

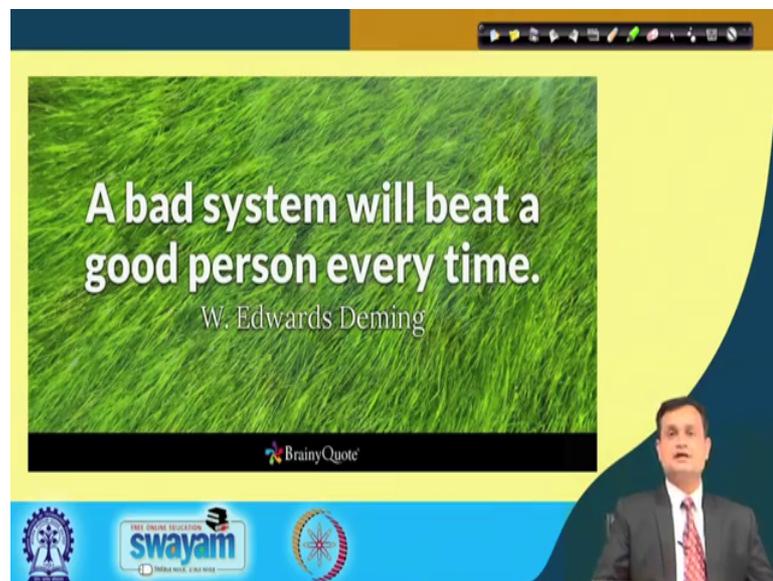
Six Sigma
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Lecture - 26
Process Capability Analysis: Minitab Application

Hello friends, I welcome you to the ongoing six sigma journey and if you recall we were discussing Process Capability Analysis in the last two lectures. So, we have covered the various concepts and process capability indices. Now in this lecture 26, I would like to share the mini tab application of process capability analysis.

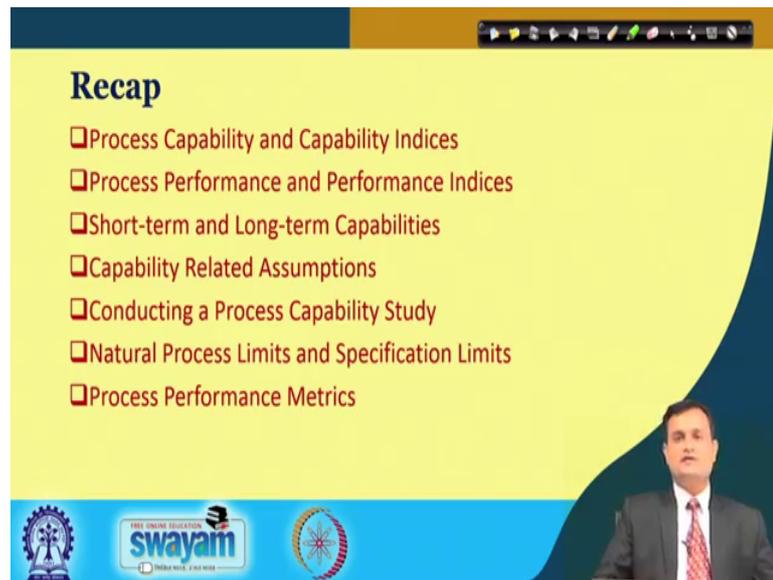
So, mini tab is a widely used software for conducting various kinds of statistical analysis and this software is widely used for say doing the various kinds of analysis as a part of six sigma. So, I will just try to show some brief application of mini tab for conducting process capability analysis.

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So, once again I would like to remind you that a bad system will beat a good person every time, this is said by the renowned quality guru W Edwards Deming and we must have a capable system capable process. So, that we do not unnecessarily take the corrective exercise in the wrong direction.

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Recap

- ❑ Process Capability and Capability Indices
- ❑ Process Performance and Performance Indices
- ❑ Short-term and Long-term Capabilities
- ❑ Capability Related Assumptions
- ❑ Conducting a Process Capability Study
- ❑ Natural Process Limits and Specification Limits
- ❑ Process Performance Metrics

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If you see the brief then we talked about short term process capability, long term process capability, process capability indices, process capability concepts, process performance and we are also seen that traditionally whatever we have seen DPMO DPU and defect related measures specific six sigma measures they are different than process capability measures or indices. And we have seen that C_p is basically indicates the potential of the process CP_{KI} C_{pk} performance of the process, then you have CP_U , C_{PL} if you are targeting only one specification limit and same way you have P_p P_{pk} PPU PPL typically when you are considering a long horizon over which the process is absorbed and for long term when you are conducting the process capability analysis.

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CONCEPTS COVERED

- Concepts Covered:
- Steps to conduct process capability analysis in Minitab
- Minitab Process Capability Analysis
- Example with demonstration to use Minitab

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INDIA WISE, LEADERSHIP

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So, typically in this particular session which deals with the mini tab application, we will try to appreciate these steps to conduct process capability analysis, mini tab process capability analysis, examples, some demonstrations and like this.

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Steps to Conduct Process Capability Analysis in Minitab

- Step 1:** Go to File menu, click on Open Project and then load the required data.
- Step 2:** Go to Stat menu, move to Quality Tools and then to Capability Analysis or Capability Sixpack.
- Step 3:** From the dropdown menu, select Normal or Non Normal analysis based on whether your distribution is normal or non-normal
- Step 4:** Click on non-normal (or normal), enter the details required for conducting the capability analysis and then click Ok.

Once we click ok, Minitab generates the process capability in a separate window.

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You will in fact, find many video lectures also available 3 minutes to 10 minutes on YouTube that can also help you to appreciate the mini tab application. A good mini tab support is also available online and you can see various examples. So, from those

sources I have taken some of the examples to discuss with you and we will appreciate how we can conduct the process capability analysis in mini tab.

