Design and Analysis of Experiments
Prof. Jhareswar Maiti
Department of Industrial and Systems Engineering
Indian Institute of Technology, Kharagpur

Lecture – 60
Response Surface Methodology Using MINITAB

Welcome to all in today's video lecture. Today, we are going to show, you the response surface methodology using MINITAB. To begin with this things, let me introduce myself, I am Shobhan Sarkar the PhD student in the department of industrial and systems engineering, IIT, Kharagpur and also the teaching assistant of the subject of design and analysis of experiments.

So, to begin with these things let us have a glance to the contents page.

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Here the response surface methodology with a small example has been given.

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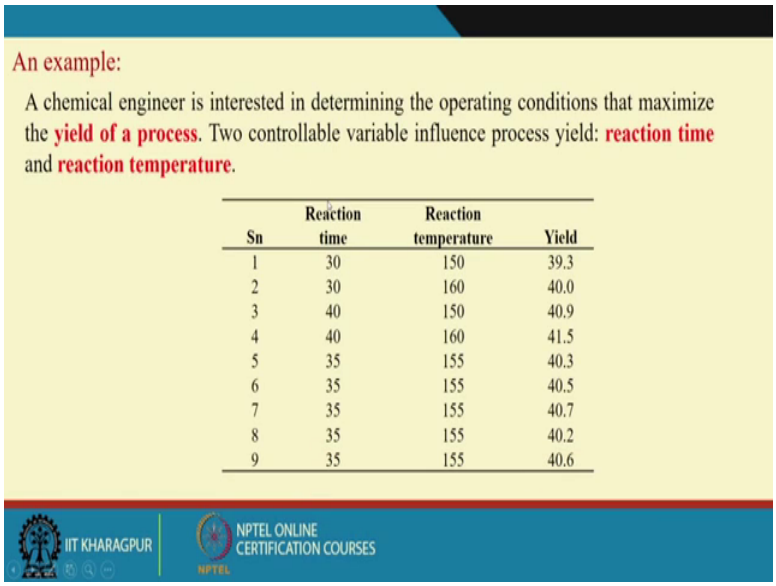

And then differences has been produced. So, coming to the coming back to the example as we can see and we have gone through a many times in the normal video lectures.

So, this example has been given for your clear understanding the main focus of this video lecture is to demonstrate how to use MINITAB in order to analyse the results experimental results of any situation.

So, situation is the problem statement is given a chemical engineer is interested in determining the operating conditions that maximize the yield of process that is this to controllable variables influence process yield that is a reaction time and the reaction pressure reaction temperature there is given here. So, 9 observations are made.

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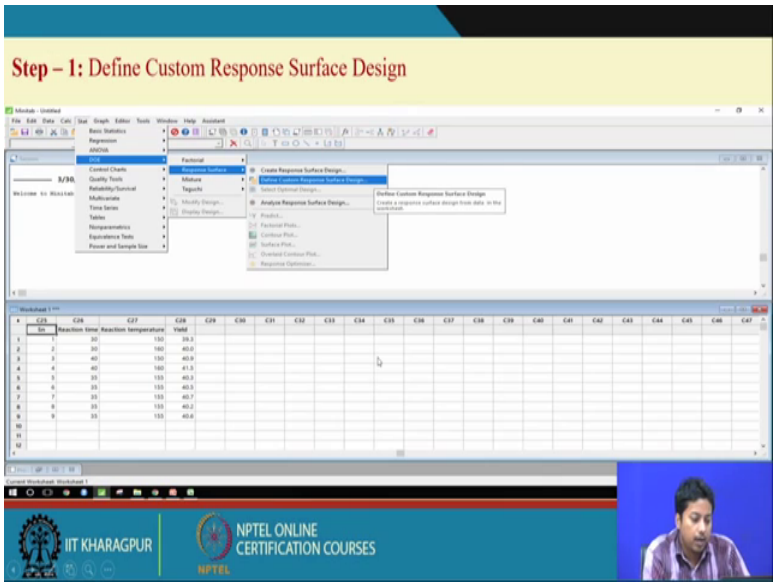

So, now we can see first this is our data set. So, initially, we have to copy and paste their data set into one excel file.

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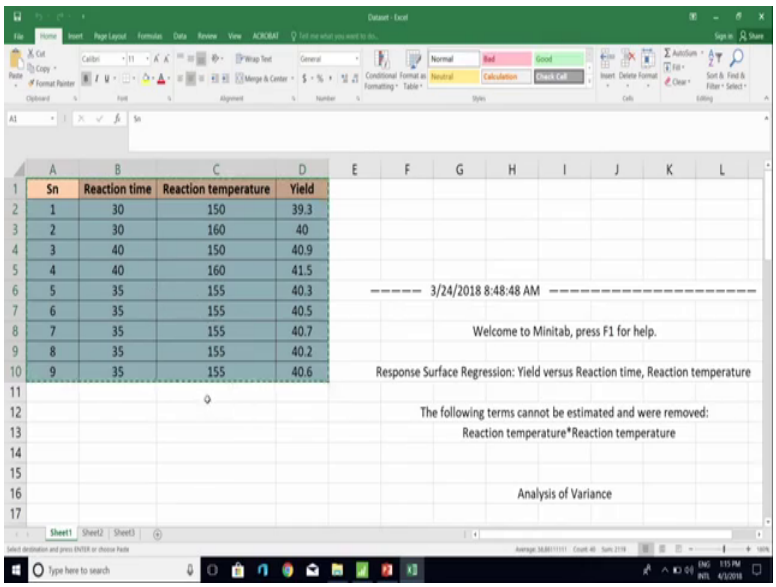

This one; so, from this we have to copy it and paste into the MINITAB window. Next, coming to the point of stat under the stat doe option is available. So, as we are analysing through the response surface.

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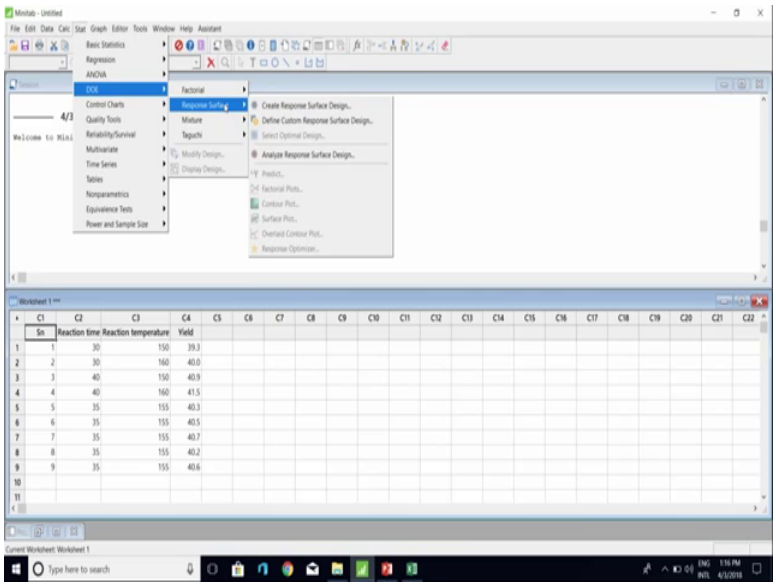

So, response surface under the doe tab, we have to select and then also under the response surface, we have to first define the custom response surface design.

