**Lecture - 42**
**Factorial Design: Minitab Application**

Hello friends. We are advancing in our six sigma journey and I hope you are say becoming matured and evolved in the concepts and in our six sigma journey. So, by the end of this course as we would be covering this course in greater detail and this will give you the full exposer of DMAIC cycle of Six Sigma.

You should feel extremely confident in executing the six sigma project or under undertaking the consultancy work at the end of this particular course. So, now in lecture 42 we will see the Minitab application of factorial design. We have already discussed the concept of factorial design in the last lecture. In this lecture 42 we will basically demonstrate the Minitab application.

(Refer Slide Time: 01:09)
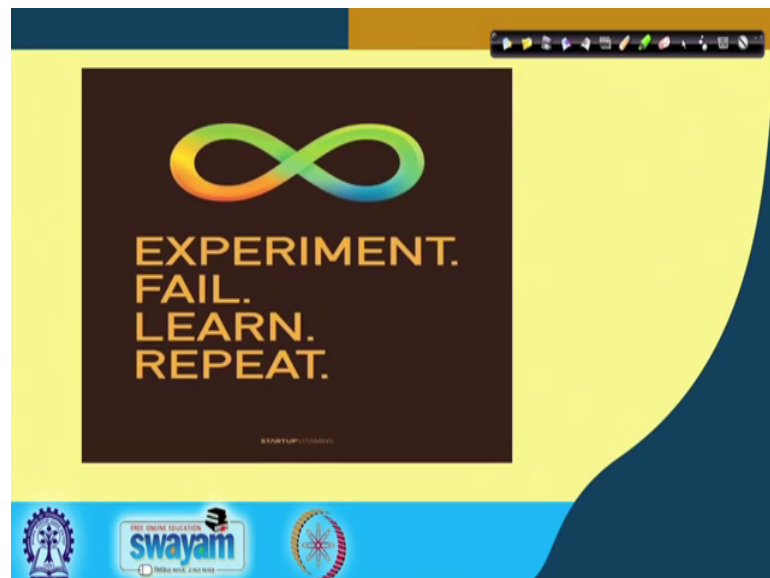


Once again I would like to remind you experiment, fail, learn and repeat. This is the only way to be evolved and better. So, same thing you apply to your learning, fine. You may not be able to understand or appreciate the concept in one go. Revisit, listen the lecture, videos again and again and also refer this suggested book. Definitely you will have a very good command over the six sigma concept and the various topics.

(Refer Slide Time: 01:43)



So, as a recap we have talked about principles of factorial design advantages, we had seen that it helps us not only to analyse the factors simultaneously, estimate the main effects, but it also helps us to have the analysis of interaction effect and then statistical analysis of this design and we have seen the better life example. So, there were two factors; temperature and material type. An illustrative example was discussed.

(Refer Slide Time: 02:13)



In this lecture we will see the application of Minitab and the problem definition is like this.
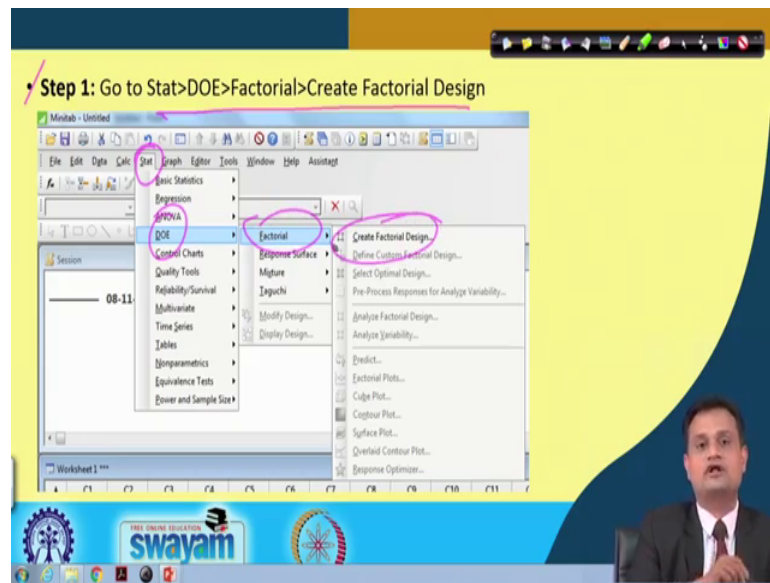
(Refer Slide Time: 02:21)



