Quality Control and Improvement with MINITAB
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Lecture - 04
Critical to Quality Characteristics

Hello everyone. Welcome to the session 4 of Quality Control and Improvement using MINITAB. I am Professor Indrajit Mukherjee, Shailesh J Mehta School of Management, IIT Bombay. So, today our agenda will be to understand how to visualize the data basically. So, last session what we have done is that we have discussed about Kano models, QFD and we have tried to link between CTQs and voice of the customers.

Now, we are interested totally now on CTQs. So, quality of conformance is important for us; control and conformance and improvement of the CTQ is our agenda ok. So, quality is all about improving CTQs; so, either I control or I improve the CTQs. So, we will discuss more about that. So, last time, we have talked about some aspects of CTQs and we have used a diagram to represent that one.

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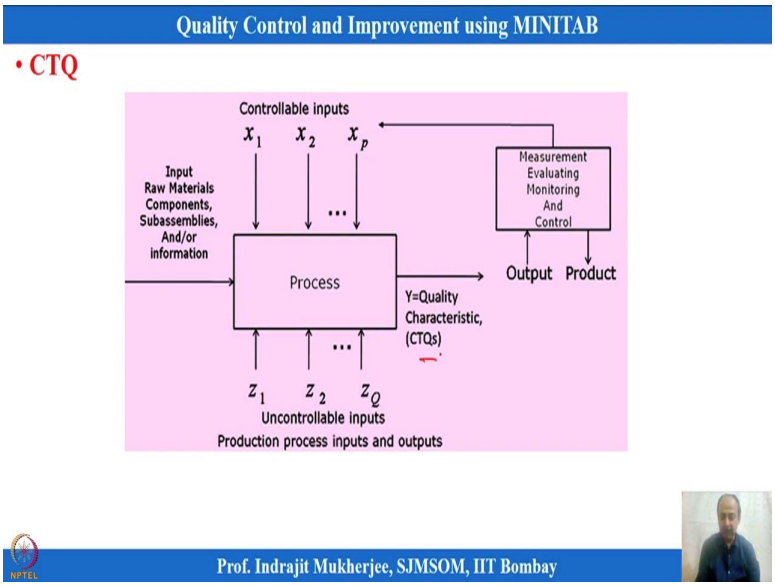

So, this is the diagram that we are using that, there will be inputs and there will be control variables which can be monitored and can be changed. There will be some noise

factors which we do not have any control as such, but we want to minimize their effects and we want the quality output CTQ to be close to the target that is defined by the designer and with minimum variability, we want to measure that one; what is happening when, what is the outcome. So, whenever we measure, we have some data on CTQs and then we have gone to visualize the data or CTQs. So, what is the status of the data.

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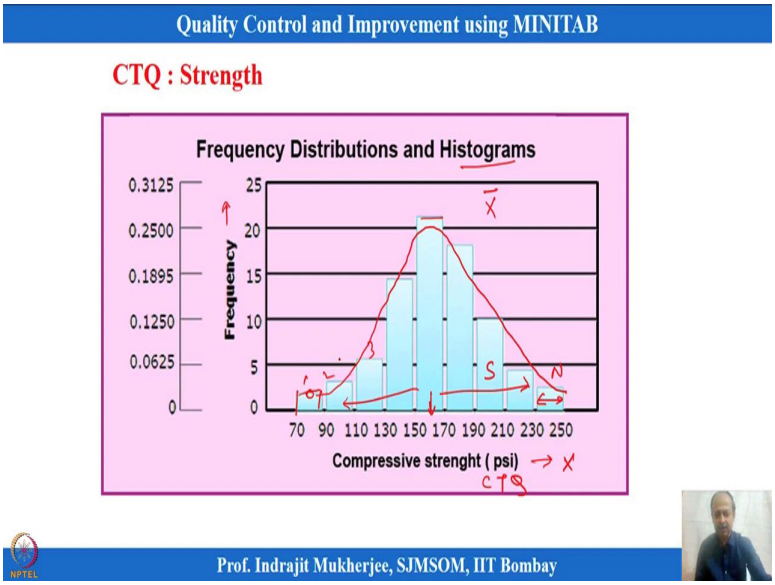

So, for that, we have shown that strength. If strength is a CTQ, then we can draw a histogram over here and histograms are like this. So, there will be frequency axis on one direction and there will be strength in one direction. So, this will give you some idea, where is a mean of the data set and what is the spread of the data set basically, what is the spread of the data set.

So, mean of the data set of a sample data set, we can express by using a symbolic notation that x-bar and the spread of the data set can be expressed as standard deviation of the data set. And I am assuming that basic idea of mean and standard deviation is already you have and so, we will go ahead with that idea that I understand mean and standard deviation.

So, but in quality concept, what mean and standard deviation means basically that will be our discussion on session 4 and what are the techniques that is used to minimize the mean and variance and also bring the mean to targets that is our overall objective, ok.

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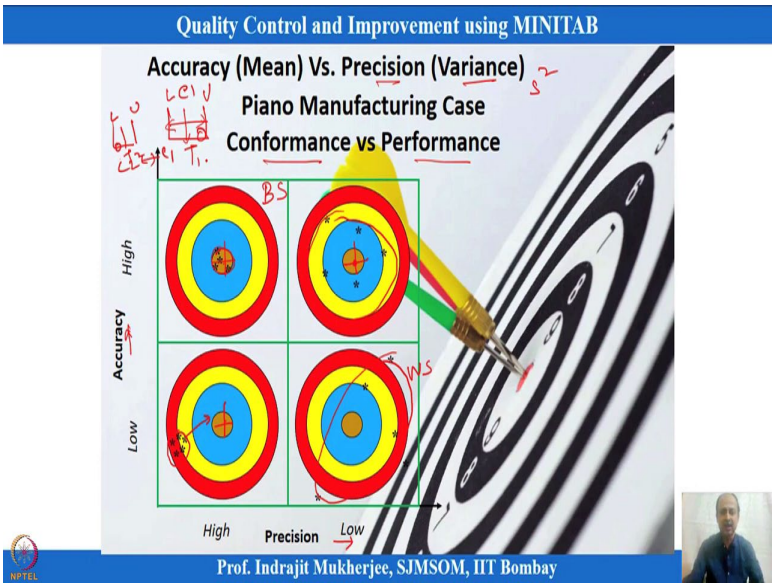

So, let us try to understand one important thing in quality which is known as accuracy and precisions. So, when we talk about accuracy, we are talking about the mean of the data set or center of gravity of the data sets or we can think of the location of the data sets basically ok. So, CG of the data set, center of gravity of the data set, central tendency of the data set, you can give different names ok.

So, one is mean how close is that to the target values and what is precision basically. Whenever I am talking about precision, we are talking about variance over here. So, variance is expressed as S square and if you make a square root of that, that will give you the sample standard deviations ok.

So, this is a bull's eye kind of scenario, so where target value is already defined. So, you have to if you are hitting this point, you are getting the maximum score ok. So, but people generally try to miss the target. So, they will there will be variations from person to person and process also.

So, there will be inputs and there will be process settings, there will be noises and that will create variations in the outcome that is CTQ outcomes ok. So, there can be different

types of variation, there can be different types of errors in either in accuracy part or in precision part ok. So, if you see the diagram over here, the one axis is accuracy over here and one axis is precision over here that is shown on the x axis ok.