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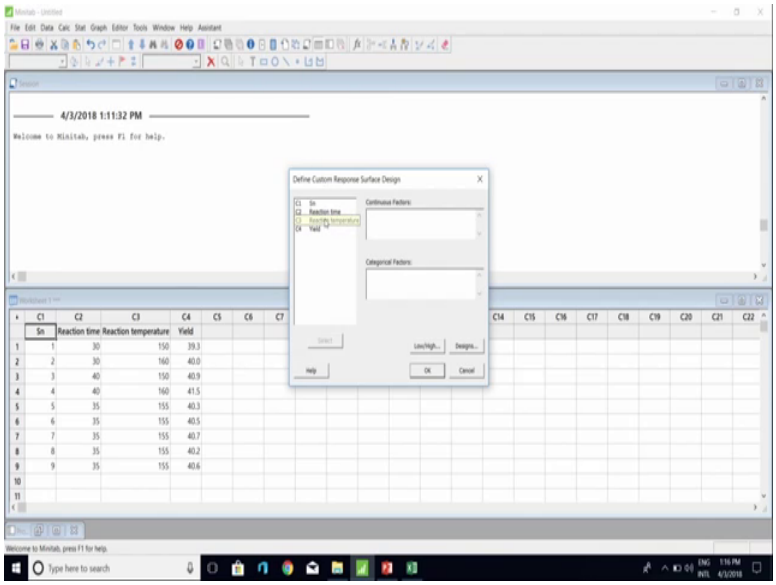

So, reaction time and reaction temperature have been selected as continuous factors.

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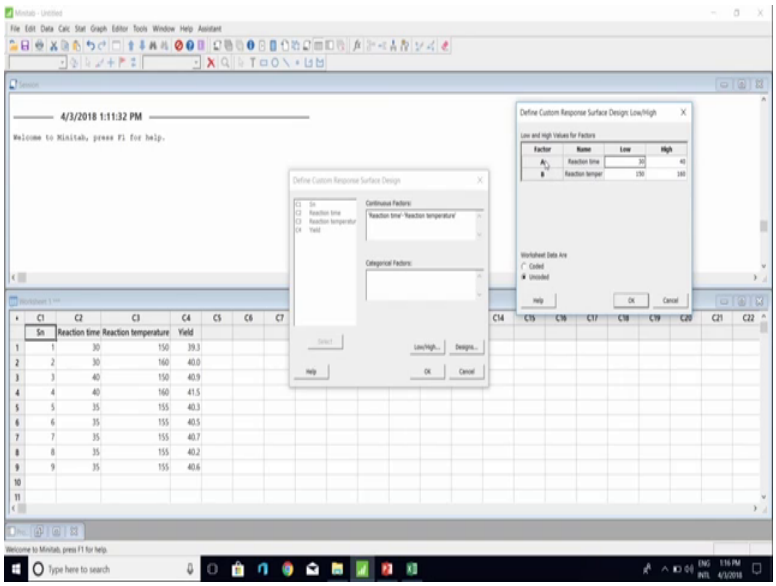

After that low and high options are selected here a factor A and factor B are given their corresponding name have also be provided.

Their low value and high value are also given corresponding to each of the factors A and B as we can see from the data set we can see that for factor A; the low value and the high value are 30 and 40 respectively, you can see 30, 30, 40, 40, 35, 35, 35, 35, 35. So, low value is 30, maximum is 40. Similar for B, factor B that is reaction temperature the minimum value and the maximum value are set as 150 and 160 respectively. So, once we have checked it and set it into this window and click it ok.

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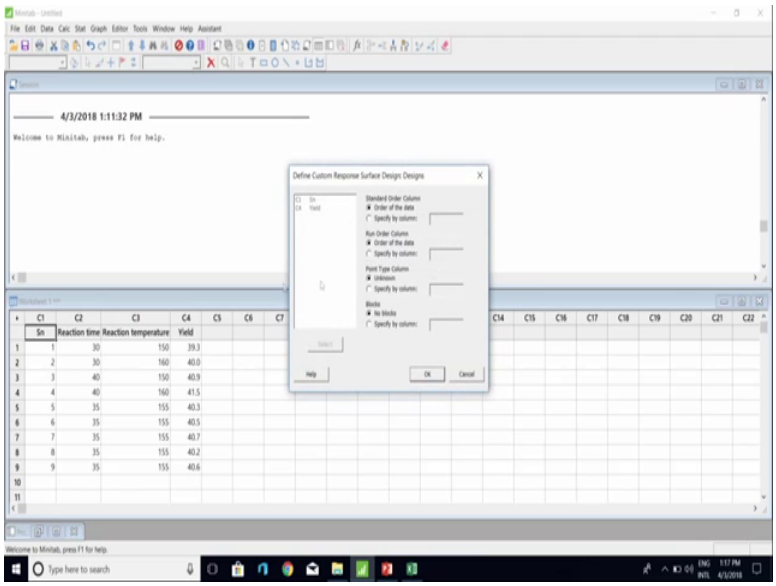

Coming to the design this design has been given so many options; first one standard order column order by the data run order column order by the data point type column, it is not required at all blocks; we are not doing any type of blocks here. So, no blocks click ok.

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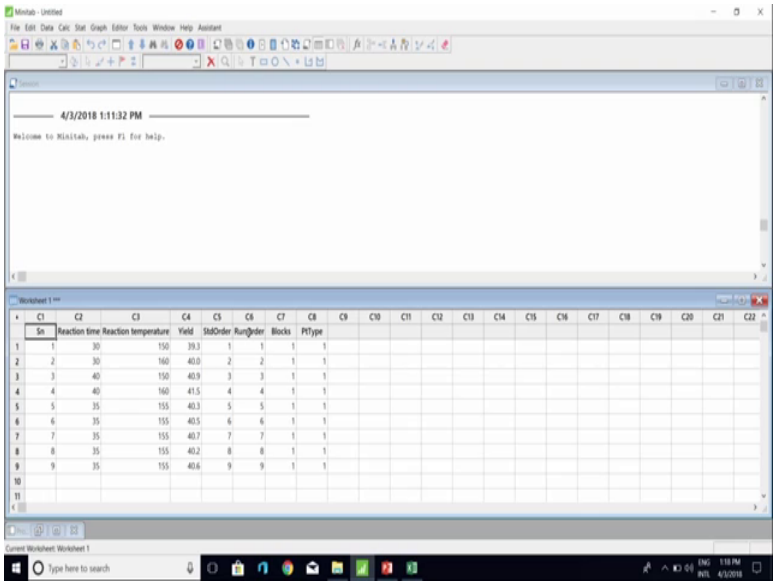

Then also click ok. So, we are we can see that new 4 columns are also added with the initial 4 columns that is they are standard order and run order blocks and point type. Now after getting this data, you have to go back to the state stat doe response surface, then

analyse response surface design, here we have to select the yield; that means, y variable the response variable click terms.

Here, we can easily select either linear either linear plus squares or linear plus interactions or full quadratic, if you click the full quadratic as per our requirements and the situation, we can see the selected terms are AB, AA, BB and AB main factors, then A square terms BB and their interaction effects click.

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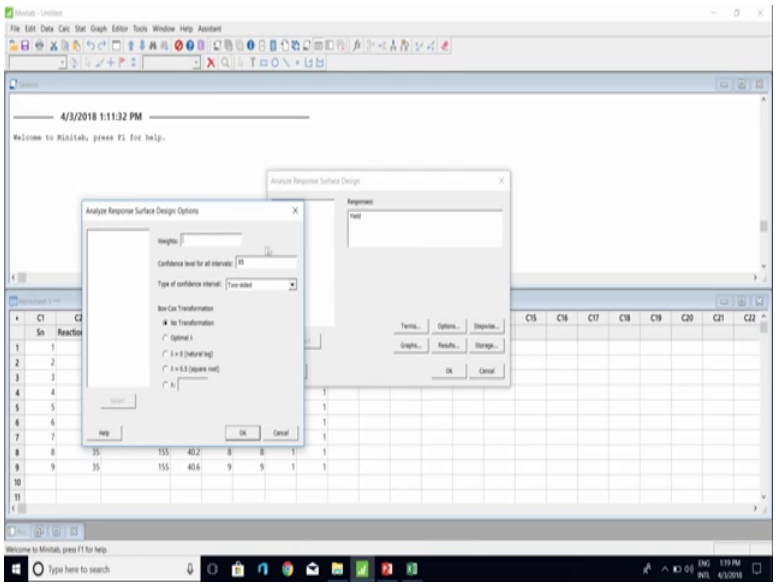

Then click the options for weight, we are not going to do any inside any weights confidence levels 95; two sided type of confidence interval no transportation is required. So, click stepwise is also not require anything.