So, you have the pressure and temperature and I want to check the yield of chemical process that is my response variable and two factors are considered. One is the pressure and another is the temperature. So, three levels of each factor.

So, when I say three level means I am considering 200 as the one level for pressure, this is level 2, this is level 3. You can take it as L1, L2, L3. This is level one L1 L2 L3. So, I am considering three level for each particular say factor and then I am trying to conduct the experiment. You can also see that I am collecting two data to replicate for each particular setting 150 and 200 I am collecting two readings. So, by chance if there is an error, I can capture this error through having such kind of replications.

(Refer Slide Time: 03:25)



So, we have the very easy steps to follow in conducting Minitab analysis. Step 1 go to stat-DOE -factorial-create factorial design. So, you have this stat-DOE-factorial-create factorial design you perform this step.
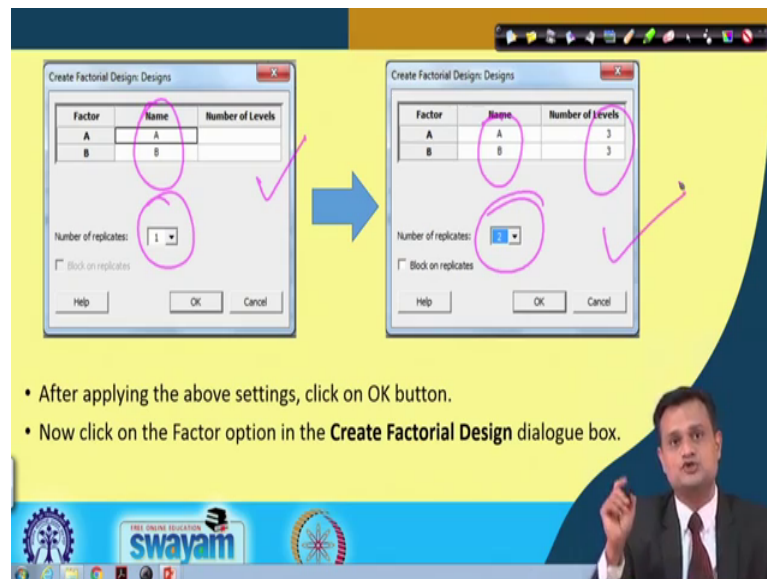
(Refer Slide Time: 03:47)
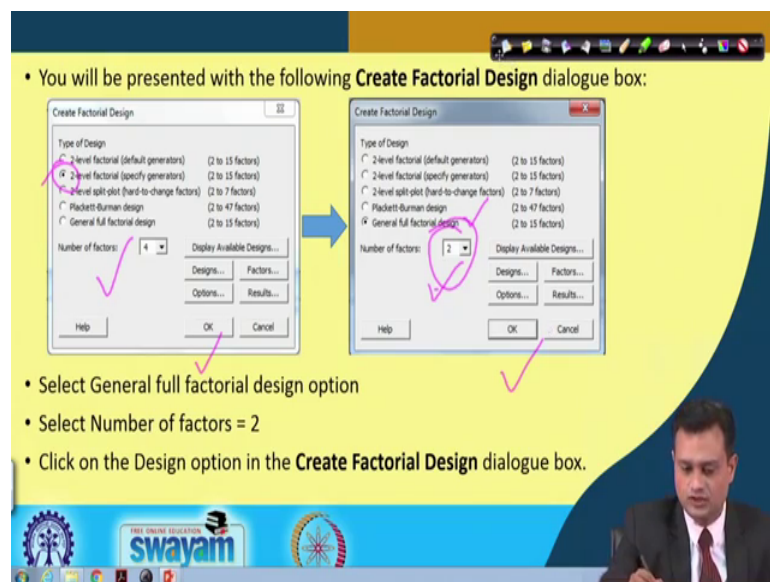