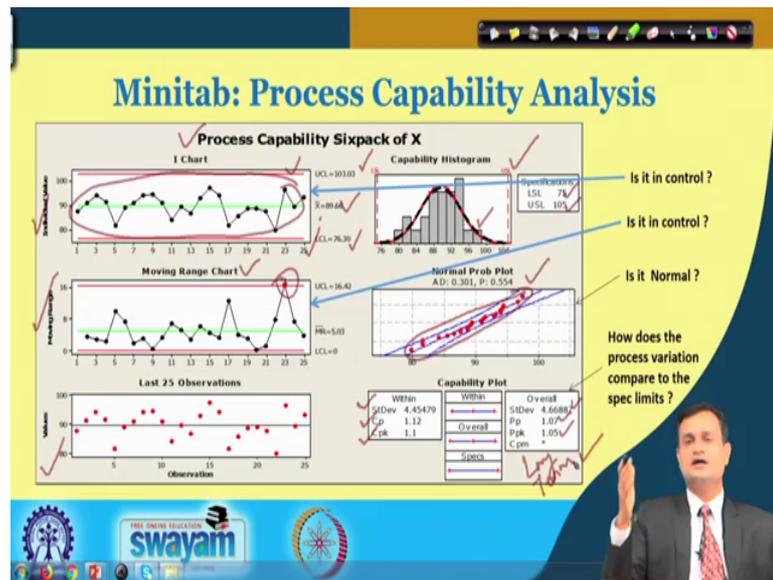
So, the steps goes like this, step 1 go to file menu click on open project and then load the required data. You may have a data in excel sheet you can import the excel sheet or you can just copy paste the data transfer the data in the new project file. Step 2, go to start menu move to quality tools and then capability analysis or capability six pack. So, here you will find two options capability analysis and second is capability six pack we will see. So, this is a say commercial version, commercial software and to suit and meet the requirements of the industry, they are offering two different kinds of options process capability analysis and process capability six pack analysis.

Step 3 from the drop down menu select normal or non-normal analysis; at this stage we will only talk about normal, subsequently in the next lecture we will talk about non normal process capability typically when my data is not normally distributed then how to deal with this and how to conduct the analysis in mini tab.

So, once you have selected the normal here in this case and typically whether your distribution follows normal or non normal. So, there are various ways and means the simplest way is to look at your histogram and that will at least give you some say inside that to what extent your data is symmetrically normally distributed or it is skewed on either side or it follows some other distribution. But there is normal probability plot and when you plot your data on this, that will clearly give you the guidelines that yes your data is normally distributed or not. So, we will see such kind of graphs also in this lecture.

Step 4, click on non normal or normal for this lecture, as I mentioned let it be normal, enter the details required for conducting the capability analysis click ok and the moment you will click ok mini tab will generate the various results outputs in a separate window.

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So, just see this and you will find it interesting that, what are the a say outputs your typical mini tab will generate when you are pressing and selecting process capability six pack analysis. Six pack here means you will allow six different results analysis present date and all are very much useful.

If you see the first one individual value I chart, then this helps you to understand that whether there are some outliers or some of the say readings they are falling typically outside the upper control line or the lower control line. So, if you recall I emphasize that in order to conduct your process capability analysis, your process must be in a state of statistical control and if this particular graph for individual shows that it is not within control or some of the outliers are there, you can exclude the outlier or first you can bring the process into the statistical control.

So, that whatever variation you absorb that is mainly within this control limit and control limit statistically it is \bar{x} plus or minus three sigma. So, you have the standard deviation value, this is your \bar{x} and when you put it as plus or minus 3 sigma, you get the typical upper control limit and the lower control limit.

Now here I can see that all the points are within and I can have a fair assumption that my processes within the statistical control. Similar way you also check for the range because many times only individual observation cannot help me, we always talk about the center or location of the process and dispersion. So, variability I can capture through this

particular moving range chart and that will help me to understand that whether my readings for range are within the prescribed limit that is the control limit or some reading is going out. So, here you can see that one of the reading is going out and if there is some assignable cause, special cause you can actually remove this cause and bring your process into the statistical control.

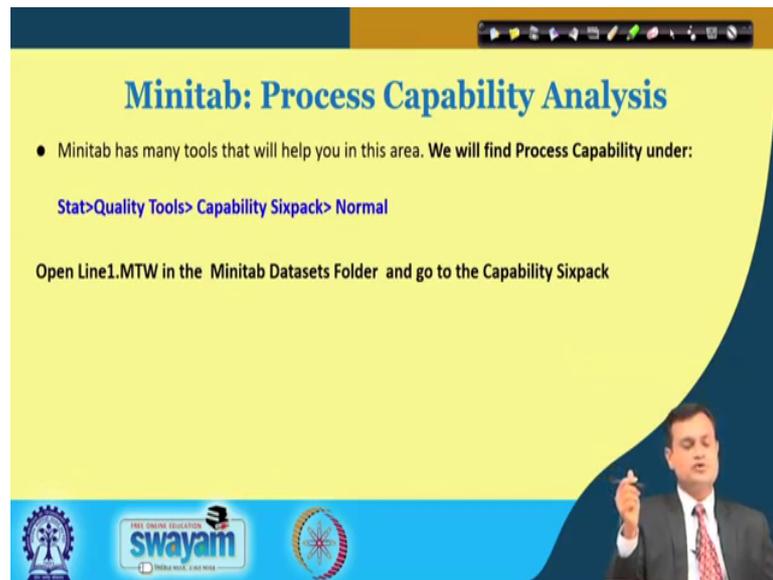
Then you have various observations and value plotted. So, this graph will just give you an idea that whether your observations they follow a random pattern or there is some kind of trained available. So, this is your 25 observation chart, now you can see here that you have the capability histogram and you have specification LSL 75 USL 105. So, this histogram as you can see will help you to appreciate that to what extent your assumption about normality is true and whether your data follows the normal distribution or not. If it is not then you must go for the non normal process capability analysis that we will discuss in the next class.