So, whenever my accuracy and precision both are high; in that case, I will hit the target and with minimum variability. That is the diagram. That is the most best scenario, we can think of. So, what is the scenario over here? What scenario is, not accurate not precise.

So, accuracy is also low and precision is also low. So, this is a what scenario, we can think of over here ok. So, here what you can see is that I am hitting the target with minimum variation over here, variability is very less over here ok and over here the other diagram, what is case, is not accurate not even variability you can see a much larger variability what you can see over here and off target is I am not hitting the target.

So, overall average is also off centered. So, it will come to be off centered. So, variation is also high. So, that is the worst case. So, what can happen in between is that so I have precision, I have high end precision, but I am off centered. So, this kind of scenario can be improved, if my process locations can be shifted; that means, the setting can be changed so that only my location is shifted, the outcome, CTQ, the average outcome of the CTQ is near to the target.

So, now I am précising the outcomes of the CTQs, but I am not accurate basically. So, I can change that one. So, this kind of correction is quite easy in manufacturing process. So, in this case, this is high precision, but low accuracy. So, I have to improve the accuracy over here and here, what happens is that the average comes out to be near the target, but variability high; this is also not a favorable situation for us.

So, in this case what I have to do is that I have to reduce the variability. So, in any processes, our objective in quality is to increase the accuracy and increase the precision; that means, mean should be in the target value and target means what designer has defined the target value or customer has defined the target value. So, I want to be in a in a process, precise and accurate both the things are important.

So, let us take an example. Let us give an example like piano manufacturing. So, this was an evidence case, where a well-known company was manufacturing piano for high end customers.

So, they want to something which is in between products, which is not so high quality. So, they want to sell those products also. So, that category of products they want to sell. So, and they have a competitor also because competitors are giving them that pressure, they are feeling that those companies are and those company's agenda was to confirm to the products specification ok.

But this piano manufacturing, what they are doing they are customizing the products then they are selling to the high-end customers or who are knowledgeable customers and for every customer piano sound quality is very important. So, and the performance of the piano or cross checks inspection was there, R and D was there to improve that one; they have a high-end quality.

So, in that case, what comes out of that there are two definitions what comes out of that; one is conformance to quality and one is performance; that means, what we have defined is quality of design ok and quality of performance basically. When it goes to the end users, how it is performing basically.

And conformance means, I have the design, quality of design and then I am manufacturing that one ok. So, the competitors are they are having they are focused on conformance basically. So, I am within the specification. So, in this case, they are manufacturing some products which is within the specification and they are doing it consistently ok and this is not to the high-end customer. So, customer segment is different over here.

So, in this case, what was happening they are confirming; but what happens is that in piano manufacturing thousands of components goes into manufacturing of the pianos. So, in that case what happens is that there will be interplay between the parts. So, if the parts are only conforming to specification, one is at the extreme end of the specification. This can be upper specification; this can be lower specification.

So, one component may be manufactured at this range and some other components. So, component one like this; some other component may be manufactured at this zone at the lower end. So, different components. So, when this component C2 and C1, when you assemble both those parts, what will happen is that all are in the extreme of the specifications.

So, the we will get more noises over here. So, in this case, what will happen is that overall performance will deteriorate. So, there will be interplay between this component 1 and component 2. So, but what is required is basically component 1 should also fulfill targets. It is having a target 1; it will having a target 2.

So, if everything is on target component 1 and component 2, what will happen is that the overall performance of the process, overall performance of the products will be the best ok. So, there will be little interplay, little noises. So, ultimately, the performance will improve. So, any company's objective is to any component that is coming out of the process should be accurate and precise.

So, if I only confirm that will not help basically to bring out high performance. So, conformance means within specification and they are consistently doing that. So, consistency in that doing conformance does not ensure performance. So, whenever you have to perform. So, it has to be high-end performance in quality. So, in that case every component is important to me; every component is important to me.

So, both accuracy and precision of every part is important basically. We cannot ignore any of the parts and say conformance. So, that goal post mentality, we cannot believe in that. So, only within specification will not help. So, every product should be manufactured on the target and the accuracy of the product and precision of the product should be very high ok.

Then, only the performance will come or on road performance of a car will happen, only if each of the components are manufactured with accurate, with near to the targets and also, the precision of the or variability of the components that are coming out of the process is very less, very very less ok. So, that is the overall idea. So, in quality also accuracy and precision is very important, accuracy and precision both are important to us ok.

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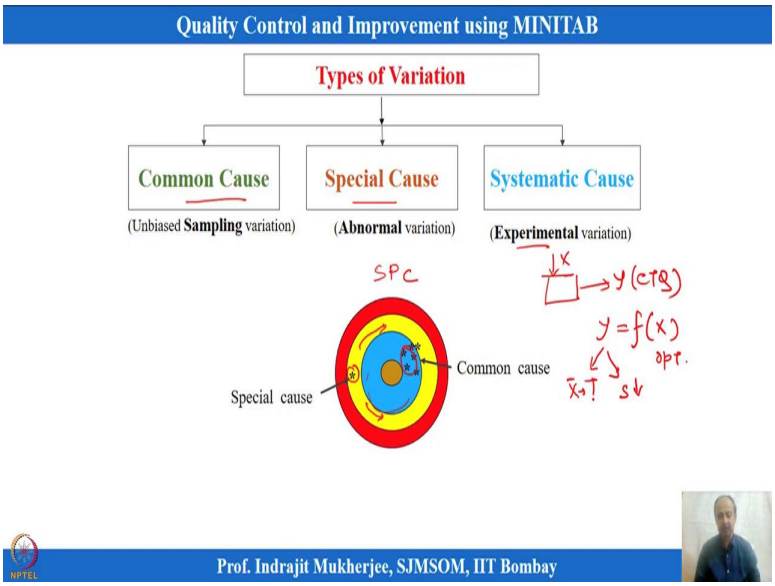

So, you may have different types of data and measure of accuracy can be different, measure of precision can be different; but anyhow, we are assuming that CTQ can be measured and that way we can improve the accuracy and we can improve the precision also ok. So, whenever the CTQ is we are measuring the CTQs, what will happen? There will be variation in the CTQs.

So, there can be different types of variability, what generally quality persons are interested into. So, one of the; one of the variability is known as common cause variability or sample to sample variability. So, this kind of variability is very very much, it is very difficult to reduce this kind of variabilities and this is when the input condition changes, it will influence whether your setting condition is same.

But because the input has changed, certain amount of inputs has changed or noise condition has changed. So, that will impact the outcomes or CTQs and there will be variation. So, this small small variation, what happens in the process that is common cause variability. So, we are initially, we do not concentrate of this kind of variabilities; later on, we will consider this kind of variabilities.

But then, there are other kinds of variability which is which can be easily handled or which can be we can deal with those things that is known as special cause variability or abnormal variability. You go to the process and what you see is that abnormal vibration is happening on the machines ok or the operator has completely changed.

There was skilled operators, now there is a new operator; operator does not know how to set the machine, what will happen is that the process behavior will change, centering will change. So, immediately, you can catch hold of those things that this has this is going wrong basically ok.

So, abnormal variability is easy to detect and then, you have to take action over there to deduce that kind of variability ok. Although, it is time consuming, you need to eliminate basically abnormal variations. These are known as special cause variability and there are quality tools to address this one and special cause, we can think of abnormal variations or assignable cause variations; assignable cause, special cause variations we can name that in different ways.