And then you go to say this particular window, you will be exposed to this particular window. So, you choose two level factorial design number of factors, you can specify if it is 4, if it is 2, then you click ok. So, in our case let us say we are selecting general full factorial and we are selecting two factor because we have two factors to be analysed. So,

we have to press ok, then you can create the design first.
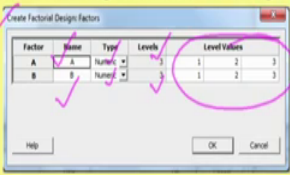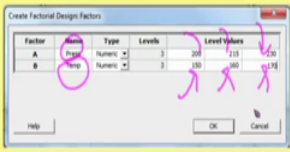
(Refer Slide Time: 04:26)



So we have now couple of other things to specify. You have two factors factor A factor B, number of replicate is 1. If nothing is specified in our case, we have factor A factor B set at three level and number of replicates are two. So, this is just the standard window. This is what is specific to our problem, so that you should not get confused.

(Refer Slide Time: 04:55)



Now, once you have this, you will be presented with the following create factorial design factor. So, you have factor A, you have factor B and both the pressure and your
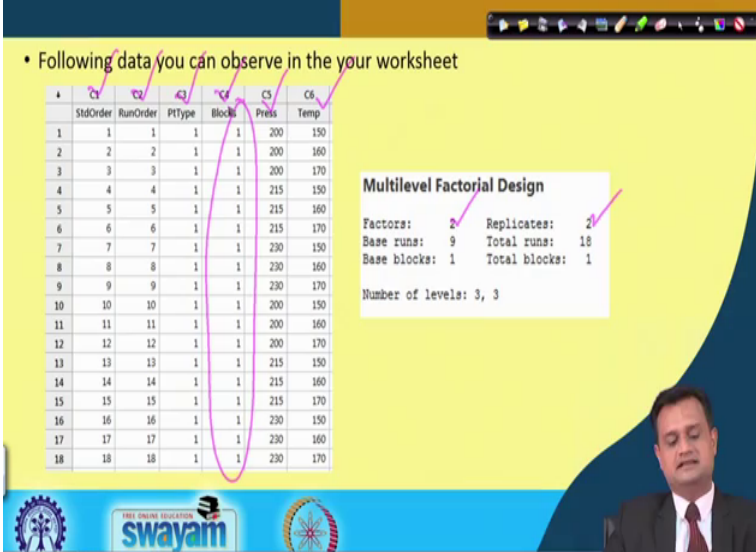
temperature or whatever factor you have they are in numerical. So, you just say numerical value. So, level 3 3 and you have the level values 1 2 3 and 1 2 3 now inside values. So, you have pressure and temperature. So, actual value you just try to insert in this particular respective cell and then you press ok.

(Refer Slide Time: 05:38)



So, with this you will than get exposed to this particular window and this window will say Randomised Runs Store Design in Worksheet. So, you just click on Store Design in Worksheet and then, you click.

(Refer Slide Time: 05:56)

So, once you have done this, then you will have the worksheet something like this. So, you have column 1, C1, Standard order, Run order, then you have the point I, you have the blocks, you have the press pressure and temperature. So, basically your randomised design is created for the purpose of analysis and this is exactly what we have. We have two replicates, we have two factors and likewise. So, there is block 1 only across you can see because we are considering entire design at one block. We are not applying any blocking and this is how say you can create your design.