Now you can see the another one that normal probability plot and what you can see here that you have the readings plotted here, all these readings in red dot and suppose if I put a pencil or pen, and if it covers all the readings on normal probability plot then I would say that my readings they form or my observations they follow the normal distribution and my assumption about normality is true. You can have capability plot also.

So, typically this is the end result that we are looking for. So, we have standard deviation, we have pp we have Ppk on this side you can see standard deviation Cp and Cpk and you can easily make a conclusion that Cp 1.12. So, technically it is greater than 1 and your processes capable similar way your Cpk is 1.1. So, it is capable.

When I look at the long term this is my long term then, Ppk and Pp value are also greater than 1. So, I would not say its a six sigma process, but for because for that I need to be close to 2, but fine technically greater than 1 it means my processes are capable in terms of performance, that is the spread variability in terms of potential Ppk in terms of location or shift in the center value or the location. So, this is a very helpful analysis and you can do it very easily in mini tab and interpret the results also.

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Minitab: Process Capability Analysis

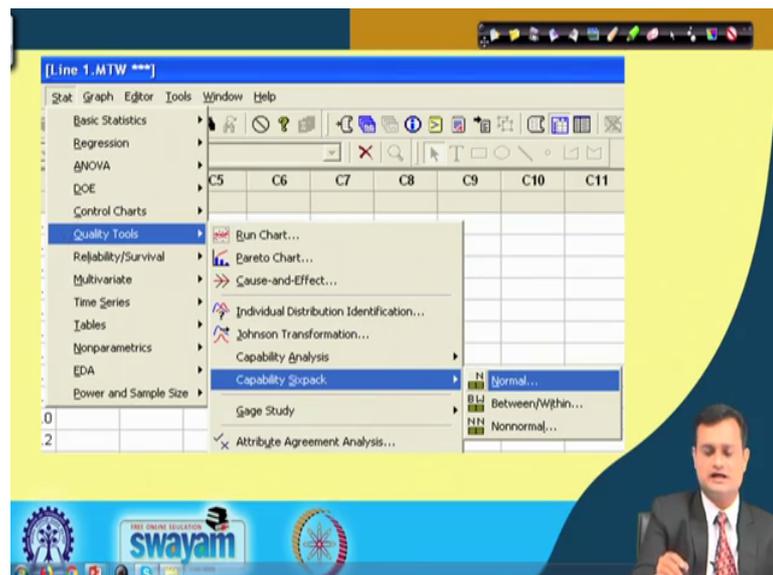
- Minitab has many tools that will help you in this area. We will find Process Capability under:
Stat>Quality Tools> Capability Sixpack> Normal

Open Line1.MTW in the Minitab Datasets Folder and go to the Capability Sixpack

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Now, the process which we follow in mini tab I have already discussed the steps. So, you have statistics the package statistics, quality tools, capabilities six pack and then normal because my assumption is that it is normal, but definitely I would like to verify it through histogram as well as normal probability plot, and then I can open some file for getting the data input or for importing the file to my mini tab and then I can conduct the minitab six pack process capability analysis.

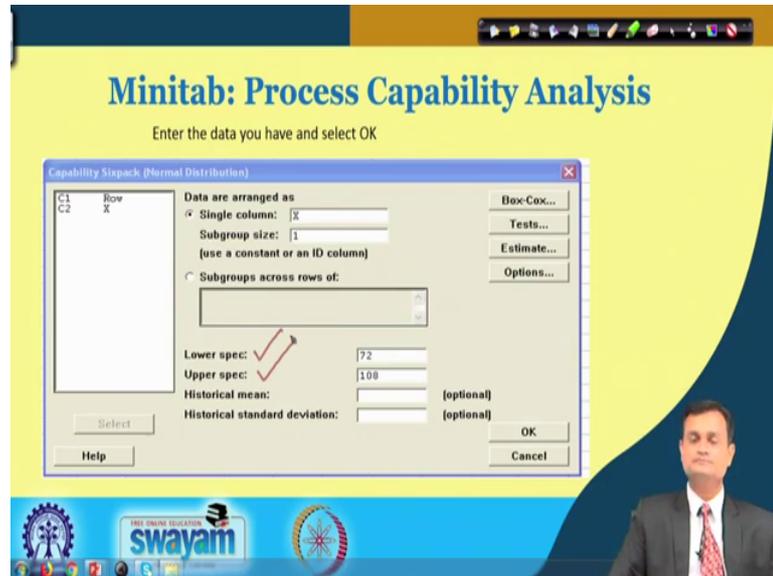
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The image shows the Minitab software interface. The menu path **Stat > Quality Tools > Capability Sixpack > Normal** is highlighted. The main window displays a data table with columns labeled C5 through C11. The bottom of the slide features the Swamyam logo and a small image of a man in a suit.

So, I was shown here with a clear cut idea that, this is the quality tool, then once you will have here you will have a drop down menu, you will have capability six pack and then you select normal. So, its a very simple and easy to follow procedure.

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Once you have done this then you will have some datas to be say inserted and here you can see that there is single column subgroups sizes 1 and you need to enter this lower specification limit and upper specification limit. If you make mistake in say inserting the data, you will get asterisks; asterisks means because of certain reason we could not conduct or software could not compute the value and we have to be careful in inputting inserting these values properly.

So, this is the six pack analysis that you have seen and we have discussed all the importance of all the six charts.

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Example

Calculate the capability indices - C_p , C_{pl} , C_{pu} , and C_{pk} for the process for which the data are given below using MINITAB. The process has subgroup size of 5 and 125 data points.
USL = 10.050, LSL = 9.950, $\mu = 9.999$ and $\sigma = 0.0165$

Now, let us take the example and try to also solve it using the mini tab. So, calculate C_p , C_{pl} , C_{pu} , C_{pk} for the process which the data given using the mini tab and the processes subgroup size 5. So, each particular sample you have 5 units its a subgroup size and 125 data points are there you have USL upper specification limit 10.0250, you have LSL 9.950 and you have mu 9.999. So, you have the data set you can compute this and you out sigma 0.0165.

