CONCEPT

Design of Experiments (DOE): Factorial Designs, Response Surface Methodology and Optimisation



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Introduction:

Design of Experiments DOE replaces one-factor-at-a-time trial and error in plants, laboratories and formulation benches, where changing a single setting at a time wastes runs, hides interactions and points to settings that fail at scale. This Core Concept course trains process, quality, R&D and laboratory staff to plan designed experiments, screen factors with fractional factorials, model curvature with central composite and Box-Behnken designs, test results with ANOVA and residual checks, and locate robust operating windows. Each participant builds a Designed Experiment Plan and Optimisation Report for one real process or formulation.

Course Objectives:

- Plan a designed experiment by defining its objective, candidate factors, levels, responses and run budget before any trial begins
- Apply randomisation, replication and blocking so that experimental results are not distorted by drift, batch or operator effects
- Select and run full factorial, fractional factorial and Plackett-Burman designs to estimate main effects and interactions with the fewest runs
- Analyse experimental data with ANOVA, effect plots and residual diagnostics to build a reduced predictive model
- Optimise process settings or formulations with central composite, Box-Behnken, mixture and robust design methods
- Produce a Designed Experiment Plan and Optimisation Report with confirmation runs ready for scale-up handover

Target Audience:

- Process engineering staff who set reactor, furnace, line and utility operating parameters
- Quality engineering staff who investigate yield loss and variation in product characteristics
- R&D and product development staff who develop and adjust formulations, recipes and blends
- Laboratory and analytical staff who develop test methods and run bench-scale trials
- Technical service staff who troubleshoot customer applications and pilot plant trials

Course Outline:

Day 1: Experimentation Principles and Planning

- Why One-Factor-at-a-Time Experimentation Misses Interactions
- Experiment Objectives: Screening, Characterisation and Optimisation
- Factor, Level and Response Selection Worksheet
- Randomisation, Replication and Blocking Principles
- Completely Randomised and Randomised Block Designs with Latin Squares

Day 2: Factorial and Screening Designs

- Two-Level Full Factorial Designs and Standard-Order Run Sheets
- Main Effects, Interaction Plots and Effect Estimation
- Fractional Factorial Designs, Aliasing and Design Resolution
- Plackett-Burman Screening Designs for Many Candidate Factors
- Centre Points for Curvature Detection and Pure Error

Day 3: Analysing Designed Experiments

- ANOVA Tables, F-Tests and Effect Significance in Minitab or JMP
- Normal and Half-Normal Probability Plots of Effects
- Residual Diagnostics: Normality, Constant Variance and Run Order
- Regression Model Reduction, R-Squared and Prediction Intervals
- Power and Sample Size Planning for Detecting Practical Effects

Day 4: Response Surfaces, Mixtures and Robust Design

- Central Composite Designs: Axial Points and Rotatability
- Box-Behnken Designs for Three-Level Process Windows
- Contour Plots, Desirability Functions and Multi-Response Optimisation
- Mixture Designs at Overview: Simplex Lattice for Formulations
- Taguchi Orthogonal Arrays and Signal-to-Noise Ratios for Robust Design

Day 5: Modelling Build: Designed Experiment Plan and Optimisation Report

- Reactor Yield Case: Screening Then Response Surface Build
- Coating Formulation Case: Mixture Blend Analysis
- Laboratory Assay Case: Blocked Factorial for Day-to-Day Variation
- Confirmation Runs, Prediction Checks and Scale-Up Handover
- Designed Experiment Plan and Optimisation Report Peer Review

Skills You Will Gain:

- Experiment Planning
- Factor Screening
- Interaction Analysis
- Analysis of Variance
- Model Diagnostics
- Response Surface Modelling
- Formulation Optimisation
- Robust Parameter Design

Why Attend This Course:

- Return with a Designed Experiment Plan and Optimisation Report for a process or formulation from your own site
- Reach reliable operating settings in fewer trial runs and less material than one-factor-at-a-time testing
- Explain experimental conclusions to managers and customers with effect plots, contour maps and confirmation evidence
- Work through plant, laboratory and formulation cases with engineers and scientists from several industries

Conclusion:

Designed experiments pay back when every run is planned to answer a defined question and every conclusion is confirmed before scale-up. The one week move from planning, randomisation and blocking, through full and fractional factorial designs, to ANOVA, residual diagnostics and model reduction, and then to response surfaces, mixture blends and robust design. The final day applies these methods to reactor, coating and assay cases and closes with a Designed Experiment Plan and Optimisation Report ready for use at work.