Then going to the graphs regular graphs under the residual plots click 4 in one's and it is very convenient to observe all the plots in a same window, it will be helpful for 4 in 1 or you can offer also the individual plots, if you want to get only histogram not others or even you can get if you want to get the 2 of 4 or three of 4, then you can easily customise your requirements by selecting your required number of plots here, we need all 4 plots in a same window.

So, click 4 in 1. So, click ok; then results a simple tables, then storage the same thing the Cook's distance leverages residuals fits coefficient design matrix which might be of interest then this can be easily inserted.

But for the time B, I am not going to show you and inserting anything. So, I leave it blank nothing. So, click it ok. So, now, click and all the 4 plots; as we have told you earlier have been generally in the same window. So, the resident versus percentage normal providing plot fitted value by the residual observation order by residual and residual versus frequency.

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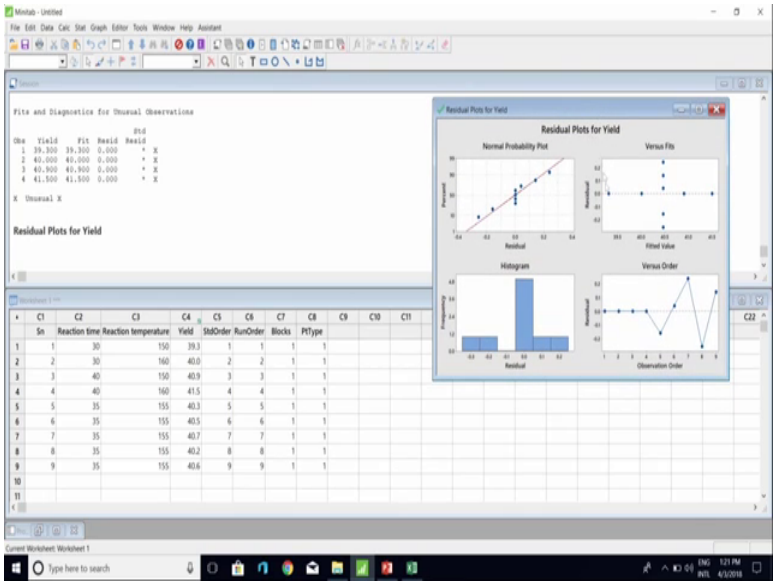

All plots are given all plots are produced here coming to this main window.

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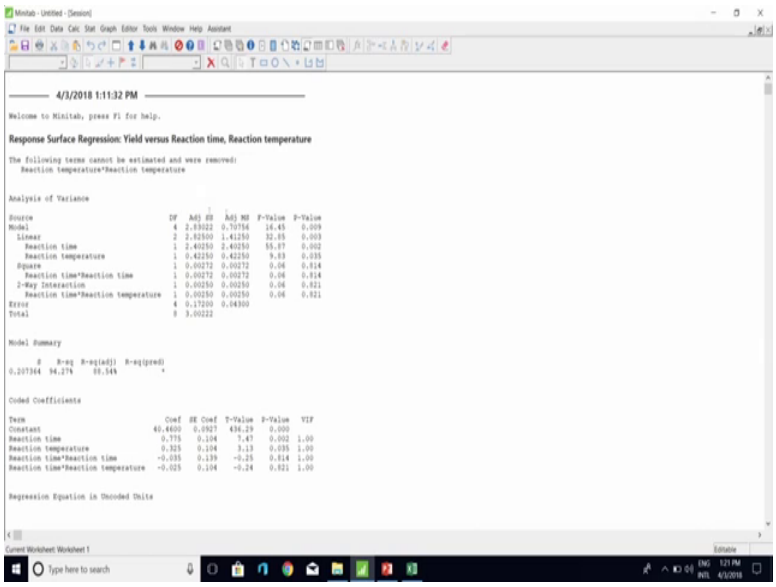

We can see the response surface regression yield versus reaction time reaction temperature analysis of variance ANOVA table are produced are model parameter model things for degrees of freedom 4 sum of square.

And this is sum square at the mean square A value, P value as already, we know all this things. So, I am not going to show you anything and interpreting in this. So, this is a linear for the reaction time reaction temperature for the square terms the; that means, A reaction temperature reaction time 2 A interaction reaction time verses and reaction temperature error, then total this is standard analysis of variance table and their corresponding sum of squares mean square mean square degrees of freedom F value and the and their corresponding P value, if any value for the P being less than 0.05 consider very significant one.

So, in that case 1, 2 3; that means, reaction time reaction temperature and the model very important and significant in this respect coming to the coefficient there is a constant term 40.46 for the reaction time the reaction temperature then reaction time and reaction time reaction time reaction temperature this all coefficients are recorded and this is a regression equation yield equal to 17.8 plus 0.408 reaction time plus 0.100 reaction temperature minus 0.0014 reaction time into reaction time minus 0.001 reaction time into reaction temperature.

This is a main our main focus is to generate to get the reaction equations from the experimental data using response surface methodology and here is a output results.

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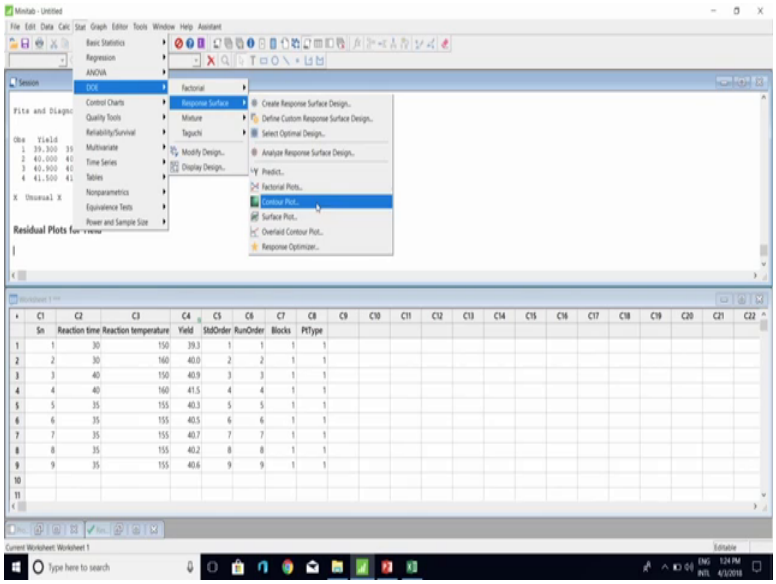

Now, I have made it smaller the coming to the doe response surface and contour plot. Now we are going to plot that contour surface counter plot, how to do this things. So, once we click the contour plot the options are coming as a response one we have selected is the yield x axis, I have set it reaction time y-axis reaction temperature or even you can alter this things as x axis as reaction temperature y axis as reaction time also we can do this things.

Then contours then options nothing to do with it the views of model it is ok, then click ok. So, here is a contour plot it is generated why it is a reaction time x axis, y axis is reaction temperature.

