Design of experiments minitab pdf

I'm not robot!

DOE, or Design of Experiments is an active method of manipulating a process as opposed to passively observing a process. DOE enables operators to evaluate the changes occurring in the output (Y Response,) of a process while changing one or more inputs (X Factors). Learn more about Design of Experiments – Full Factorial in Minitab in Improve Phase, Module 5.1.2. of Black Belt Training. How to Run a Design of Experiments – Full Factorial in Minitab 1. Create the Factorial Design by going to Stat > DOE > Factorial > Create Factorial Design: 2. Next, ensure that [2-level factorial (default generator)] is selected 3. Input/Select 3] for the [Number of Factors] 4. Click on [Designs…]: 5. Ensure that [1/2 fraction] is highlighted 6. Input/Select [3] for [Number of replicates for corner points] 7. Click OK: 8. Select [Options] and un-check [Randomize runs], make sure [Store design in worksheet is checked] 9. Click OK: 10. Select [Factors] and the dialog box below will show-up; load in the factor names and level settings 11. Click OK: Minitab will create a worksheet containing the DOE array: The first blank column in the worksheet (here C8) is reserved for the Response values After running all of the experimental runs enter the results in to the worksheet: The second series of steps allow us to analyze the results as well as produce the charts and graphs that help us communicate our results. 12. Go to Stat > DOE > Factorial > Analyze Factorial Design: 13. Enter the column (here C7) that contains the response in the open window called Responses (or just double-click on C7 in the left box) 14. Then click on [Terms…]: 15. Select the terms you want in the model (in our case we want all three factors) 16. Either double click on the term or use the [>] between the windows 17. Then click OK: 18. This time select [Graphs…] 19. Select/Check [Pareto] 20. Click OK: The following Pareto chart of the results is very effective in communicating the experimental outcomes: The details behind the analysis will be contained in the Minitab Worksheet. This is the ANOVA table for the experiment: Learn more about Design of Experiments – Full Factorial In Minitab in Improve Phase, Module 5.1.2 of Black Belt Training. black beltdesign of experimentsdoefull factorialMinitab DOE (design of experiments) helps you investigate the effects of input variables (factors) on an output variable (response) at the same time. These experiments consist of a series of runs, or tests, in which purposeful changes are made to the input variables. Data are collected at each run. You use DOE to identify the process conditions and product components that affect quality, and then determine the factor settings that optimize results. Minitab offers five types of designs: screening designs, factorial designs, response surface designs, mixture designs, and Taguchi designs (also called Taguchi robust designs). The steps you follow in Minitab to create, analyze, and visualize a designed experiment are similar for all types. After you perform the experiment and enter the results, Minitab provides several analytical tools and graph tools to help you understand the results. This chapter demonstrates the typical steps to create and analyze a factorial design. You can apply these steps to any design that you create in Minitab. Minitab DOE commands include the following features: Catalogs of designed experiments to help you create a design Automatic creation and storage of your design after you specify its properties Display and storage of diagnostic statistics to help you interpret the results Graphs to help you interpret and present the results In this chapter, you investigate two factors that might decrease the time that is needed to prepare an order for shipment: the order-processing system and the packing procedure. The Western center has a new order-processing system. You want to determine whether the new system decreases the time that is needed to prepare an order. The center also has two different packing procedures. You want to determine which procedure is more efficient. You decide to perform a factorial experiment to test which combination of factors enables the shortest time that is needed to prepare an order for shipment. Page 2 Orient yourself to Minitab 18 and quickly begin using it to analyze your project data. Get step-by-step guidance on collecting data, setting up your worksheet, performing the analysis, and interpreting your results. You can also find in-depth topics on statistical concepts and other resources, including the methods and formulas used in Minitab. The Data Set Library includes numerous Minitab worksheets. Find the ideal worksheet for you to demonstrate and practice various analyses. The Macro Library contains over 100 helpful macros that you can use to automate, customize, and extend the functionality of Minitab analyses. Hii all ….!! Hope everyone is safe and healthy.Previously i've shared a post on DOE on minitab and how to perform it, but it is quite in a simple way without much explanations.Today, this post is going to be a full length post which will mostly cover all aspects of DOE.This post might get heavier for those who have no previous experience, hence to gain some, visit: Design of Experiments Using Minitab In Six Sigma, we have two ways of implementation which depends on the scenario i.e., DMAIC & DMADV.