They are different names for this type of variability. So, these are very very peculiar type of variations. So, suddenly, behavior abruptly changes. So, this can we use a special kind of techniques in quality which is known as statistical process control to identify which is normal and which is abnormal. So, there will be common variations within the circles that you are seeing.

So, these variations are common variability, we will try to decrease that one after means in using different techniques; but currently, I want to differentiate between let us say common variability and special cause. So, I have a yellow, yellow zone what you see over here. So, I can define a zone, whenever it falls beyond this blue zone over here, we say that there is something going wrong in the process; that means, suddenly abrupt something has happened in the process.

So, that is a special cause and immediately, the process will be stopped diagnosed and we will take some corrective action. So, alarm will we will set an alarm. So, it is like signaling system also we can think of. So, whenever it is yellow, we should be very precautious; we should say take some corrective actions. But red zone, what does it indicate?

May be out of spec; out of specifications basically ok. So, in yellow zone over here, we get concerned and we try to eliminate why this is happening and if it is red zone, product may be discarded all together. It has gone out of specification what is defined by the designer.

So, there will be common cause variation, there will be special cause variation which we want to block and if it goes beyond certain extent, the product may be rejected; project may be rejected. So, one is common cause variations which generally happens in a process or sample to sample variation, we can think of. One is special cause variation that are detectable.

So, in that case and that can be eliminated, if I can eliminate recurrence of those kind of causes, some amount of variability can be reduced over here. And the third one is systematic variation; that means, I intentionally induce variability in the process. So, that is known as experimentation in the process.

What we try to do over here is that basically there is a process over here and there will be what diagram what we have shown is y is coming out of the process, there will be x variables over here. This is the CTQ that we are measuring over here. So, what we try to do by experimentation is that we try to build a function between y and x over here and then, try to determine what is the optimal condition of x that will give me the best y or y hitting the target value with minimum variation that s is over here and the average value is coming to the close to the target values over here ok.

So, what should be the condition of x? But, first what we need is that what is the functional relationship. If I get a function, then I can optimize that function. So, systematic cause or intentional variation is induced to understand the behavior and understand the relationship between y and x and so, that we can model that one and we can optimize that one. So, that is known as design of experiment part.

So, we have a control part which is known as statistical process control, we have an experimentation part and control part together over here, which enter there is a we are doing experimentation, we are setting the process, we are setting the standard operating practice and we are controlling that also.

So, that is the ultimate thing that in quality people tries to achieve ok. So, and this systematic experimentation, how it will help is that it will even reduce the common cause variability over here. So, that you see a common cause variation can with the influence even with the influence of common cause variability, the outcome will be very precise and very accurate ok.

So, that is the overall idea. Now, all these variability, when I am talking about variability in the CTQs, then I need to visualize the variations. I need to visualize the variation so that I can do something on that.

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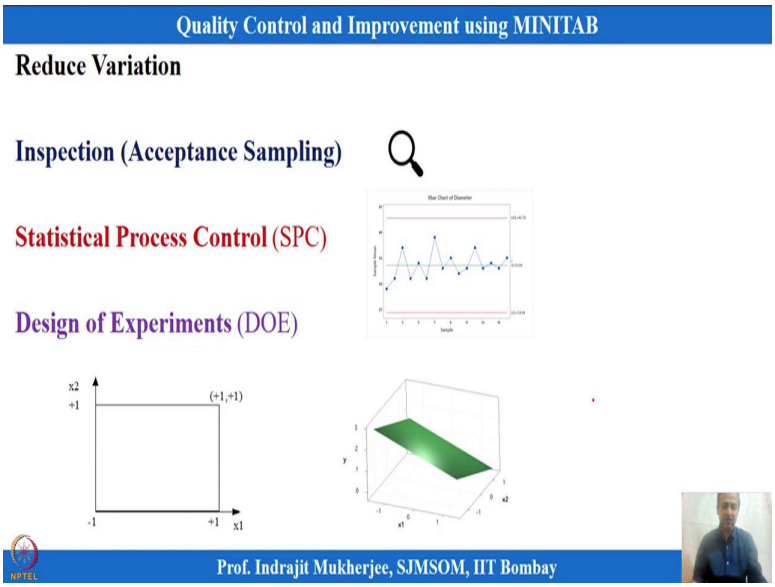

So, visualization is very important. So, our overall objective is to reduce variation. I told that quality objective is to reduce variation assuming that it is on the target. So, I want to reduce the variations. So, variation, reduction, there are different ways of doing that. One other I told that we are talking about statistical process control, which helps into eliminating the special cause or abnormal causes or assignable causes.

And design of experiment can also reduce the variations; common cause variations can also go down, when I am using design of experiments and we have one phase at the initial starting point of quality, we have an acceptance sampling; that means, we are doing inspections, we are trying to eliminate good pats and separate good pats, good products with the bad products.

So, in this case, what happens is that we try to segregate that one and we have certain plans, acceptance sampling plan which is used which is also using statistical techniques over here and which gives you a basis of selecting an item and not selecting an item from the vendor or suppliers ok.

So, this is only post modeling. Products have been produced by the vendor and it has come to your end and I want to reduce the variation over here. So, I tell them that you segregate, this is not good and so, in that case, you give me good products. I have an acceptable quality level.

So, you have to achieve that one, then only I will accept your products. There can be small rejections, but there is always a probability of rejection; but we will if you reach this quality level and in, then only we will we will do sampling inspection. Inspections can be 100 percent inspection also; totally segregate good and bad, but because of economic constraints, sometimes what we do is that and also suppliers improve.

So, we go for sampling inspections. So, in that case, not all complete products will be taken; some part of that will be taken and based on that, I will make a decision whether to accept. But I am taking a risk over there ok. So, one is to reduce the variability in the input conditions, what we can do is that we can implement inspection over here.

So, inspection is one of the quality aspects which generally they implement in a quality program. So, you start a quality initiative. So, initially you may do inspections. Then, you implement statistical process control to remove assignable cause, then design of experiments to do further improvements. So, that way, we are reducing variability ok.

So, but remember that inspection is a post mortem activity; nothing is done on the process. So, only thing is segregation is happening over here; but other things are happening in the process, statistical process control, design of experiments all are happening in the process, ok.

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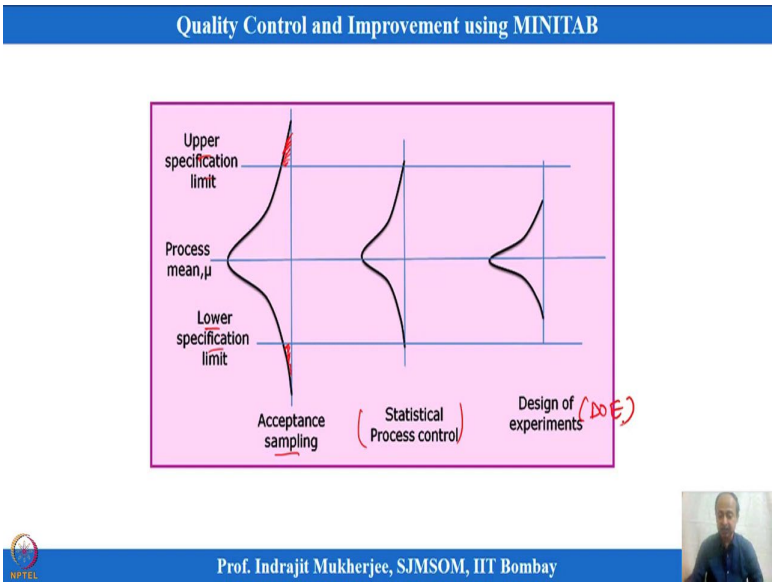

So, now what that is diagrammatically illustrated over here, what you see is that variability of the process, this is like a normal distribution. You have heard of this in statistical ports, which is having a mean μ over here. This population mean over here and with a standard deviation σ like that.