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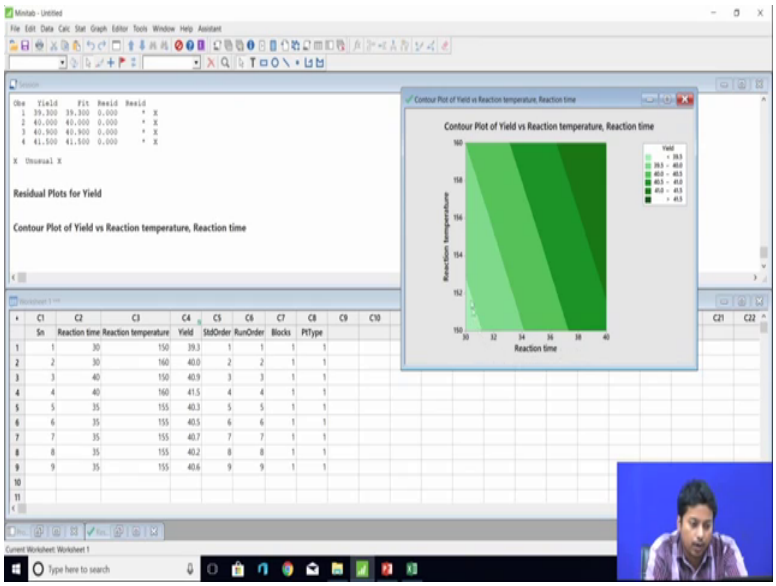

And this is a contour plot this contour plot of yield versus reaction time reaction temperature versus and reaction time, you can see this thing and subsequently, it will be able to interpret these things, similarly, if you want to generate the response plot.

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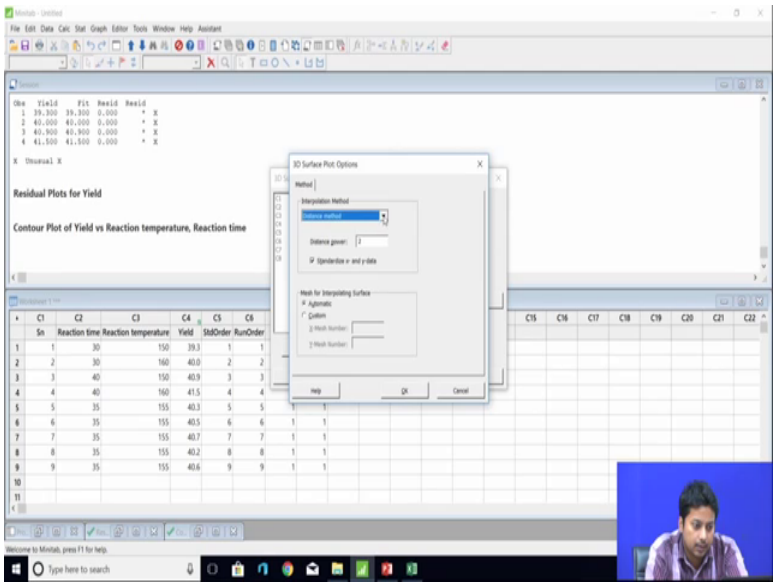

Then you have to click the 3-D surface plot here the wire frame is selected click ok.

Similarly, you have to put the z variables as I have selected z variable as yield as z variable reaction time is a y variable and reaction temperature as x variable the surface option, it is a distance method we are selecting one may afford the acumens polynomial

method their result will be varied accordingly according to your choice distance power is two is then scale nothing to do with it.

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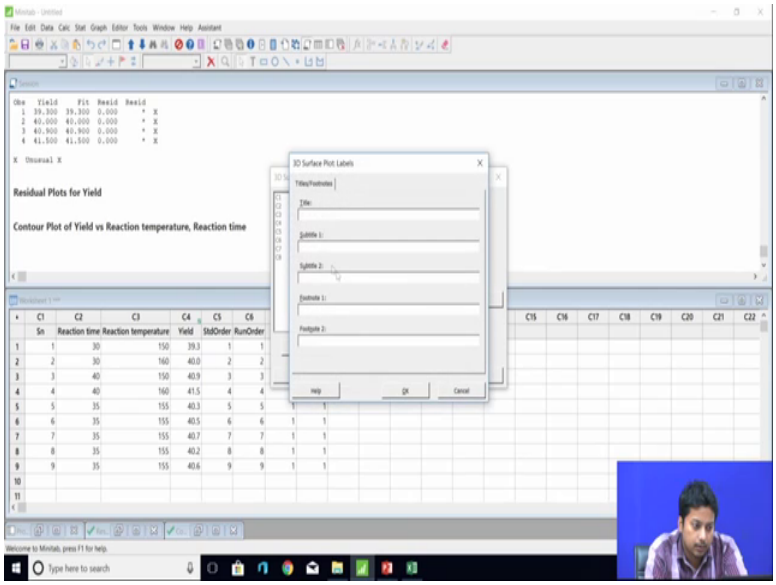

Then click the labels again if you want to add something with it as a title subtitle two footnote you may add for your convenience is it a data label data display symbols surface symbols project lines, then data options all rows, I have clicked it click and then click.

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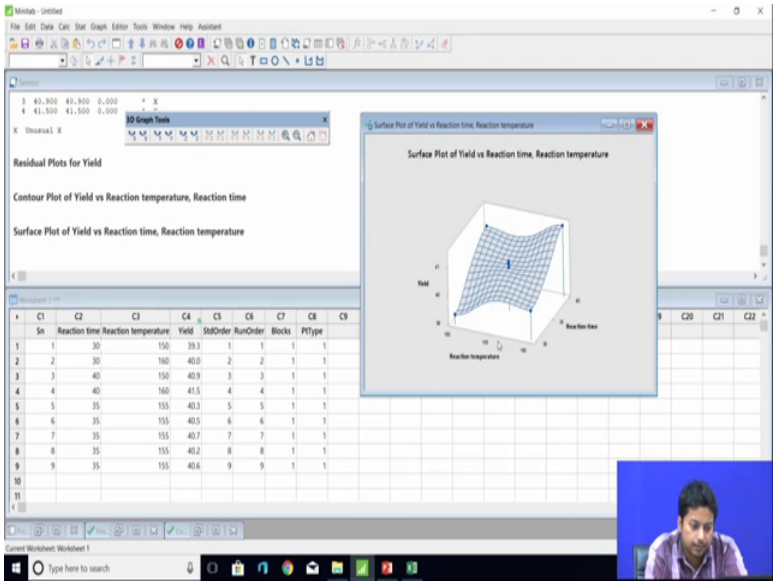

Here we can see this is a 3-D graph tool, this is a surface plot are generated their reaction time is here reaction temperature x and y and yz is vertical axis is representing the yield here is a surface plot; Now, coming back to the point of the PPT.

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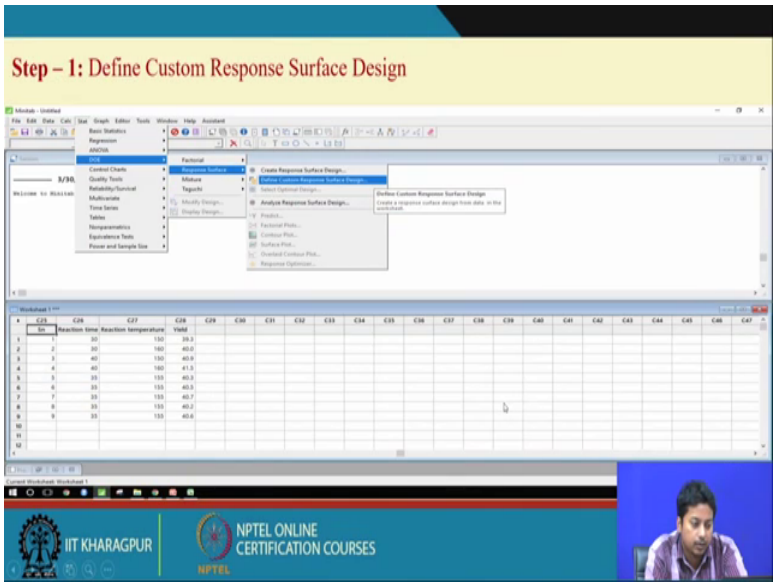

Similar to this process the presentation has been made for your convenience to follow.