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Capability Analysis through Minitab Example

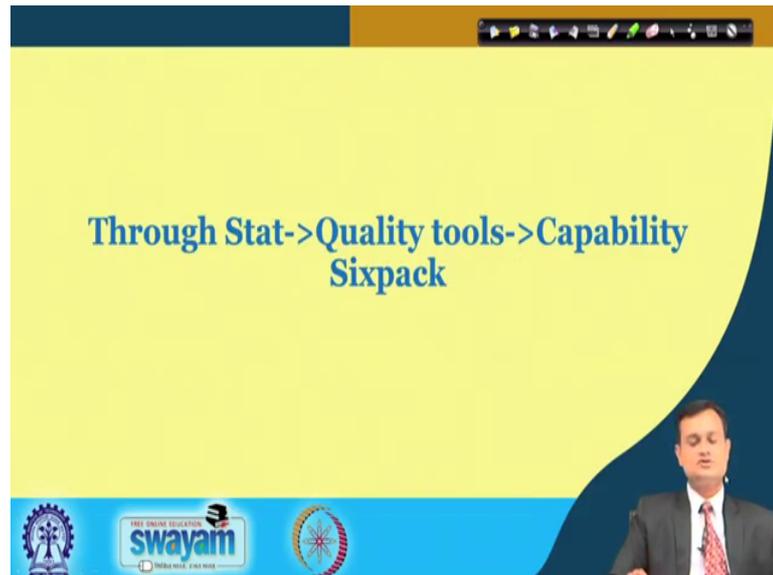
Capability analysis can be done in two ways

1. Through stat->quality tools->capability sixpack
2. Through stat->quality tools->capability analysis

The following slides will show both ways

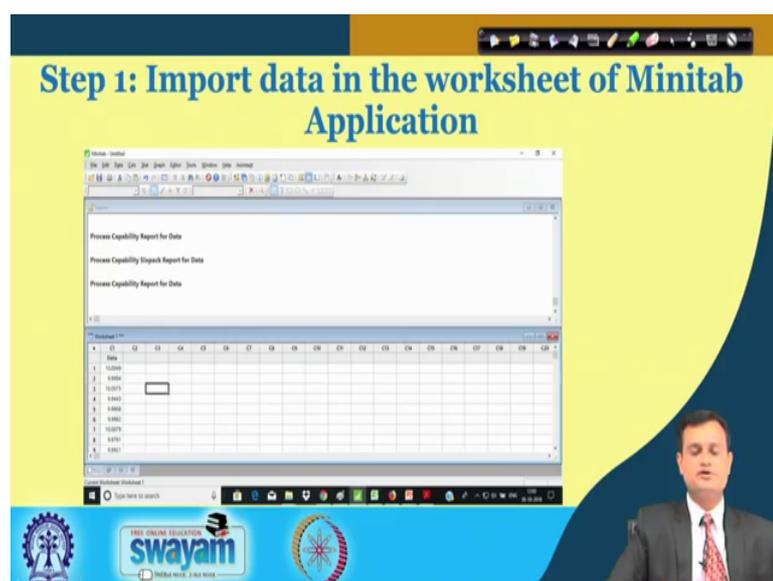
Now, as I mentioned you can do two kinds of analysis, number 1 you can go to stats quality tools and capabilities six packs. So, it will give you six different outcome, each one will help you to appreciate the data and the results and comment on the capability of your process, and second is through stat quality tools and capability analysis. So, now, we will see in the subsequent slides how to carry out this exercise.

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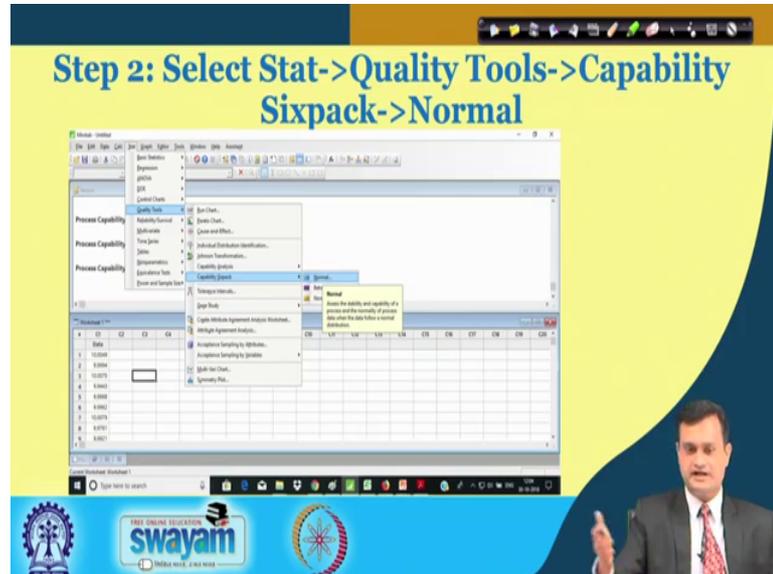
So, first let us say capability six pack.

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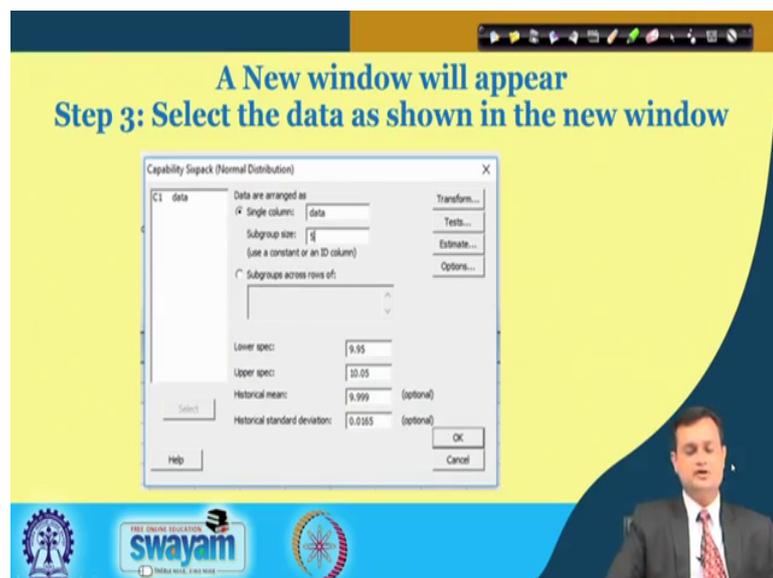
So, I have this particular window; this is step one import data in the work sheet of the mini tab application and it is like excel sheet only.