So, where this is just population information over here, what do you see diagrammatically and there will be specification limits over here; upper and lower limits what is specified over here, what will happen in inspection, there will be rejection because I am not doing 100 percent over here.

So, there will be products which are bad. So, there will be, but some amount of variation can be reduced over here. So, overall variation will be high. If I am doing only inspection over here sampling inspections, so I cannot do much on these variations over here.

But when I am using statistical process control applications of the this type of techniques over here, what I can do is that I can eliminate special cause variability like supplier to supplier, there is huge variation over here. I can remove a supplier which is giving a high variability product. So, I can remove that one that is the assignable cause or special cause what we can eliminate out of the process, ok.

So, that way, we can identify which is creating more problems. They use a visualize to visualization tool in statistical process control and that will indicate which is normal,

which is the abnormal scenarios and those abnormal scenarios, we take actions so that it does not recur. So, that is known as that tool is known as statistical visually, we can differentiate between normal scenario and abnormal scenarios. That is known as statistical process control technique, that we use over here.

And the third one, what we do is that we have a design of experiment that I want to reduce it further. So, in that case, what is required is systematic experimentation or statistical experimentation that is known as design of experiment; DOE, we can write over here as design of experiments over here. That is the final phase of quality. So, we do design of experiments over here ok.

So, our objective is to understand. So, you see that the variation is represented like normal distribution, but we have shown also histogram as the variation. I want to see where is the mean, how much is the standard deviation. So, visualization now and also try to figure out the what is the value of mean, what is the value of standard deviation.

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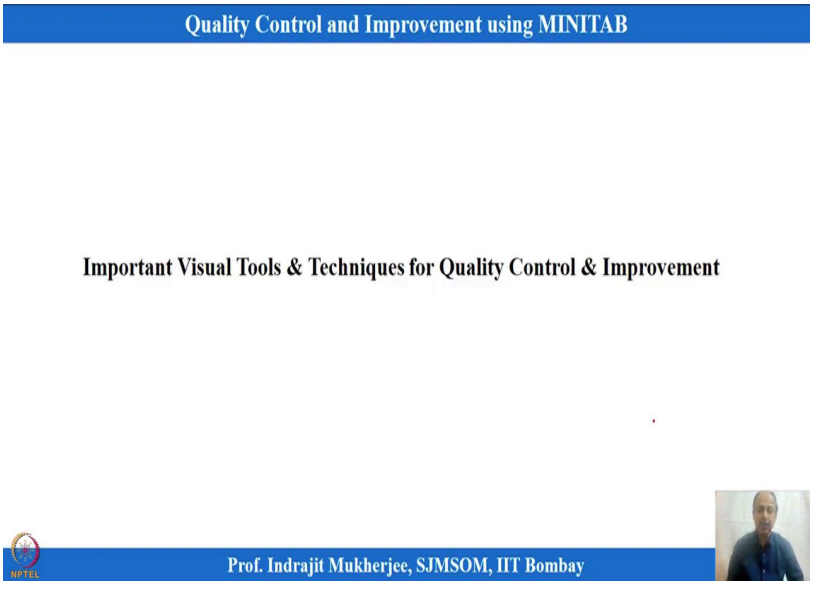

So, for that, visualization of the data is important. So, what we will do is that we will try to use visual tools, try to understand how to visualize the using a specific software which is over here MINITAB. But there are other software, where you can visualize. R interface can be used and you can use SAS or any other interface; but here, we will talk about how to use MINITAB in quality control and improvements ok.

So, first, we will try to do basic things visualization of the data; that means, we will try to draw a histogram in MINITAB. That will give you some sense and then we will go ahead. So, for this session, we will discuss about how to implement how to visualize using MINITAB, some data set which is which we want to which can be a CTQs.

So, histogram what we have; what we have told is that it will have frequencies on one axis over here and it will have CTQs defined on this axis; x axis will be CTQs and y axis will be frequency observations over here. So, there will be this will be bins and in this case, class number of class will be there; 1, 2, 3, 4 like this, N number of classes will be there and interval will be there. In a class, there will be intervals and there were highest frequency will be plotted over here.

So, this will be like and if you join the midpoints over here, you can see some belt shape kind of curve that you can see over here which may be a normal distributions. So, if you join the midpoints of the histogram, each of the bins like this midpoints, you can just join them and you can see what is the shape of the or shape or of the data set basically of the data set ok.

So, in this case, frequency on one axis and one axis is CTQs. So, let us try to plot this one in MINITAB. So, I will just introduce the MINITAB software to you and then, in next session, we may go ahead with using that ok. So, when this MINITAB software can be downloaded from websites.

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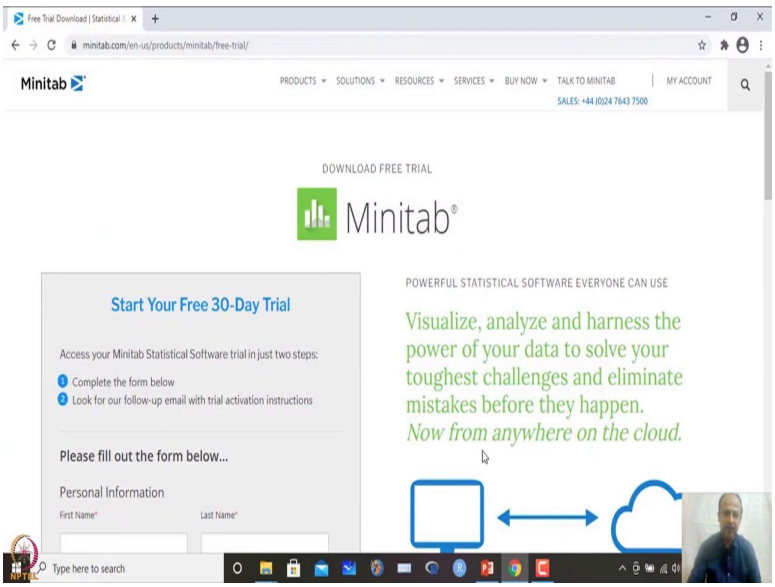

So, I am showing you the websites, maybe from MINITAB used to you can start a 30 days free trial and try to download the MINITAB software and 19 version is available, I think. So, this MINITAB 19 version; there can be earlier versions also, somebody may have installed earlier versions and maybe 17, 15. So, it is they continuously update the recent mode 17, 18, 19.

So, I will use the 19 one, more or less that is the latest one, what I can understand at present. So, that we are for academic purpose, we are using this MINITAB 19 for illustration over here ok.

So, whenever you install MINITAB from that website, you download that one and you install that one, what will happen? You get a icon over here in the desktop. So, if you double click that icon, what will happen is that interface will open and in that interface, we will be working using that interface to visualize the data over here ok.