(Refer Slide Time: 6:41)



Now, once this is done and you have insert the response value in the worksheet from the given question, so you have the response value. So, you just look at this now you have a randomised design, so that no bias can come in to and 200 150. What is the response value? 200 and 160 what is the response value? So, you just try to include this C7 and put the response value.
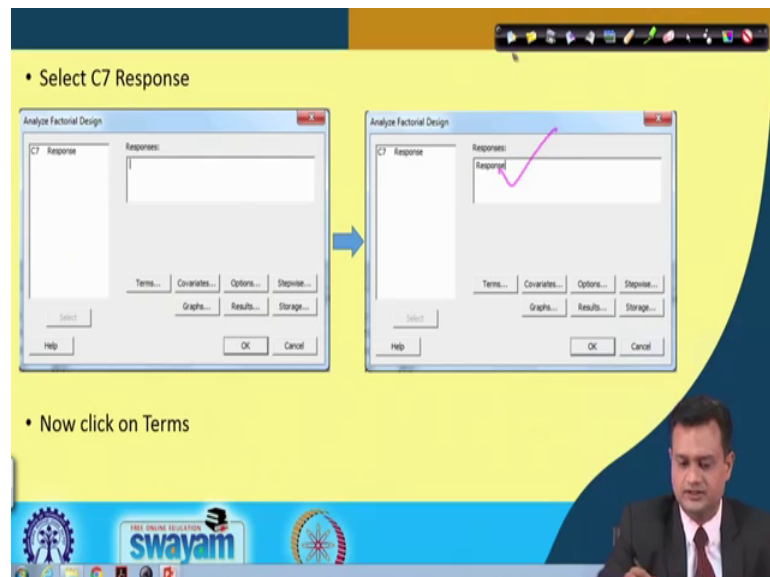
(Refer Slide Time: 07:13)
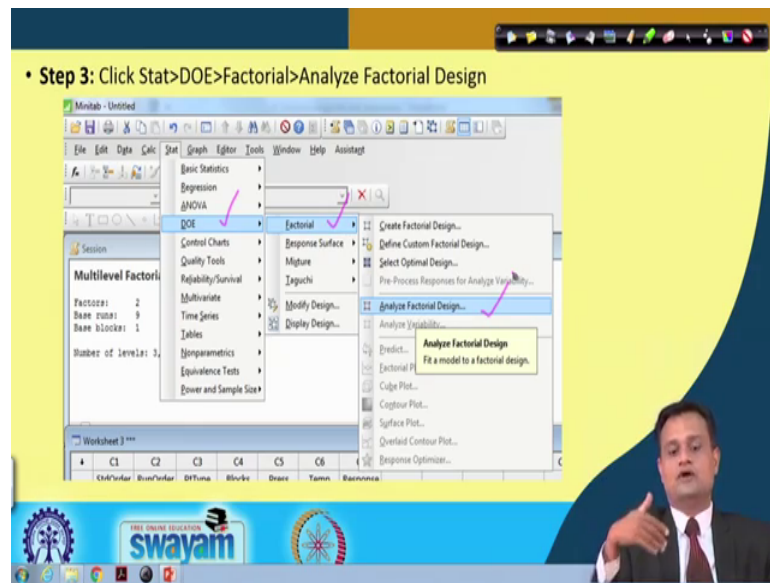


So, this you have to carefully insert now, you go to doe, factorial, analyse the factorial design. So, please try to appreciate there are two steps. One is creating the design that will give you a randomised design. You have to insert the response value and then, you analyse the design. So, first is the creation of the design and then you analyse the design.
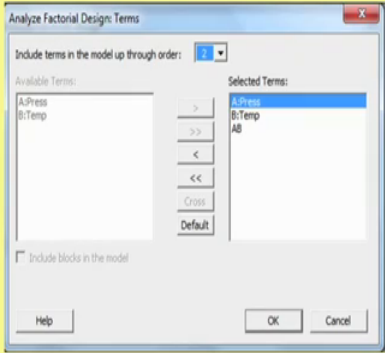
(Refer Slide Time: 07:42)