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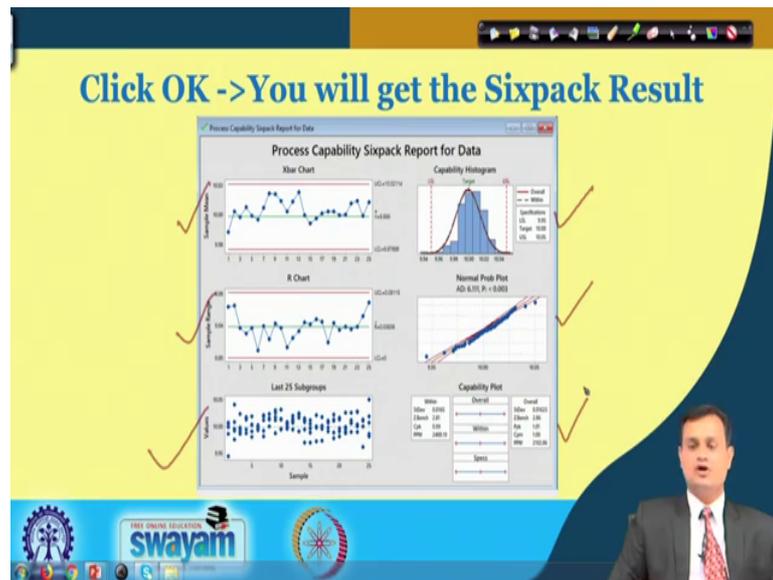
Then you have capability six pack. So, from quality tool you go to capability six pack, I am elaborating it and then you select the normal.

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Then you put the data lower specification, upper specification, mean standard deviation and you press the ok.

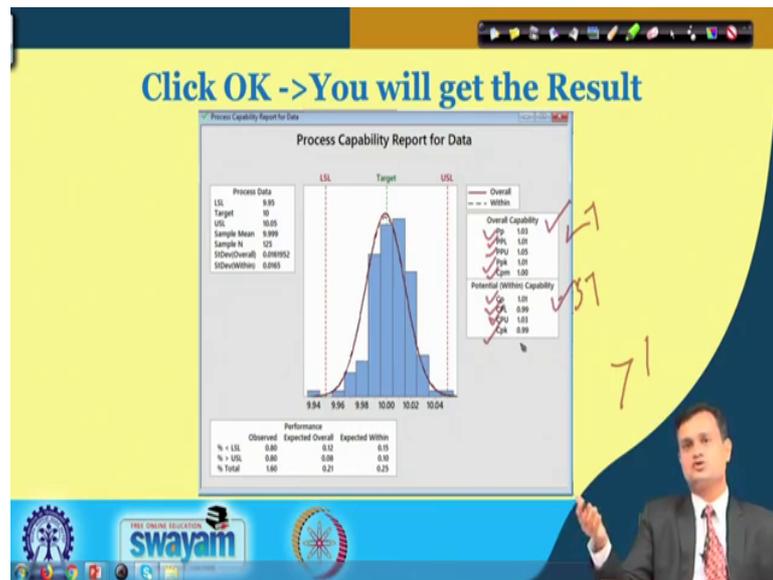
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So, you will have six different charts of graphs in front of you and as I mentioned that these two will help you to understand whether my process is in control or not, this will help you to understand whether my data is randomly scattered or there is some pattern available.

This tool will help you to understand whether my data is normally distributed or not, and this will basically give you the value of your process capability short term that is C_{pk} C_p and long term it is P_{pk} P_p and so on. Now you can use the other option that is simple quality tools capability analysis. So, once again import the data, then go to quality tools capability analysis and select the normal. Once this is done once again you insert the values of your upper specification limit, lower specification limit mean and the standard deviation and your sub group size 5.

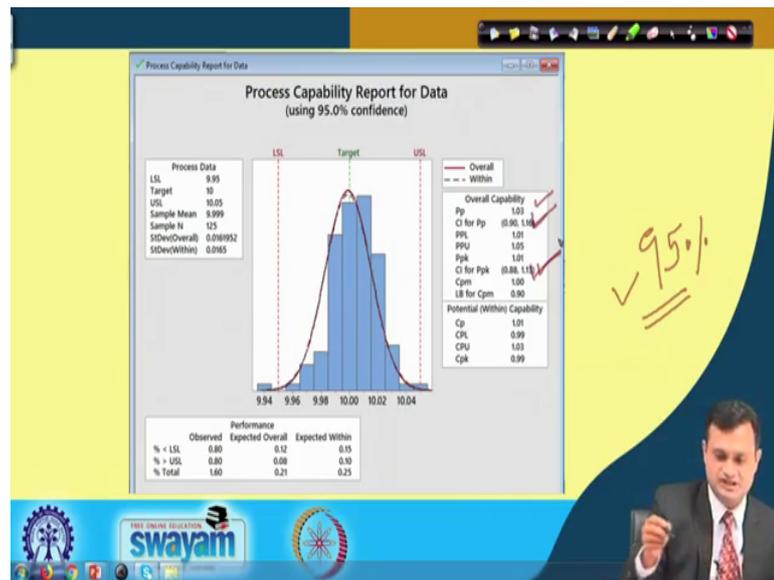
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So, you will have the different analysis window or different graphs available, not like six pack where you are getting six different graphs in one window. Here it will generate first let us say process capability report for the data and you can interpret very easily this is the overall capability and this is the within capability.