[How to] Design an Packed distillation column ? [How to] Perform material balance Let's say for an example, we have taken a process which is designed in a laboratory and scaled-up in plant for meeting commercial orders. The theoretical yield that can be obtained is 750 Kg for 500 Kg input and post completion of design at lab scale the yield is standardized as 600 Kg with a acceptable variation of ~25 Kg on both sides. The remaining yield i.e., ~150 Kg (Theoretical yield - standardized yield) can be considered as losses which might be attributed by the limited conversion during reaction, losses of product due to partial distribution into spent workup layers, slight solubility of product in the solvent used in isolation.Post completion of scale-up, the commercial yield is at a level of 550 Kg i.e., 50 Kg less than that of the lab standard, with some variations with about ~50 Kg on both sides which are attributed by some common cause variations.Now, the actual scenario begins,Our supply chain team has fore-casted an order which could be a future requirement. Based on the requirement and product time-cycles we came to be a conclusion that if we need to meet the supply demand then we need an average output of ~590 Kg / batch.In this scenario, as per the lab design and standard yield (at lab) the maximum yield that can be obtained is 600 Kg (with some allowable variation) and the target to meet the requirement is 590 Kg/batch, then we can consider that there is a scope for improvement and as a regular practice we can have some kaizens implementation / PDCA, but to be more precise and to show a better commitment towards towards meeting the requirement we can implement a green belt six sigma project (i.e., DMAIC approach) to improve the output. In an alternate scenario, lets say we need to get a output of ~650 Kg / batch to meet the future market demand, we can improve the process performance by proposing some kaizens but the point is the process is designed for a standard yield of ~600 Kg and that could be a limitation and to further increase the output, it requires a design change (i.e., DMADV approach). That is where mostly we implement DOE to further refine/optimize or to extend the design for meeting the demand.So basically there is a insight about the difference in implementing the DMADV vs DMAIC approach to many that DMAIC shall be applicable to existing process and DMADV shall be applicable to new development, but the above scenario is an exemption to their insight.Let's get into our topic i.e., performing DOE, but before that there is a need to understand the basics like Fractional Factorial Design.Process Safety Management Evaluation of Differential Scanning Calorimetry What is resolution ?Resolution indicates the degree of factorial. In Minitab DOE, the levels is considered as 2 by default, unless you proceed with "General Full Factorial Design". Below is the screen depicting the resolutions:Lets say, for a 2 factor experiment the total no. of experiments shall be 2^2 = 4.for a 3 factor design, the total no. of experiments shall be 2^3 = 8 and if we want to reduce it to half factorial design i.e., 1/2 th fraction, it shall be 2 ^(3-1) = 4, which is called as resolution 3.Similarly, with increase in factors there will be increase in resolutions, which indicates we are reducing the study of interactions.As the resolution count is low, the risk will increase because we are not studying all the interactions and this is applicable only when we are high on confidence about the interaction. What are Replicates ?Replicates itself indicates those are copy of the experiments which are previously performed for the same factor levels. So, then a doubt might strike through your mind that "Why to replicate and what's the necessity of replication?".Why to replicate and what's the necessity of replication?Replicates help us in identifying the variability and deriving smooth conclusions.What are Blocks in DOE ?Blocking is a technique which help in reducing the effect (i.e., bias and variance) due to nuisance factors, by separating the factors based on interest.What are nuisance factors ?Nuisance factors are those which have an impact on the response but not of primary interest.What are Center Points ?The term itself indicates that center point will take a value of levels mid point. Lets say i've taken two factors and the factors are Dose & pH, where the levels of these factors are between 2 and 10, that means the center point would be 6 and 6.But please note that the no. of replicates are applicable only to the levels mentioned and not for the center points, until or unless