So, with this you go to this particular window and you will have response here to specify.
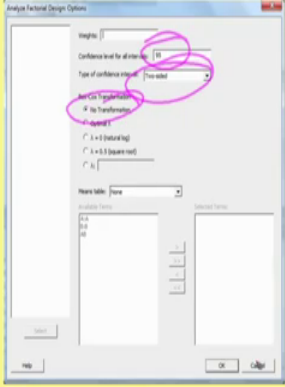
(Refer Slide Time: 07:56)



So, this is your particular response window and then, you can just click. So, now you have pressure, temperature and AB that is the interaction effect.
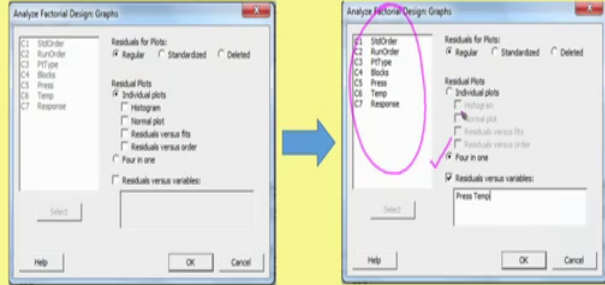
(Refer Slide Time: 08:03)



Now, you can specify level of significance or level of interval confidence, interval 2 sided test you want to conduct let us say you specify.
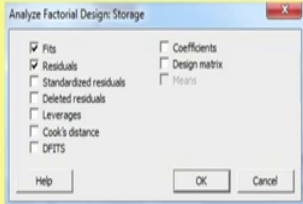
(Refer Slide Time: 08:20)



And no transformation and then you click ok. So, what you will get is something like this. Standard order, run order, point type, blocks, press, pressure, temperature response and you select for in one. So, because you have to validate or check the adequacy of the model also and then you click.
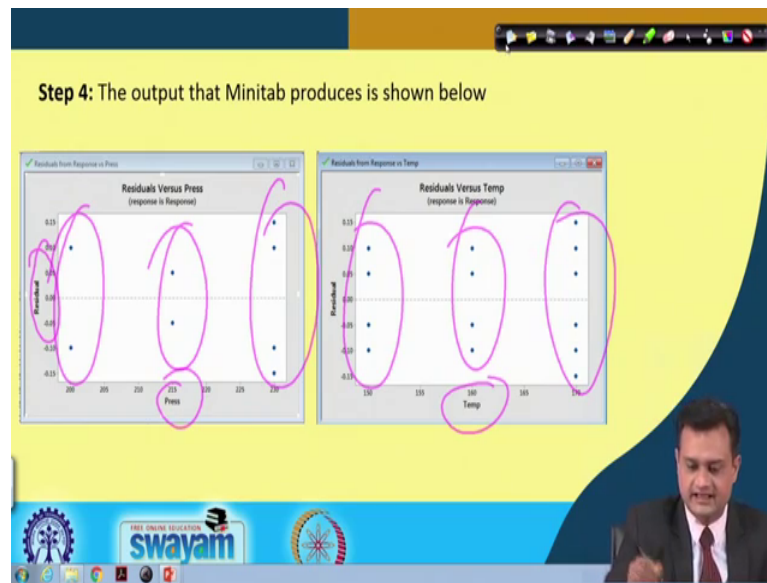
(Refer Slide Time: 08:41)



So, with this you will basically have the different outputs to analyse.

(Refer Slide Time: 08:44)



So, let us say output that Minitab produces. So, you have pressure and temperature. So, at different pressure and temperature I am trying to analyse the residual for checking my equivalence of variance and more or less I can say that not much difference is present.