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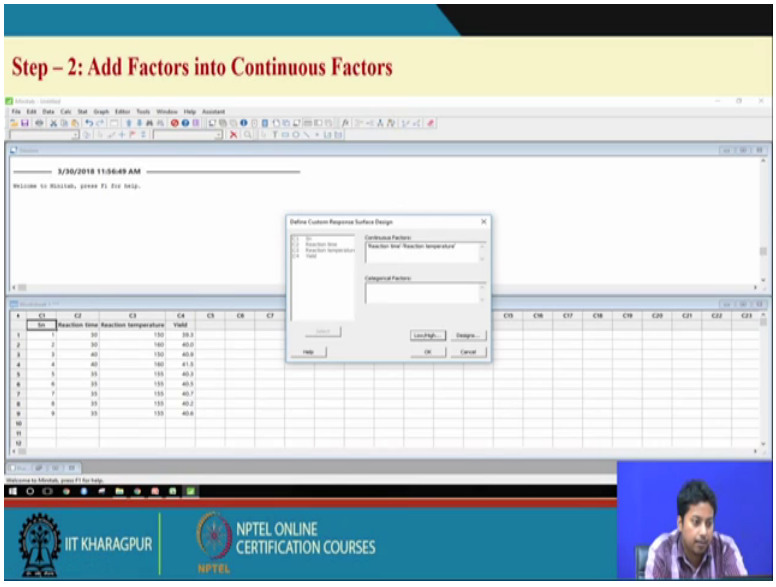

And to practice in MINITAB the step 1, step 2, step 3.

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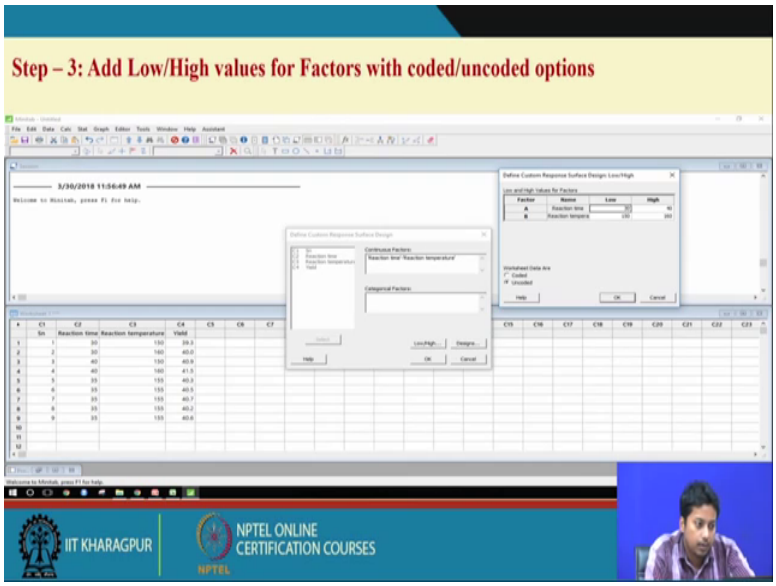

Adding the high and low values for the factors which coded and uncoded point options.

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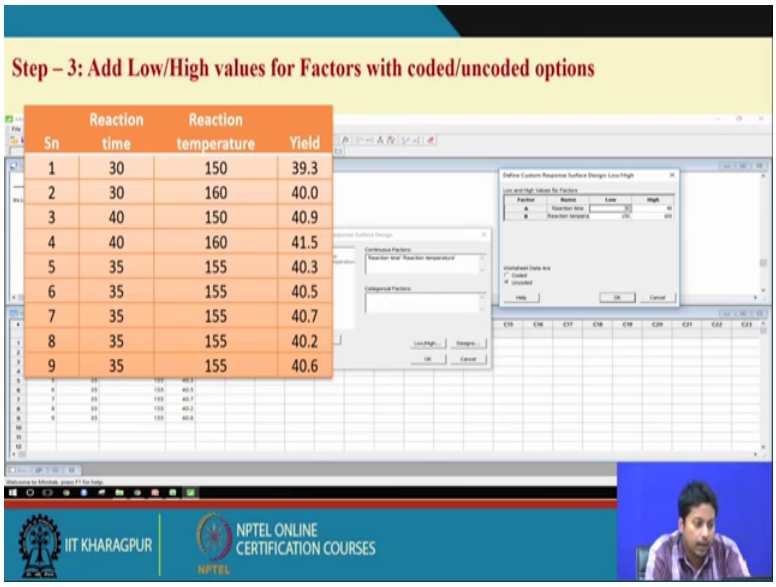

Step 3 again this is A where the data set is given from which we can easily set as low and high value.

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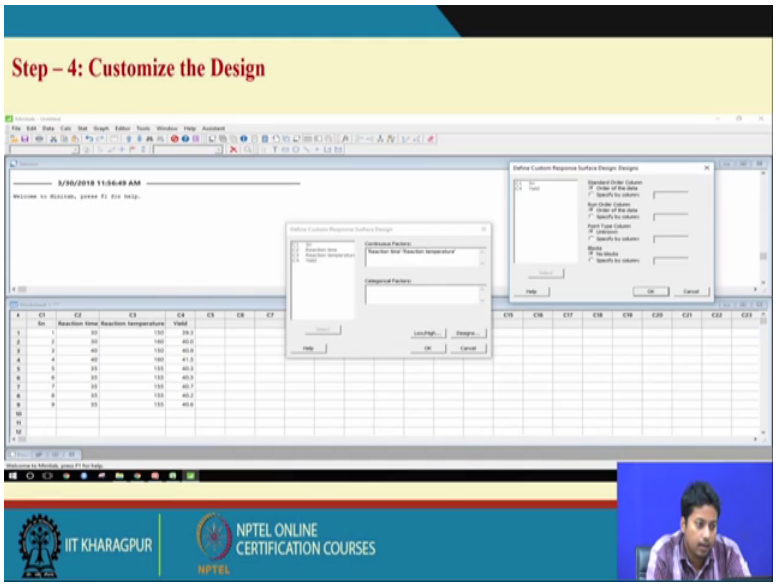

Then customise the design step 4, then 5.

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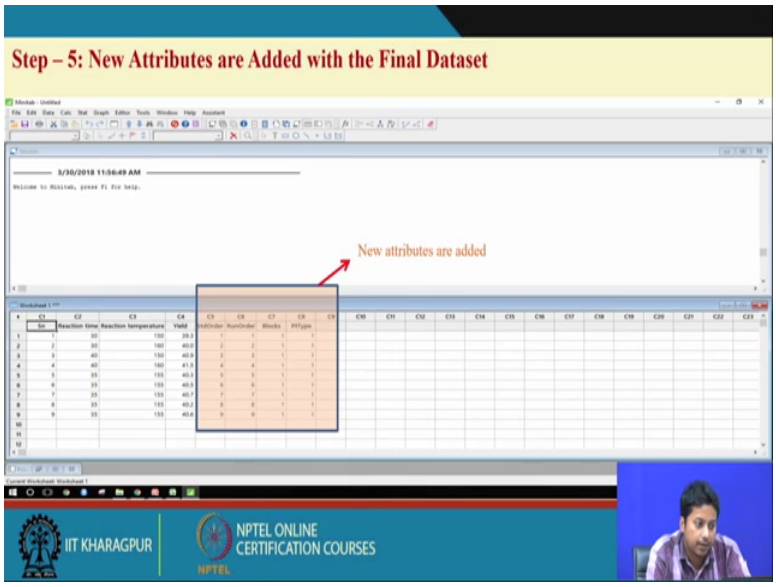

Step 5 is new attributes are added with the final dataset the step 6 is analyser response surface design.

