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Individual Project 4

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Understanding Design of Experiments

Design of Experiments is defined as a numerical study that indentifies the variables in a process or product that are the critical parameters or cause significant variation in the process. It can be applied when investigating a phenomenon in order to gain understanding or improve performance. Experimental design (commonly referred to as DOE) is a useful complement to multivariate data analysis because it generates “structured” data tables. These “structured” data table’s helps to further understand the experimented data in a visual state. DOE can help increase the cost savings of an existing process improvement and your speed to market for new products or services, while decreasing the investment in and anxiety of your planned experiments.

The order of tasks to using this tool starts with identifying the input variables and the response (output) that is to be measured. For each input variable, a number of levels are defined that represent the range for which the effect of that variable is desired to be known. An experimental plan is produced which tells the experimenter where to set each test parameter for each run of the test. The response is then measured for each run. The method of analysis is to look for differences between response readings for different groups of the input changes. These differences are then attributed to the input variables acting alone or in combination with another input variable.

DOE is a type of statistical tool, along with statistical process control it is one of the main tool. Statistical process control (SPC) is the primary TQM tool. It is a charting technique used to monitor process variations and correct problems before producing scrap. Because DOE identifies the critical parameters and their target values, its use should actually precede SPC in most circumstances. It is not unusual to find after an experiment that SPC was controlling the wrong variable or that the target was incorrect.

DOE uses different types of testing during its process, which includes hypotheses testing, t-testing, and f-testing. These tests help allocate and differentiate the different experiments, by having some statistical evidence that they work. The hypothesis tests are only concerned with whether or not two samples have identical values. For example, if there were two bathrooms designed the same way but one was rotated completely opposite of the other, the hypothesis test would differentiate the right choice. The t-test compares two averages by separating differences, while the f-test works with randomized groups. The t-test and f-test are normally used together. The t-test can only be used when one or two samples are available for testing and for more samples the f-test is used also.

The advantages of DOE are: it eliminates the ‘confounding of effects’ whereby the effects of design variables are mixed up. Confounding of effects means we can’t correlate product changes with product characteristics. It helps handle experimental error. Any data point may contain bad data, i.e. is accurate to only +/- ?%, Experimental Error, The effects of variation in: Raw Materials, Test Instruments, Machine Operators, etc. It helps determine the important variables that need to be controlled. It helps us find the unimportant variables that may not need to be controlled. It also, helps measure interactions, which is very important.

There are several steps common to most DOE methods. The first is to define the problem to be solved. Next is to list the factors that might affect the way the process operates. The third step is to conduct experiments to study the factors in different combinations. The last step is to choose the combination that yields the best results. Process documentation can then be used to train employees in the most efficient method. Several different methods of completing DOE tasks have been developed. Some of the methods include the following:

1. Taguchi orthogonal arrays - named after Genichi Taguchi, a Japanese quality expert widely recognized as a pioneer in DOE systems, this method allows for the estimation of many main effects in relatively few runs.
2. Response surface designs - nonlinear surfaces are fitted to factor points, allowing for exploration of a particular factor region and identification of optimal factor settings.
3. Latin squares - this method is used when main effects are of interest, factors have more than two levels, and interactions are negligible.
4. Screening designs - many factors of interest can be tested in relatively few trial runs to learn which ones are important and should be studied more closely.
5. Classic factorial designs - simultaneous assessment of the effect of several factors on a response is provided.
6. Optimal designs - Designs covering nonstandard situations are generated via computer algorithms. These design algorithms attempt to generate the best design - maximal information, good statistical properties, minimum number of runs. This method is also known as algorithmic designs.

In order to be a powerful and useful technique, careful attention must be considered in; setting good objectives, measure response variable quantitatively, replicate conditions to dampen noise, run the experiments in a random order to eliminate any biasing, block out unknown sources of variation, know which effects will be aliased from interactions, use results from one design to the next experiment, and finally confirm results with a second experiment.

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