(Refer Slide Time: 09:06)
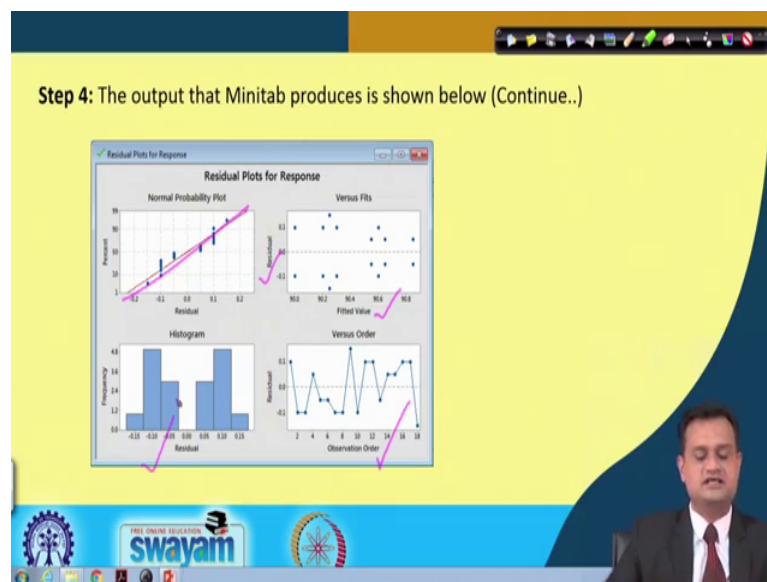


So, I can go ahead with this, then I can check as usual my normal probability plot. Majority of the points are covered. This will give me the residual versus fitted value. I do not observe any particular trend. So, there is the assumption of independence is satisfied again you can see the individual observations and I do not see any disturbing trend. So,

my data is free from that bias and then, you can see the histogram also.
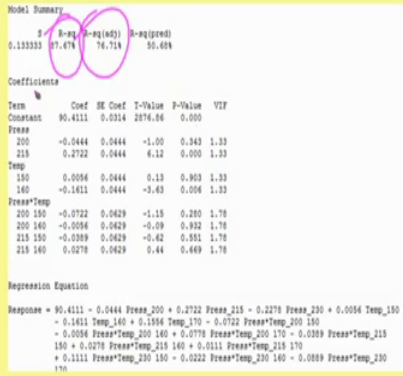
(Refer Slide Time: 09:40)
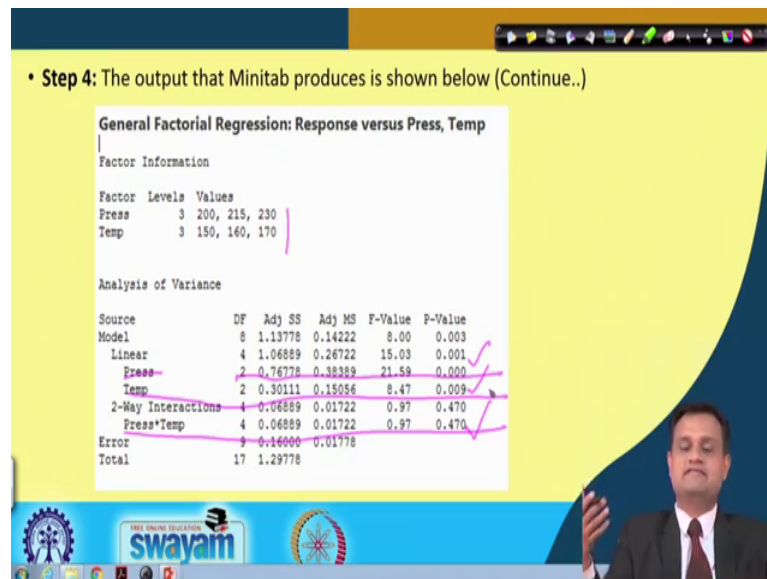


So, this will basically help me to check the adequacy of my model. Now, you can interpret the results i there is only a meaning in interpreting the results if my model is correct. So, I checked first the model adequacy and now I am trying to check the results. So, these are the factors you have set and what you see here that for pressure the P value is 0, for temperature P value is 0.009, two way interaction pressure into temperature interaction 0.470.

So, what do you say here now you are very much familiarised. So, in both the cases your P value is extremely low. Even if I operate with 0.025, it is a two tailed then my, these values are less than the critical value, set value of alpha 0.025 and they fall in the rejection region. So, I will reject the null hypothesis at a given level of significance and I would say that my assumption that pressure and temperature are not significant or do not have any effect is not correct.