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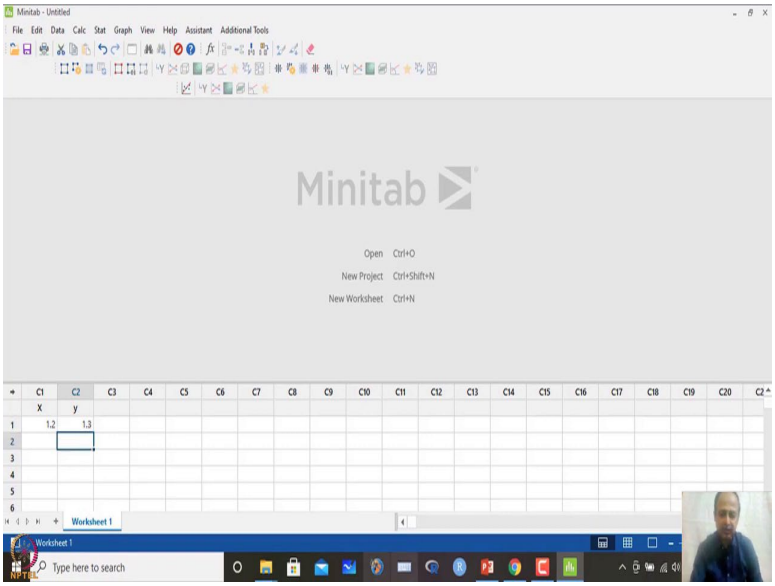

So, there are three areas over here. What you can see is that this is one of the area, where the data set can be you can write down the data sets over here or name the data set as x over here and you can write the numbers over here. So, C1, this row 1 here from here, the data will start basically. It is the column headings that you can provide over here x and y we can provide headings over here, you can write the numbers over here; whatever number you think out.

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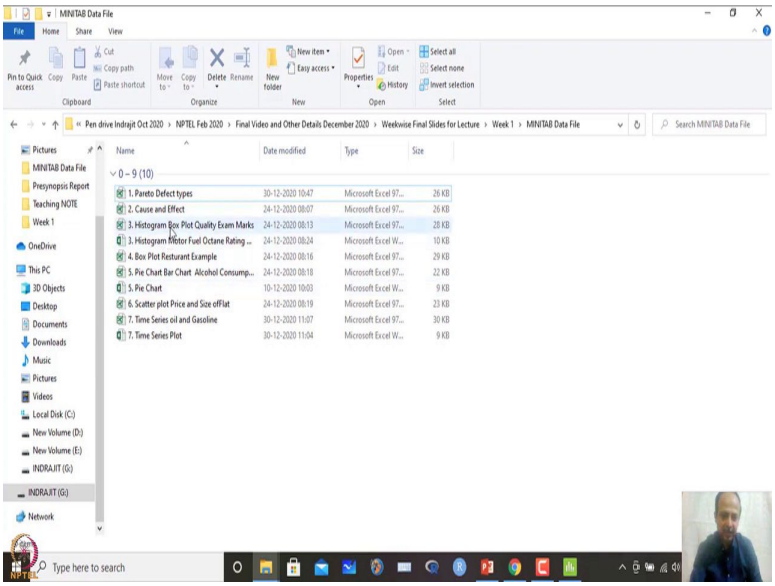

And you can also paste it from excel sheets. So, if we take it from excel, let us say some MINITAB files and you can open some excel files, maybe a quality course marks, we want to paste that one in this.

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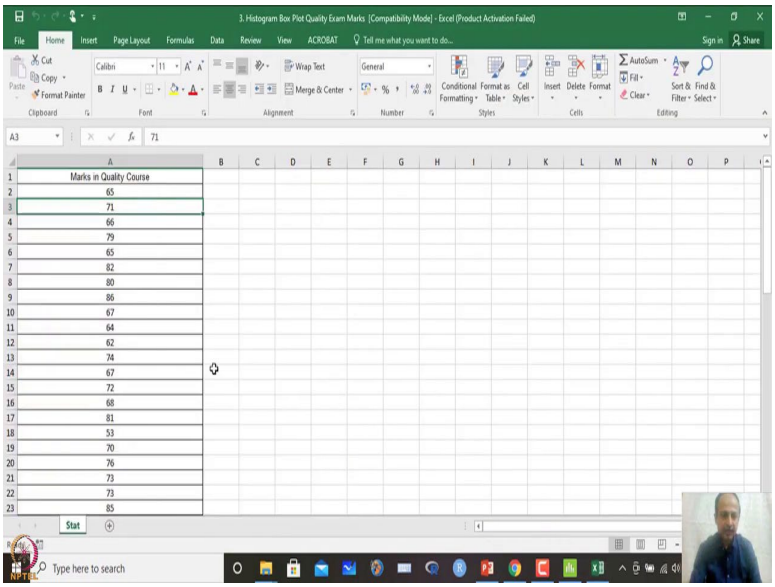

So, what we will do is that we can just this is in excel sheets, what we I can copy this column over here control C and then, what I can do is that I can paste the data sets over here and control V over here.

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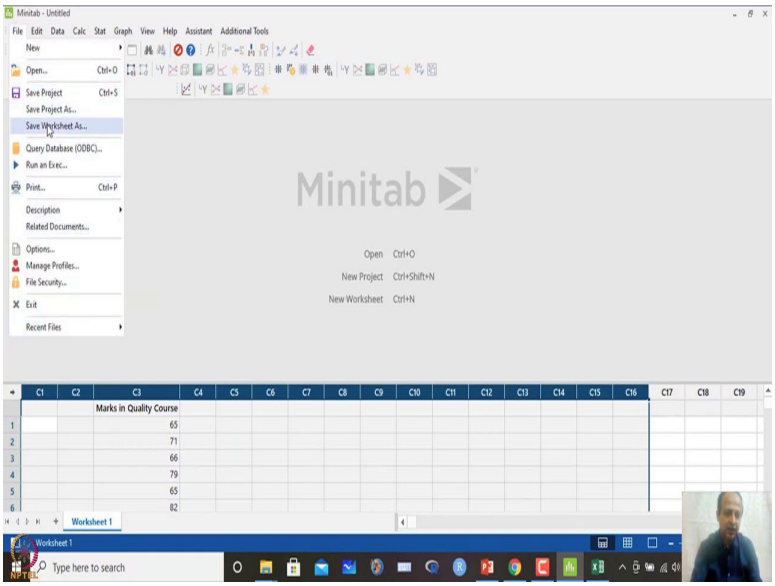

Always remember that the first row over here is the title of the column. So, you cannot paste number over here. So, number starts from row number 1 like this; 1, 2 whenever 1 here from you can write the numbers. You cannot paste numbers over here and MINITAB cannot analyze that one so in this case. So, these are the here you can place the data like this.

So, in this case, I have placed in C3 columns and then, I can save this file also; that means, I can save this is known as worksheet in MINITAB. This worksheet can be saved.

