

Design of Experiments using ECHIP:

Optimising Processes and Products by Experimentation

Introduction

Complexity is the greatest impediment to finding the sweet spot in processes and products. Sifting through all factors to find *that* combination that matters needs a rigorous systematic scientific approach that only the method known as design of experiments can provide.

One easy way to do this is to use the one-factor-at-a-time approach. Here, you work through each factor varying the levels of the factor whilst controlling the others to be a constant and note the effect on the output variable. However, with this approach the all-important interactions between factors will be missed. On the other hand, the traditional statistical approach emphasises hypothesis testing and the search for statistical significances. This approach works well in the statistician's hands, but not for the general run of the mill engineer or scientist. What works better is an approach that uses the Response Surface Method (RSM) to show an interpretable picture of the process or product factors. From this not only is it possible to find the optimum combination of factors but also to see where the current is located and what it needs to be done in order to get there.

Fundamentals of Design of Experiments (DoE)

Experiments are usually designed and carried out to determine the settings to be used on input/control variables (or factors) to achieve some desired or optimal value for the characteristic(s) of the output product. Controllable factors are set to particular values in the course of an experiment. One single set of factors and controlled settings is known as a run. The set of all runs in an experiment is a design. In an industrial context, a run can often be quite expensive. So, a well designed experiment aims to gain as much information from experimentation in the smallest number of runs.

Because of inherent measurement and process variability, the significance of factors can only be determined within a statistical framework. It is rare that factors have an obvious (large) effect. In any case, the search for the optimum result often gets to the limit of the current measurement and control accuracy. The statistical accuracy can be improved by taking a larger sample, but the control accuracy can only be improved by improving the instrumentation or the process.

Factors not thought to be important are nevertheless controlled at specified levels. This control of environmental factors is another reason why on-line experimentation are

usually difficult to management. The more usual situation is to conduct the experiment off-line, in a laboratory context.

How ECHIP Helps

The designers of ECHIP have recognized the practical problems in experimentation and have set out to create a stand alone DoE package that:

- Manages the experimental cycle
- Highlights the effect of sample size on the desired experimental outcome
- Creates a recommended optimally generated design
- But, allows user intervention to alter the design where there are particular needs
- Has single button analysis
- Gives a graphical presentation of the results through RSM
- Determines the location of the sweet spot together with its confidence interval, with or without, constraints
- Allows the integration of the results with popular packages
- Gives the experimenter the opportunity to recover from poor experimental results or inadequacies of a design (because of a restriction on the sample size) by augmenting the current experiment by additional trials.

Despite the large number of options, the user may safely use ECHIP's default recommendations to create robust experimental designs and statistical analyses.

All the standard initial analyses are performed, but the prime thrust of ECHIP is to use the response surface to identify the settings to give an optimal or desired value(s) for the characteristic(s) of the output product.

Thus ECHIP provides the researcher with a tool to identify desired settings for the input/control variables with a minimal number of trials.

The Benefits of DoE and ECHIP

An un-optimized process or product wastes raw materials and capital. DoE enables processes to be re-targetted to their sweet spots. ECHIP achieves this in the minimum number of trials and the quickest time by leading the researcher through the experimental cycle. The consequences are lower cost processes and faster product development cycles.