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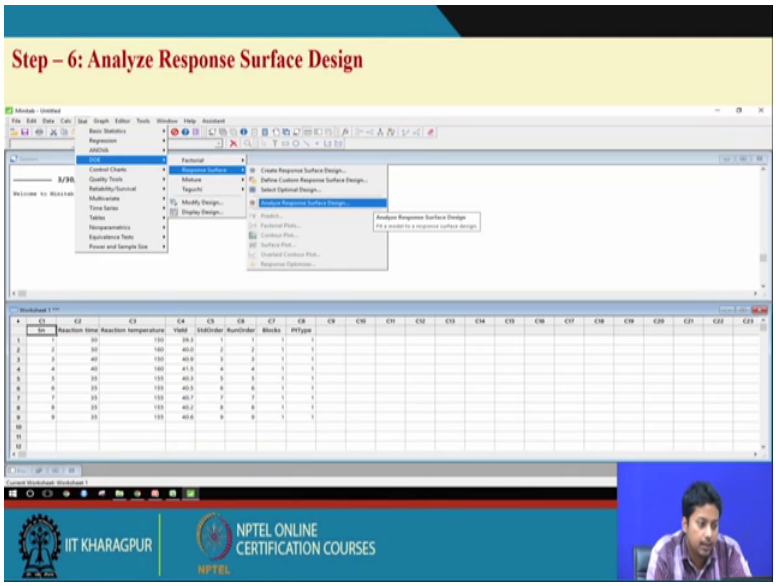

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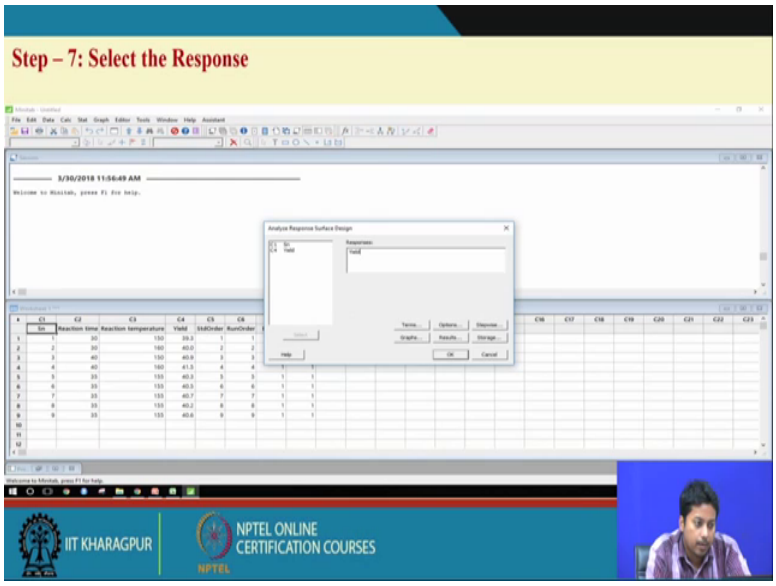

Step 7 is select the response y yield is considered as a response here.

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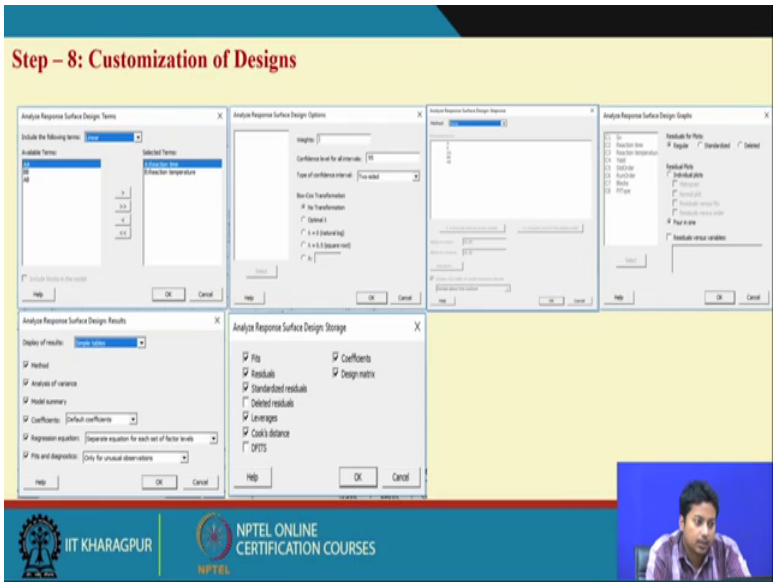

Then customisation of design, it is a completely a user specific here we have shown you that the following terms is linear one may afford the linear plus squared terms or quadratic terms, I have selected here the quadratic terms.

That is why result will be deferred from this the results that of the, of this particular PPT, then this option should come up and all the snapshots are given for your convenience.

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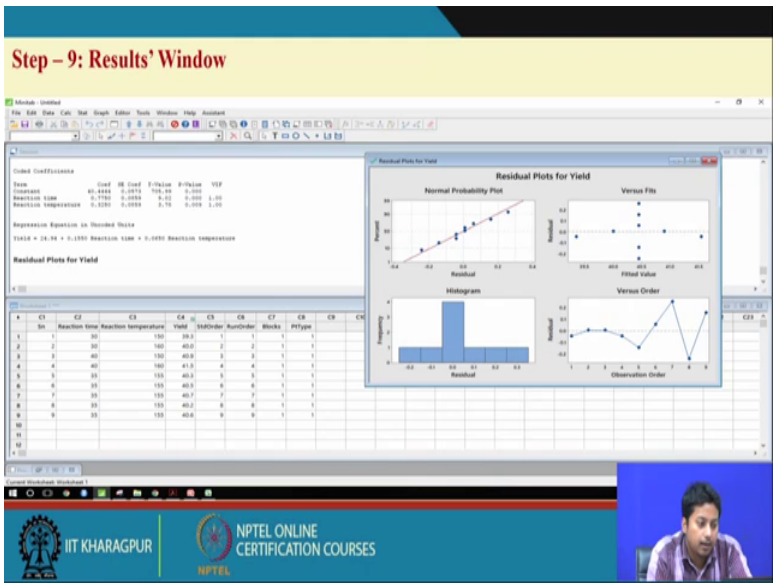

Then results into this results in the coming is a 4 residual 4 plots are given are produced here is a data set.