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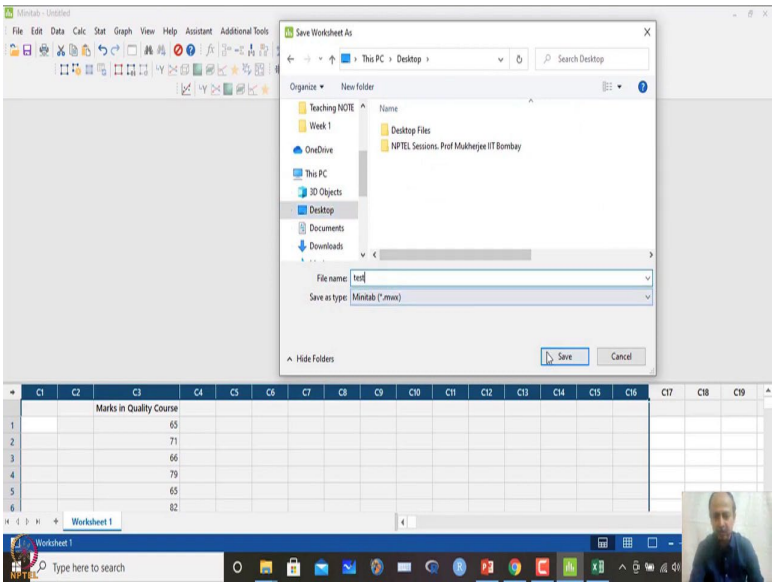

So, if you go to file and then, you go to save worksheet as and let us say I am saving it in desktop and I am naming it some test files. So, whenever you do that, you save that one. So, this will be saved as test mwx, what you see on the below over here and these files can be called time and again, to do the analysis.

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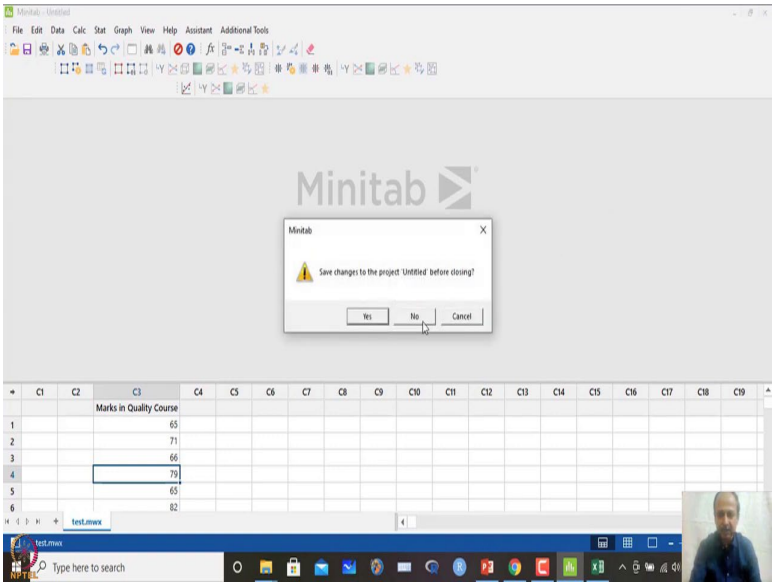

So, and if you close this one, let us say I am closing this one and then, it will ask a projects can also be saved. So, we will talk about projects. But I am not interested in

projects at this time point. Because I want the data set only to analyze because analysis can be done multiple times.

So, if I get the data, that is sufficient for me to analyze. So, I am saying no to the project savings. So, I go out of this and then, what I can do is that later on, I want to see the data set and again analyze this one. So, I open. So, this is saved in desktop and with a file name test over here and I have opened that file by double clicking that file over here.

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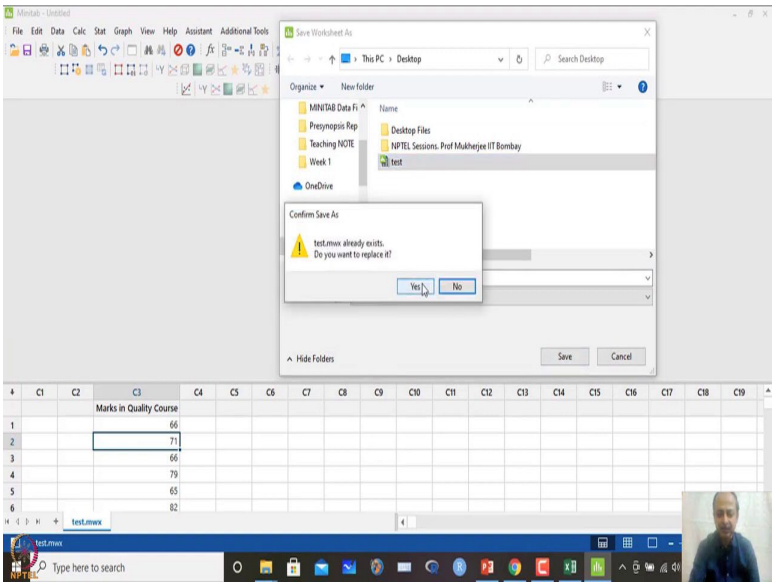

You can see that the marks are stored over here. So, if you change the marks over here, let us say 66 and then I want to save this one, what you can do is that go to file save worksheet as and then, just replace this file over here test and you replace the file, it will ask whether you want to replace that one. You replace that one.

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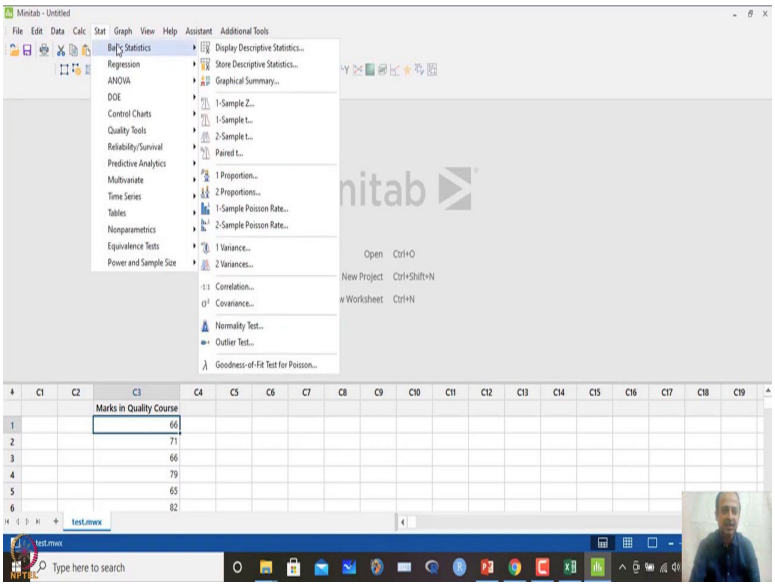

And immediately what you see is that it is replaced, it has become 66 now. And now, you can analyze the data. So, if you have to do the analysis on the top, you will find options over here statistics and there are various options that you can see over here.

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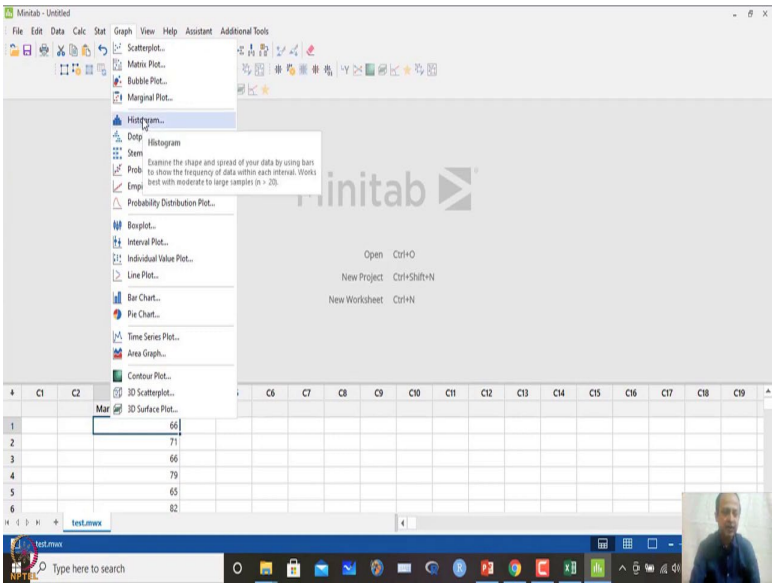

Like graphs you have many options; one of the options is histogram over here. So, whenever you click histogram, then we can draw histogram of this dataset and whenever you click a histogram over here and then, analyze, then click OK and what will happen is that we will take in the next session.