So, this is your long term this is your short term and you can see that Pp value PPL value PPU Ppk Cpm as well as C p all these are greater than one. So, my process in this way is capable, but if you see the C pl its point ninety nine its almost it is 1, but by chance if it is low then it would say that I have a little less capability when I look at the lower specification limit otherwise my C pk C pu C pk more or less they are one or very close to 1 so my processes capable.

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You will see another report that is 95 percent confidence and we will see in hypothesis testing, but many times I want to conduct the confidence interval and want to see that my specific value of interest, does it fall into that confidence statistical confidence interval or not.

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Example

Source: Six Sigma Quality: Concepts & Cases- Volume I_STATISTICAL TOOLS IN SIX SIGMA_DMAIC PROCESS WITH MINITAB APPLICATIONS

We want to assess the process capability for a production process that produces certain type of pipe. The inside diameter of the pipe is of concern. The specification limits on the pipes are 7.000 ± 0.025 cm. There has been a consistent problem with meeting the specification limits, and the process produces a high percentage of rejects. The data on the diameter of the pipes were collected. A random sample of 150 pipes was selected.

So, here you can see that this particular say graph has given you Pp, but confidence interval for Pp. It means this says that I am creating the confidence interval for 95 percent. So, please remember that statistics is basically based on the random phenomena,

chance phenomena and we try to take the sample and based on that we try to derive the inferences. So, we cannot be sure 100 percent, we have to make certain assumptions as well as we have to work within with certain probability. So, here I say that 95 percent confidence I have that my value p value will fall in the range of 0.90 this is the one I am referring to 1.16.

So, I have 95 percent confidence in my result that my P p value will fall within this interval 75 percent of the time similar way I would be interested to see that what is the confidence interval for P and your P p value is 1.01, but if you conduct a study number of times you would find that find for different subgroup or for different window of time you will have different, P p value, but with 95 percent confidence I can say that my P p value will fall within 0.88 to 1.13.

So, this is something that is additional, we can do in the process capability analysis and we can create the confidence interval for various indices. So, just see the example here to strengthen your understanding, we want to assess the process capability for a production process that produces certain type of pipe and typically the inside diameter is the CTQ Critical To Quality, the quality characteristic in which I am interested and that is of concern.

So, specification limit for this is 7 plus or minus 0.25 mini tab centimeter and there has been a consistent problem with meeting the specification limits. So, you are encountering the rejection and now I want to see that whether my process is really capable or not. So, I took the random sample of 150 and I measured the inside diameter and then I am trying to conduct the process capability analysis.

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Solution Steps

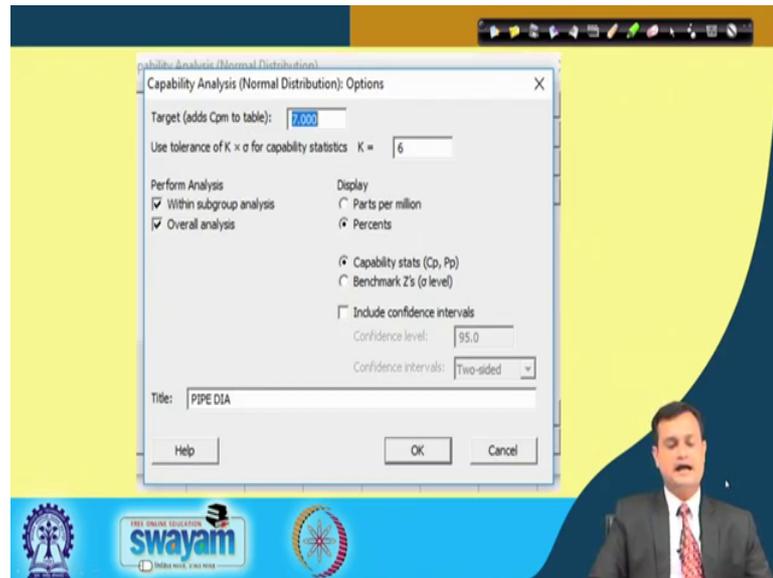
- ✓ Generate random data using Excel sheet with upper limit as 7.025 and lower limit as 6.975.
- ✓ Use the command sequence Stat & Quality Tools & Capability Analysis & Normal
- ✓ In the Data are Arranged as section, click the circle next to Single column and select or type C1 Pipe Dia in the box
- ✓ Type 1 in the Subgroup size box
- ✓ In the Lower spec. and Upper spec. boxes, type 6.975 and 7.025 respectively
- ✓ Click OK
- ✓ Click the Options tab on the upper right corner
- ✓ Type 7.000 in the Target (adds Cpm to table) box
- ✓ In the Calculate statistics using box a 6 should show by default
- ✓ Under Perform Analysis, Within subgroup analysis and Overall analysis boxes should be checked (you may uncheck the analysis not desired)
- ✓ Under Display, select the options you desire (some are checked by default)
- ✓ Type a title if you want or a default title will be provided
- ✓ Click OK in all dialog boxes.

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So, you can see the steps it is same as I mentioned that you open the window, import the data or copy paste the data, say define the subgroup size also enter the upper and lower specification, limit your standard deviation and mean value and then you just try to click ok if you want to conduct six pack analysis choose that option. If you just want to go for process capability analysis choose that option and that would serve your purpose.