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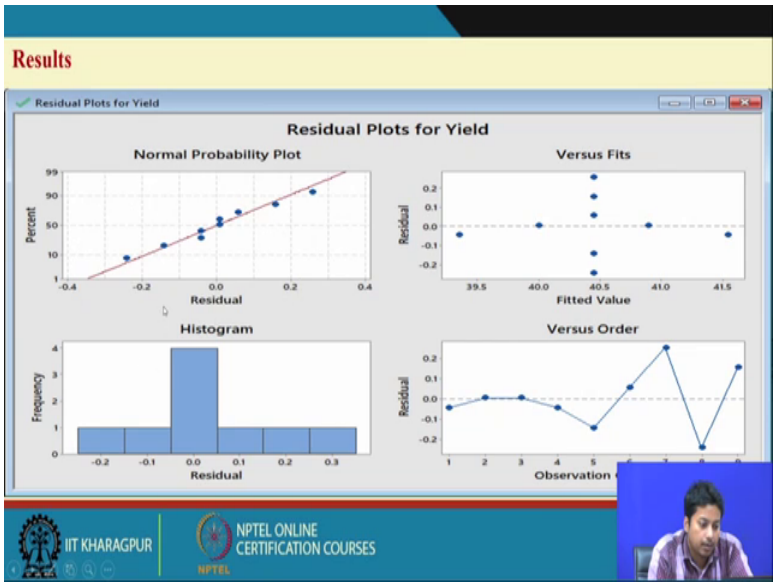

This is a 4 plots as we have discussed.

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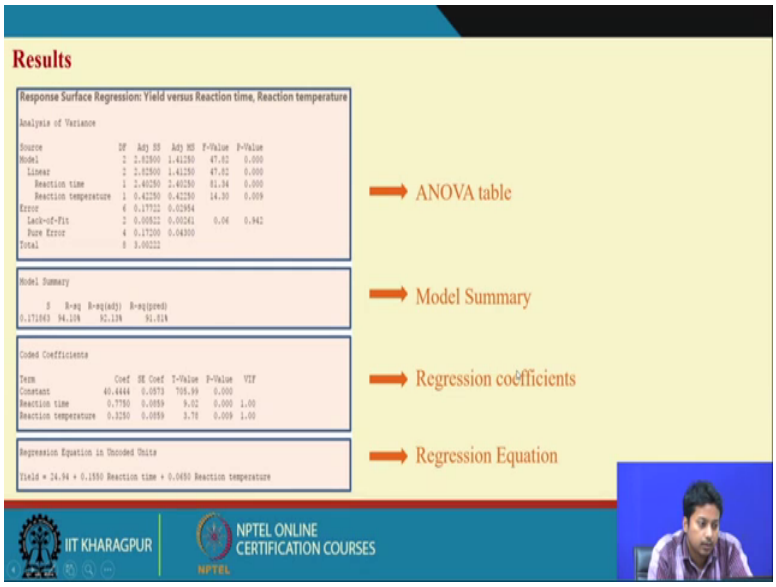

And here is the ANOVA table model, summery, regression coefficient regression equations, we can see here the regression equation, we have generated and is a ANOVA table from this we can easily interpret which factor is very important; that means, significant which is which is not we can easily interpret, we can also observed the coefficient of constant term the reaction time the reaction temperature.

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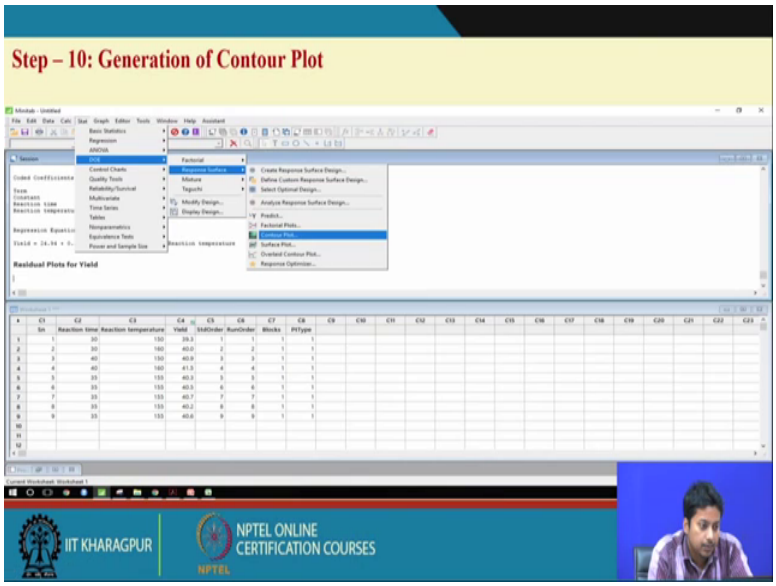

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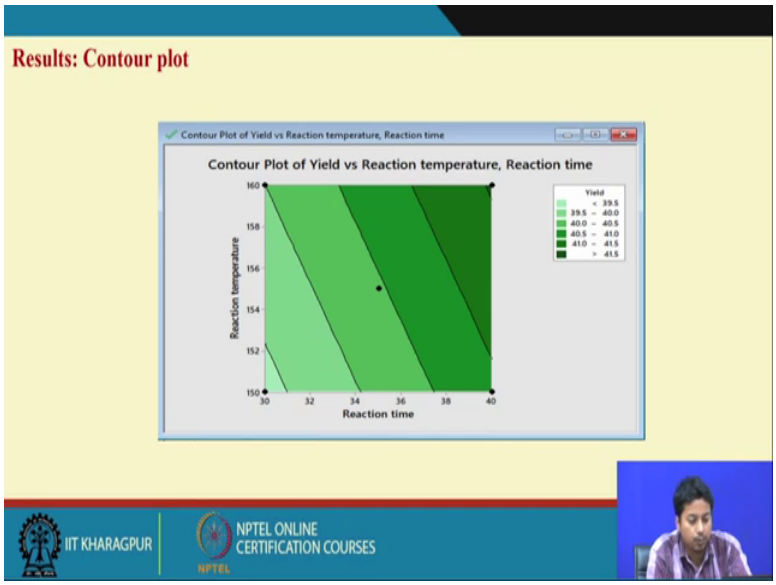

So, generation of the contour plot, we have already discussed and also demonstrated, you here is the output of the contour plot.

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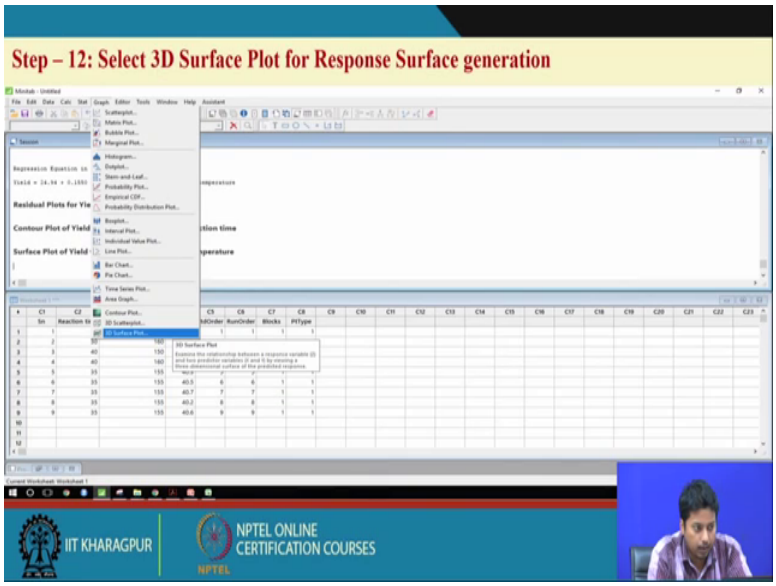

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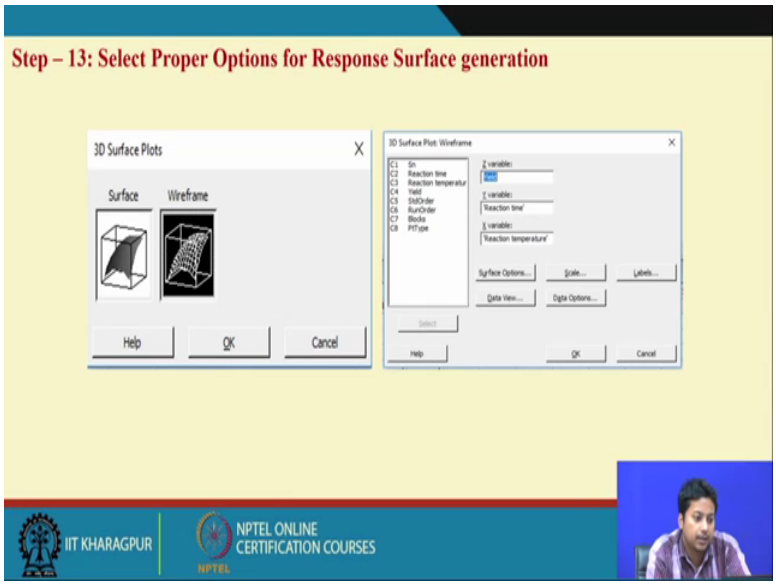

Now, here is a generation.