we have selected blocks more than 1.I've done a full time project during B. Tech final semester.As i'm providing it here, i have mentioned that "i've done it", but actually we had a team of 5 members and the project is "Industrial waste treatment (parameters we have taken is turbidity and COD) using Response Surface Methodology (Minitab)".Being a team member i've dealt with lab experiments along with other members and our team leader (Battula Amritha) has taken the responsibility of performing DOE in Minitab. Being frank i was quite uncomfortable with DOE during the project time, but after started working with Dr. Reddy's Labs got the significance of it and i'm grateful to our guides / Mentors "Ms. Kalyani Gaddam & Dr. Shisir Kumar Behera". Study ExampleLets start our show,Lets jump into topic i.e., creating a factorial design for identifying the best set of parameters to get optimum output. And begin the design for a reaction where the factors are Reagent mole Equivalent, Temperature and Dosing time.As per the proof of concept studies (i.e., POC), to further finetune the process DOE study is proposed and the levels of the factors are as below:Reagent mole Eq.: 1 to 5,Temperature : 20 ºCto 80 ºC,Dosing time: 2 to 10 hours.[How To] Perform Energy Balance ? Capacity Enhancement in Manufacturing / Production So, now there are three factors and the levels are 2 for each factor.The number of experiments shall be 2 ^ 3 = 8 experiments.Lets have one center point for these factors to evaluate the performance in-depth i.e., if we don't have center point then the performance of the factors at the mid can't be understood.So the no. of experiments would be = 8 (full factorial) + 1 center point = 9 experiments.And to have better understanding of the bias / variability, lets have replicates and i would prefer 3 replicates each. So the number of experiments would be = 8 x 3 + 1 = 25.[please note that the replicates is not applicable to center point here].Step - 1: Create a factorial design[Approach: Stat --> DOE --> Factorial --> Create Factorial Design]Then the session window would be displayed with the factors, runs, blocks, replicates and center point we have selected and the worksheet would be containing the StdOrder, RunOrder, CenterPt, Blocks and the factors we have selected. The worksheet is depicted below:Step - 2: Now its time to perform the experiments as per the randomized runs provided by minitab in worksheet & Include the results of the experiments against the runs as shown below:[i've considered the conversions just for completing the case study]Step - 3: Analysing the Factorial design[Approach: Stat --> DOE --> Factorial --> Analyze Factorial Design]Below is the output after analyzing [check in the session window]Interpretation:From the ANOVA (Analysis of Variance) table, it can be observed that the P - value for all of the factors and interactions between factors reported as less than 0.05, which indicates that those interactions are having significant impact on the conversion (i.e., output response).The response can be predicted based on the regression equation,Conversion (%) = 51.62 - 0.097 Eq. + 0.0135 Temp. - 0.424 Time + 0.05174 Eq.*Temp.- 0.0069 Eq.*Time + 0.00712 Temp.*Time + 0.00191 Eq.*Temp.*Time+ 31.04 Ct Pt** Ct Pt are error estimates, which shall be eluted during the usage of center points.Rationale for P - value & 0.05:Rationale shall be explained in my next post, which shall be about hypothesis testing.Below are the graphs (Normal & Pareto)Normal Plot:Interpretation:Based on the normal plot, it can be concluded that the interactions are having significant impact on the output response.Pareto Chart:Interpretation:From the above pareto chart, it can be concluded that the factors and their interactions are having significant impact on the response, except interaction ABC, which is below the dotted line. Step - 4: Interpretation using Cube plot[Approach: Stat --> DOE --> Factorial --> Cube plot]Cube Plot:Interpretation:From the above cube plot, the 3D interactions can be observed and the way in which response is varying can be found.Step - 5: Analyzing through response optimizer[Approach: Stat --> DOE --> Factorial --> Response optimizer]Enter the target value for conversion as shown below:Interpretation:From the above response optimizer, we can conclude that the target of 95% conversion with a desirability of 0.4000 i.e., 40%. Now i've changed the target to 90 from 95, now check the interpretation:Interpretation: From the above response, it can be concluded that the 90% conversion can be achieved at points Eq. = 5.0, Temperature = 80 C & Time =10 hours.Calculation of RMCC of a product [How To] Perform and evaluate TLC? Now lets check by maximizing to possible extent with high level of desirability.Interpretation: From the above response optimizer, it can be concluded that the maximum conversion can be achieved is 92% at inputs of Eq. = 3, Temperature = 50 C and time = 6 hours.

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