The main effects they are important they have the impact on the say particular response which is considered here pressure, temperature, interaction. Now interestingly you will see that this value is much higher than my 0.025. So, basically it falls in the acceptance zone and I will accept my null hypothesis and say that the interaction effect is not prevailing. So, the interaction does not have statistically significant impact on my response.

(Refer Slide Time: 11:35)



So, this is what exactly you can do. Very easily you can check also the R square adjusted R square. So, more or less these values are satisfactory more than 74-5 percent 80 percent.

(Refer Slide Time: 11:49)



And you can accept the model and it explains the variability, total variability captured by the factors considered.

Now, you go to say doe stat DOE factorial and analyse factorial plots. So, this is the option that you have.

(Refer Slide Time: 12:10)



And what you get here is response you specify.

(Refer Slide Time: 12:14)



And then you can also analyse this. So, there is something interesting and lot of output you can generate through Minitab. So, wha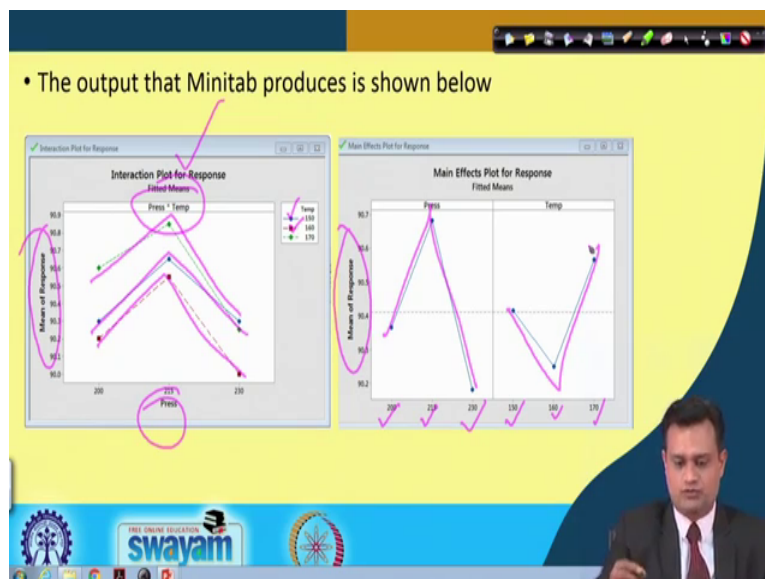t you see here this is the interaction plot for response. So, this is my pressure temperature. Here I am considering the mean response and here I am considering the pressure

So, what is the impact of my interaction on my response that is being analysed? So, what you see here that blue line is basically this particular one that is the temperature 150, this

line is basically 160 temperature and this is 170. So, more or less you can see that the interaction is not present and that is what we tried to prove through statistical analysis also. You can see the main effect plot for the response and what you see here that this is the pressure 200 2 1 5 2 30. This is the temperature and I can see that mean response changes significantly and pressure and temperature they are significant in terms of their impact on the response.

So, this is what we can do through Minitab very easily and we can focus more.

(Refer Slide Time: 13:36)



So, you can also refer this video link that will also help you to strengthen your understanding on factorial design and you can use this book which demonstrates the Minitab application for factorial design and this particular link.

So, thank you very much for your interest in learning the Minitab application for analysing factorial design.

(Refer Slide Time: 13:45)



And factorial design is a very very important concept and maximum information I can extract by adopting such a strong design of experiment strategy and I hope you will apply it in some of the problem whether manufacturing or service industry. If nothing if you are a student, just try to solve couple of problems given in the suggested text books that will itself help you to have better understanding. So, what you do? You do first manually already equations are explained and they are given, you do it manually, also try to solve it using Minitab, compare your results and that will give you better confidence.

So, thank you very much. Be with me. Enjoy.