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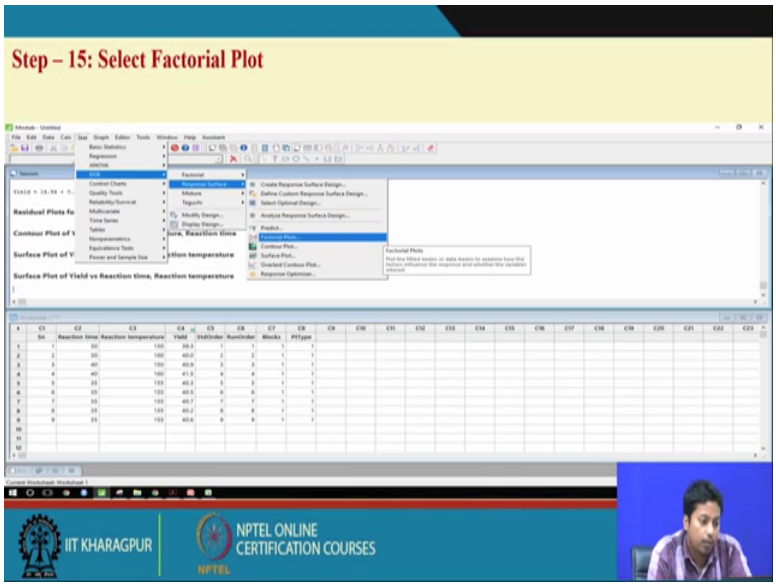

So, last point is the select the factorial plot. So, to do the factorial plot coming back to the MINITAB coming to the stat doe response surface, then factorial plot this option is there click it and you have to set response as yield.

And then this is a selected this variables then options if you want to add something you can add this are the graph plots ok, then view models again this a response is yield. So, click it ok.

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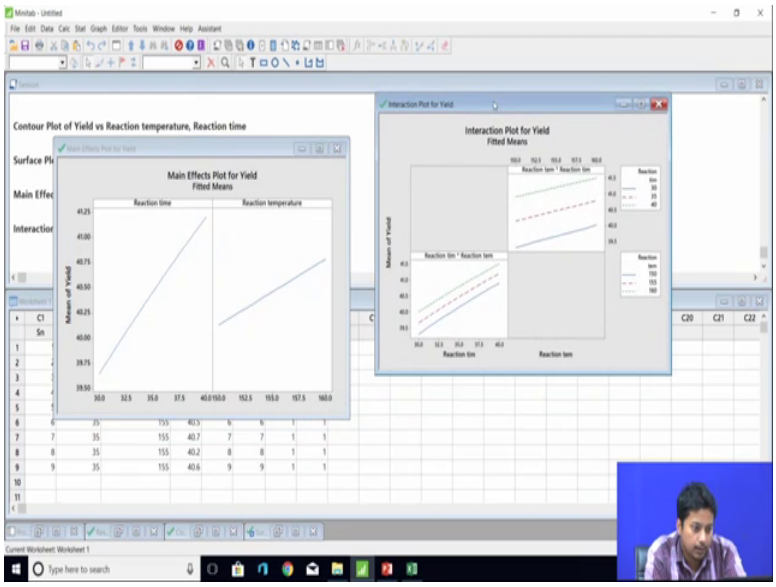

So, you can see is a interaction plots are given the main interaction plots are given. So, this is a mean of yield, this a reaction time this is a reaction temperature and again this is a mean of yield. So, here the yield is from low to high reaction time is low to high 30 to 40 and mean of yield is 39.5 to 41.25. So, as the reaction time increases the mean of yield also increasing.

Similarly, we can see you 150 to 160 this scale is given for the reaction temperature and the mean of yield remain same, we can also experience the same kind of behaviour of the graph that is as it is increasing the mean of yield is also increasing, but it is it is too steep in nature where as it is comparatively flat than this one coming to the interaction plot here we can see the reaction time in the reaction term and then reaction temperature here the reaction temperature and reaction time is given and the mean of yield in a same plot it is given; so, through this graph.

And the tables and that is ANOVA tables, you can easily interpret which variables are important what is the degree equations ultimately you are getting you can see which regression equation will be how you can get the factor plots, how you can generate the surface plot in the response surface methodology and how you can get the contour plots throughout this experiments; through the following this procedural which are nicely illustrated from the beginning of the slide one may easily carry out the experiments using MINITAB environment.

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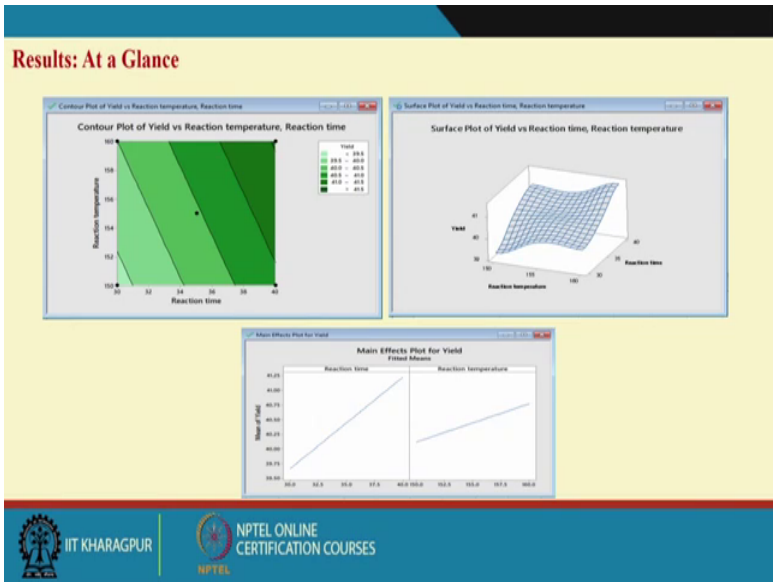

So, using these things ultimately, you will get this type of graph and this has been given in a same window to visualize; how you can interpret through MINITAB software.

This is a contour plot; this is a surface plot and is a factor affects main factor affects by choosing differently I have also shown to you the interaction effects with mean of yield when here, I have not selected this things this is completely depends on users requirement as you require it you can also generate many more graphs using this MINITAB software, it will be really helpful for this analysis purpose and for Aadhar statistical analysis purpose is really very useful.

So, this is a final results using this MINITAB for response surface methodology, if you have any further queries or questions how to use the MINITAB for experimenting in design analysis by experiments or other purpose, if you have any queries any doubts, you can ask me and we can discuss with us we will try our level best to help you out and give you, we will try to provide you the required solution; So, that you can get the best out of this particular software MINITAB to fulfil your purpose ultimately.

Thank you.