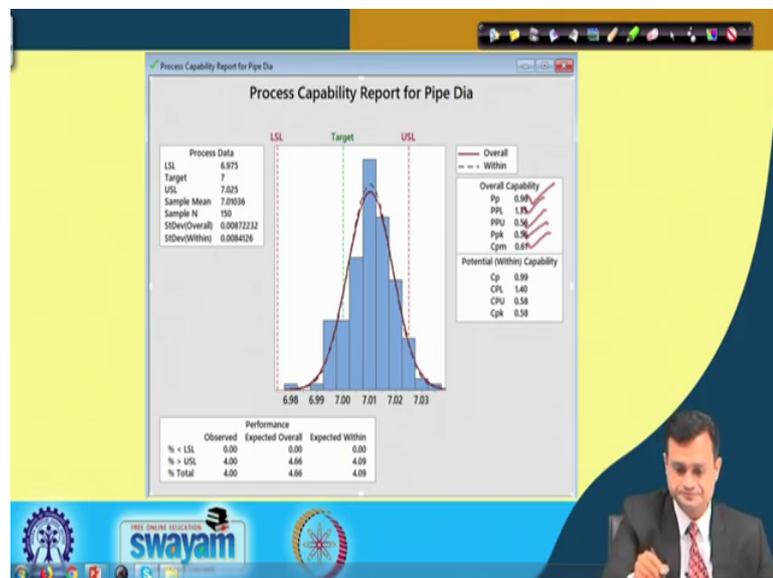
So, this is the initial window where I put the data, this is the pipe data you can see in first column, and then say second window I am going. So, capability analysis I am choosing and that is normal I am entering the data of LSL USL sigma mu and then I am also putting the target.

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So, we discussed C pm and this particular target related indices is also called Taguchi capability index, here I am specifying my target value and with respect to that I want to conduct the analysis.

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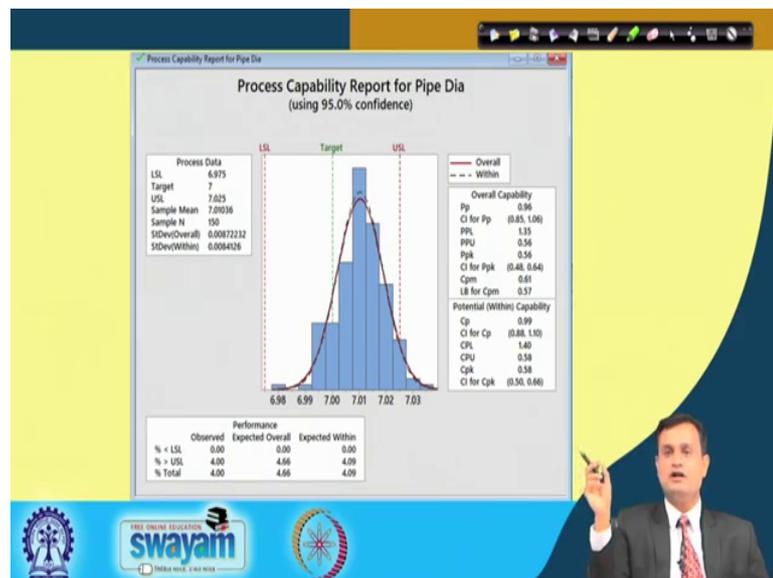


So, once this is done you can figure out that exactly what is happening with your process and just see these values you have Pp 0.96, you have PPL 1.35 PPU 0.56 Ppk 0.56 and Cpm 0.61.

So, excluding PPL that is on the say lower side, all other values are less than 1 and clearly it indicates that your process has problem. Now if you see the PPL this is quite good 1.35. So, you have a comfortable zone towards lower specification limit and if there is a need to readjust your center to the target or to some value, then you can little bit more towards the lower specification limit and you can try to control the scrap which is increasing your cost.

But this is a short term measure for long term; obviously, you have to correct the setting if there are worn out parts you have to replace them if there is an issue with the operator skill, you have to train the operator and likewise you have to take the long term actions also.

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So, this is 95 percent confidence and same way you can see that what is the band, statistical confidence interval band within which at 95 percent confidence my Pp will fall my Ppk will fall and so on.

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Caution! - Why are some capability analysis results shown as asterisks in the output?

- If a capability index cannot be calculated, Minitab inserts an asterisk (*) next to the index in the capability analysis results.
- If you see an asterisk in your output, it may be due to one of the following reasons.

Reason 1: Only one specification limit

If you enter only an upper or a lower specification limit, but not both, Pp and Cp indices cannot be calculated. Pp and Cp are both calculated using the distance between the lower and upper specification limits. If only one specification limit is entered, that distance does not exist, and Cp and Pp values cannot be reported.

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So, you have certain cautions and I mentioned that if you do not enter the data properly, your mini tab output will show you the asterisks for some of the indices or some of the results, and this asterisks indicates that either reason number 1, only one specification limit. So, if you have entered only one specification limit, but not both then typically your Pp and Cp were $USL - LSL$ is required that will show you the asterisks.

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Caution! - Why are some capability analysis results shown as asterisks in the output?

Reason 2: No target

If you do not enter a target for the analysis, Cpm cannot be calculated. Cpm is a capability index that measures whether the process meets specification and is on target, by taking into account the data's deviation from the target value. If no target is entered, that deviation does not exist, and Cpm cannot be reported.

Reason 3: Two boundaries

If you select both specification limits as boundaries, all capability statistics will have asterisks (*) instead of values in the output.

You should only use a boundary when it is not possible for data to exceed that specification limit. For example, if you record downtime for a piece of equipment, a lower specification of zero should be checked as a boundary because negative downtime is not possible.