What will happen? This session window here, you will get the data sets. So, I am just showing you just for illustration over here; more details, we will do it afterwards. So, I am taking histogram over here, from the top-down menus over here.

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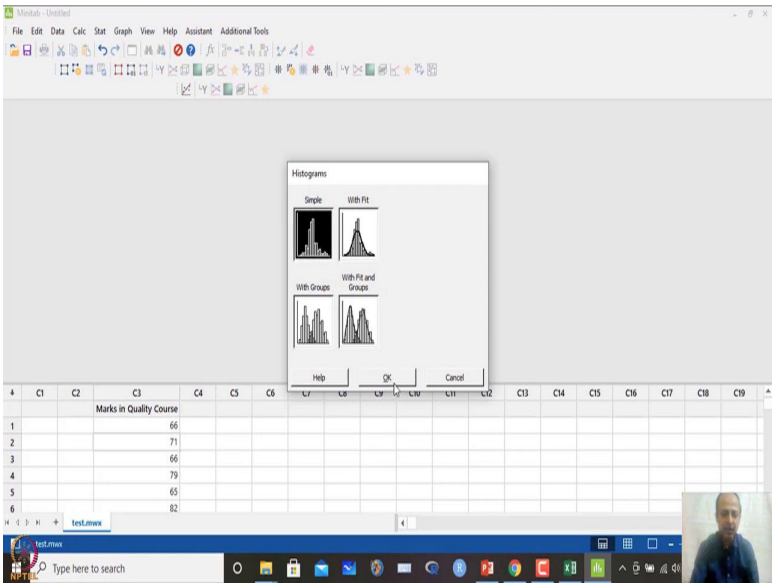

I want the graph histogram of this data set of quality marks, so I will go to histogram and I will say simple histogram, draw the histogram of quality course.

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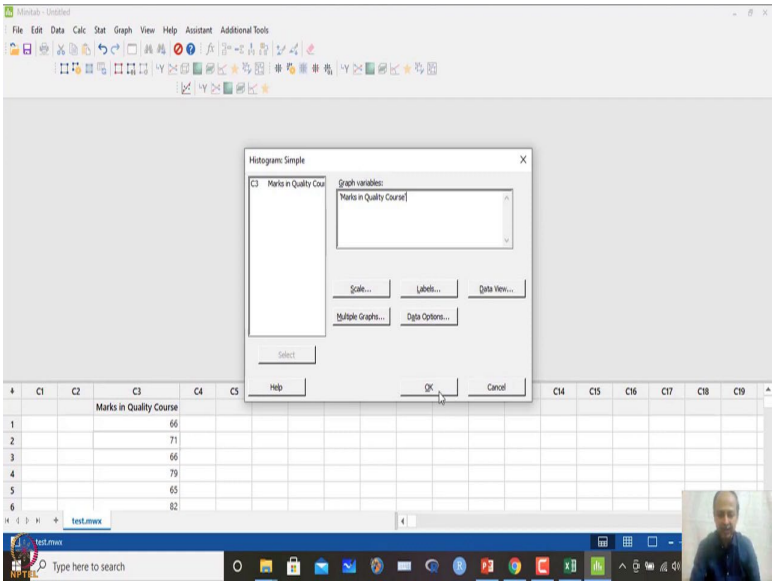

So, then it will ask which variables over here? So, I will double click this variable; my cursor should be over here in graph variables. So, it will blink in this graph variables,

then what I will do? I will hide double click this one C3 and I do not I am keeping all as default in MINITABs. Later on, we will see what are the options that we will have. Then, I click OK over here, immediately this in the session window that you see. This is the session window what you see.

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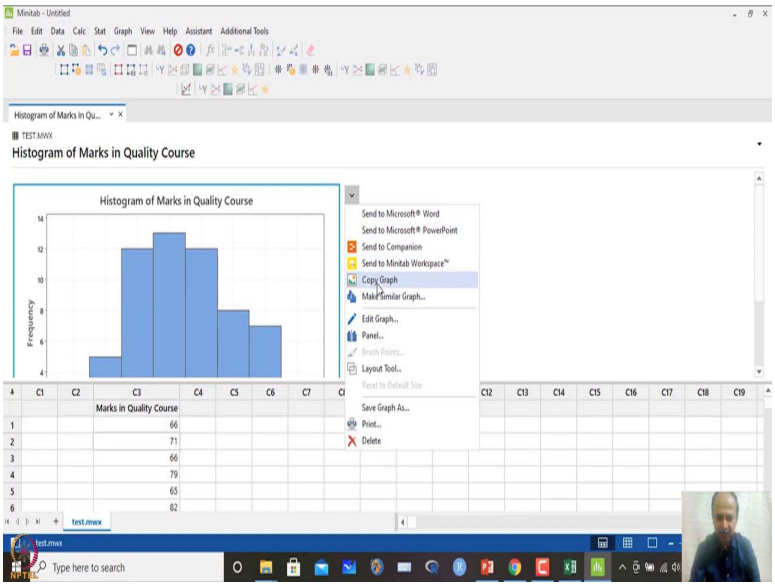

So, this is the session window of these projects over here. So, this is the distribution of marks or histogram MINITAB has drawn automatically.

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So, if you double click this one in the graph, so immediately it will enlarge this one and you can enlarge this one, you can copy the graphs also. So, you can edit the graph also.

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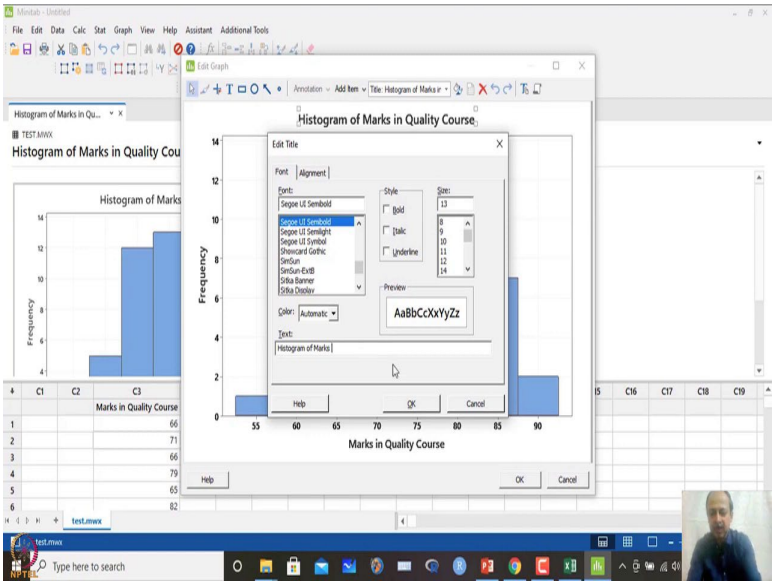

So, if you want to edit, just click double click this one and if you want to change this histogram of marks, you can do that and click ok.

