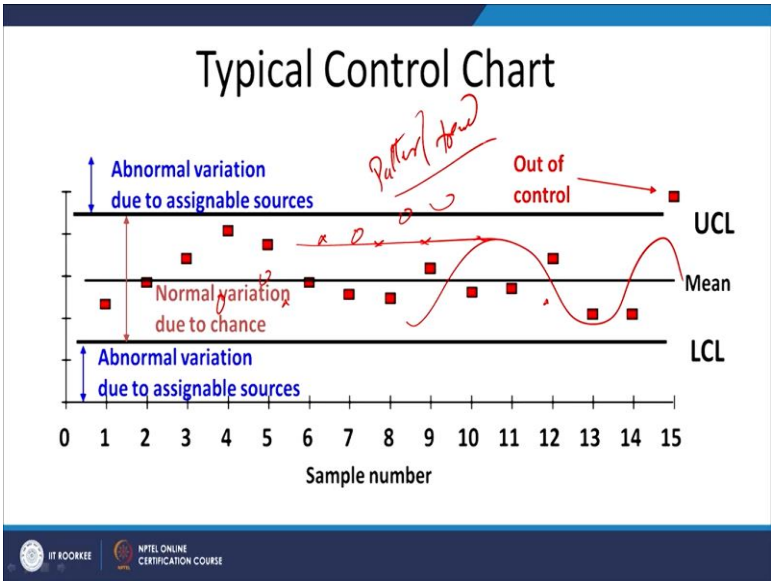
So basically we try to determine the, there, there two ways to develop to identify these control limits. One is based on the range on, another is based on the standard deviation. So, since there are two ways of quantifying the variability, one is range, another is sigma. So when the data points are many sigma is more useful as compared to the arrangement, data points are a few than it is good for when a few samples than it is good for good to go for a range.

So there are two ways to identify the upper and lower control limits to set a control chart that is based on the range or based on the sigma. So what we do? Standard devolution of all these data points is identified and then at 3 sigma, high side and three sigma lower side, upper and lower control limits are set to develop our control chart. So when our data points is start to fall beyond these control limits, like say, this data point is falling beyond the control upper control limit.

So this is out of control. This sample is corresponding to the out of control situation. When the data points are falling randomly about the mean or the central tendency, then it is called normal variation due to the chance causes. And when the data points are falling beyond the acceptable, or the upper and lower control limits, then that is termed as abnormal variation due to the assignable causes.

And that, so this is the variation due to the assignable causes. When the data points are falling beyond acceptable there is one more possible situation when they the data points are falling in such a way that there is a particular kind of trend. What kind of trend we can see here.

(Refer Slide Time: 27:34)



Like all the data points are falling just one side like this. So the, that this is one kind of situation or there is another situation where data points are falling cyclically. So our data points are continuously increasing. So there can be various situations, means these are different patterns or showing trend in variation in the quality characteristic sample, as a function of samples or subgroup. So when there is a pattern, means presents of pattern in data points suggest the possibility of presence of the assignable causes.

So now I will summarize here this presentation. In this presentation basically, I have talked about the various causes of the variation, like assignable causes and the chance causes and what are the different constituents or the parts or the features of the control chart and how to make the inference, from the control chart when the data values are plotted. Thank you for your attention.