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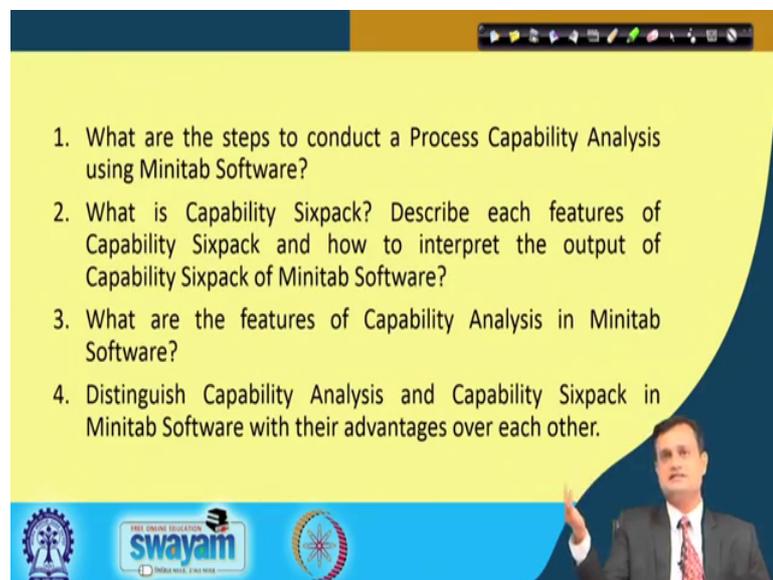
Similar way you know target. So, if you do not enter a target for the analysis what is your target value? Cpm cannot be calculated because this is Taguchi process capability index

which demands that, you should specify the target. If you are not interested in that kind of analysis fine you may not enter, but otherwise it will show you the asterisk. Two boundaries, if you select both specification limits as the boundaries, all capabilities statistics will have asterisk instead of values in the output.

So, here you are creating the boundaries selecting the boundaries as the specification limit and you should only use a boundary when it is not possible for data to exceed that specification limit. Just to share the example if you record downtime for a piece of equipment, a lower specification of 0 should be checked as a boundary because negative downtime is not possible.

So, some time to restrict my data within a particular range, negative downtime has no value no importance no significance would be interested to specify the boundary, but defining a logical boundary leads to say inability of the software to give you the result and then it will show you the asterisk. So, to end this session, I would like to float couple of questions as think it.

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1. What are the steps to conduct a Process Capability Analysis using Minitab Software?
2. What is Capability Sixpack? Describe each features of Capability Sixpack and how to interpret the output of Capability Sixpack of Minitab Software?
3. What are the features of Capability Analysis in Minitab Software?
4. Distinguish Capability Analysis and Capability Sixpack in Minitab Software with their advantages over each other.

So, you have certain steps to follows in mini tab can you just summarize this steps once again. What is the capabilities six pack described the features of this and how do you interpret the various outputs of six pack? What are the features of capability analysis in mini tab software and we discussed already that can you distinguish the capability

analysis simple and capability analysis six pack in mini tab software with couple of advantages and disadvantages over each other?

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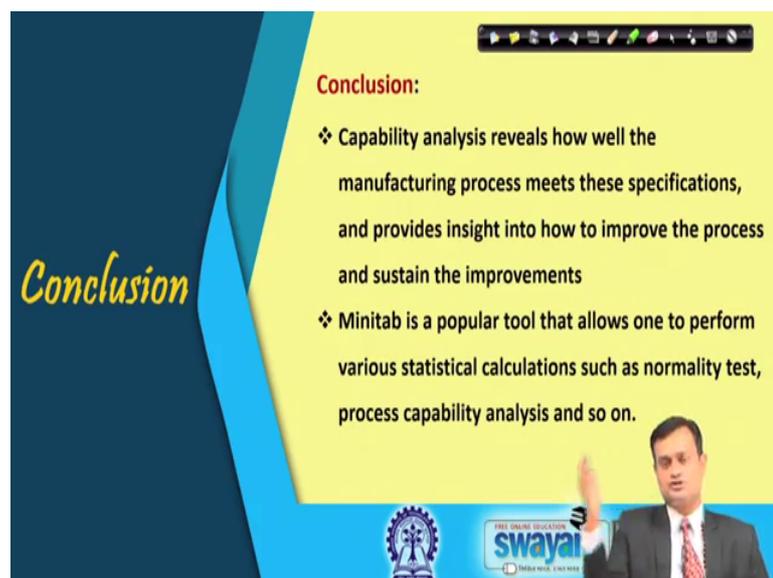
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- ❑ The Certified Six Sigma Black Belt Handbook by T. M. Kubiak, Donald W. Benbow, Pearson Publication.
- ❑ Forrest W. Breyfogle III, Implementing Six Sigma, John Wiley & Sons, INC.
- ❑ <https://support.minitab.com/en-us/minitab/18/help-and-how-to/quality-and-process-improvement/capability-analysis/supporting-topics/capability-metrics/capability-analysis-results-shown-as-asterisks/>
- ❑ <http://support.minitab.com/en-us/minitab/18/help-and-how-to/quality-and-process-improvement/capability-analysis/how-to/capability-analysis/normal-capability-analysis/before-you-start/overview/>

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So, I have highlighted here couple of links from where I use the example, I took the example you can also further refer it, you can refer the mini tab support or you can put process capability analysis in mini tab in YouTube and you will also get some of the good useful videos.

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Conclusion:

- ❖ Capability analysis reveals how well the manufacturing process meets these specifications, and provides insight into how to improve the process and sustain the improvements
- ❖ Minitab is a popular tool that allows one to perform various statistical calculations such as normality test, process capability analysis and so on.

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So, conclusions about the capability analysis we have devoted almost a three lectures on process capability analysis, because a bad system will beat the right person every time. So, I must check that whether my process is capable or not and if not first correct the process improve the capability instead of putting your effort or taking the action in the wrong direction.

So, capability analysis reveals how well the manufacturing process meets this specifications and provides insight into, how to improve the process and foster improvement and mini tab typically is a popular tool which allows one to perform various statistical calculations such as normality test non normal process capability and so on.

So, thank you very much for your interest in learning this particular session on process capability analysis with the use of mini tab, I would advise that either you take the same data or some other data or some random data and put it in the say mini tab software new project file, and conduct the mini tab analysis as advise this will really help you to gain the confidence in the use of software. So, keep revising, keep introspecting refer the suggested text and sources to strengthen your understanding and be with me enjoy.