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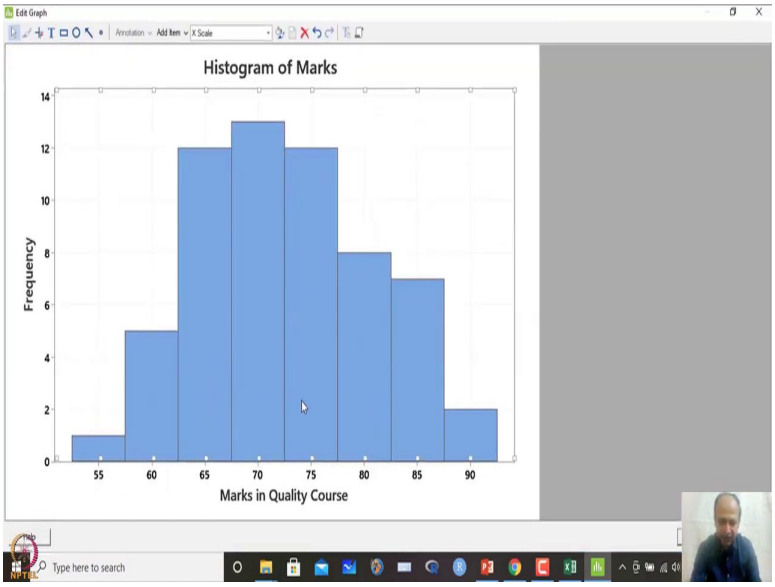

So, many possibilities I can change; frequency, if you want to see in one column, what is the data values within that bin. So, the bin is starting from if you click this one, the bin is

starting from over here 62 this is coming out to be this is coming out to be this bin will come out to be.

So, in this case, let us enlarge this one so that we can. So, this bin is giving you 67.5 to 72.5. MINITAB does it automatically histogram, there are rules to define class and class intervals; number of class and class interval based on the data set. So, those calculations can be seen in books.

So, in this case, what I am interested in where is the central tendency of the data. Around 70, we can see the central tendency of mean of the data set. I need to understand the varying variance of this data. So, that we will talk about how to see that one. So, only thing is that what I am saying is that you can draw the you the diagrams will be plotted in the session window.

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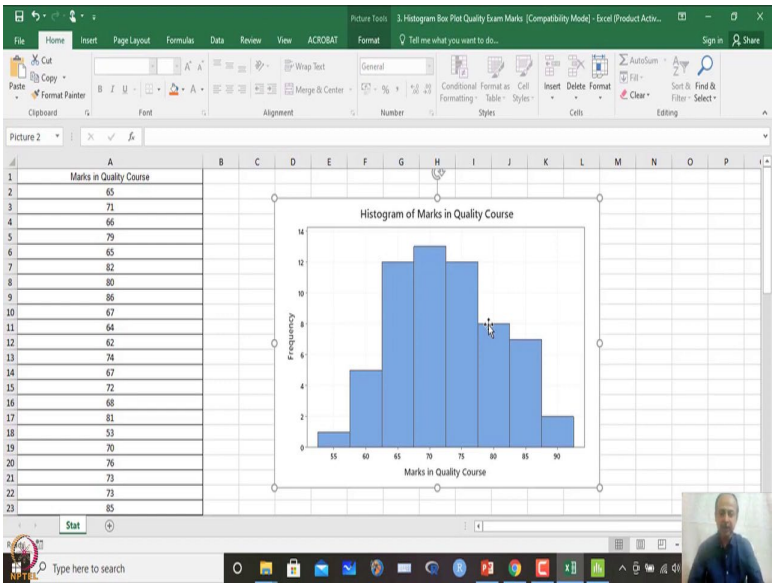

Then, you can copy this graph like copy if I want to copy this one and paste it in some other interface. So, if you want to I have copied this one, I want to paste it in excel. So, I will right click this one and I will paste this one. So, automatically MINITAB this diagram has come in the excel ok.

So, in reports, any reports you want to place what file or any other files, you can just paste it; paint shop, anywhere you can take this one and you can just paste this diagram ok. So, that is all what we want to discuss in this session for the session 4. So, we will

continue with visualization of the data. So, we are talking about accuracy and precision. For that, we are using histogram.

One thing, we should remember that this is for continuous data that we are doing over here. So, in this case, what we are doing is that we are assuming. So, in this case, what we are doing is that we are assuming this data set what we have CTQs that we have written over here.

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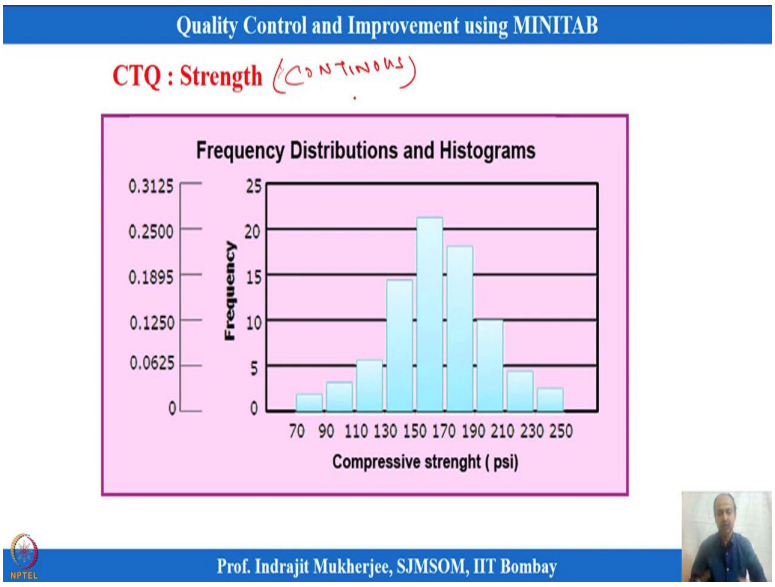

So, this CTQ is basically is a continuous variable. So, this is continuous. So, that means, a within the scale it has infinite possibility; number has infinite possibly, only the least count of the instrument that is measuring the strength and that data I am just monitoring. So, in this case, maybe second place of decimal or one place of decimal.

So, it depends on least count, but there are infinite possibilities of measurement within a range of let us say 150 to 170 infinite possibilities of numbers can be measured. So, this is a continuous data and that is why I am drawing a histogram. Histogram is for continuous data. Whenever, I have a continuous data, I can use histogram to see the mean and variation of the data; how is the spread of the data; what is the shape of the data; where is the central tendency, all these things can be seen visualized.

Numbers can be calculated, numbers can be seen by some other options and spread also can be seen by some other options like box plot, what we will discuss in the next session.

So, we are discussing about visualization of the data. So, we will continue because this data visualization is very important in quality. If I can visualize, then I can take some corrective actions based on the data and then, I can interpret something.

So, this is known as we can say descriptive statistics of visualization of the data and based on that, we make some initial conclusion about the data or make some initial assessment of the data basically ok. So, we will continue from here in session 5.

Thank you for listening. So, we will continue with data visualization in quality.

Thank you.