



TenStep Supplemental Paper

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Improvement – The Journey

Improvement means performance enhancement and can be achieved by improving one of the many characteristics of the product or process. Improving performance by improving design is one way of achieving enhanced performance.

For a typical high-volume manufactured product, manufacturers aim to reduce the variability of the product. In the process of quality checks, they improve its acceptance levels. The focus is on improving performance by reducing defects and non-conformities.

Monitoring critical processes, conducting experimental tests, and optimizing process performance make this possible. Many statistical methods exist that allow organizations to reduce defects by optimizing performance. One such method is Design of Experiments.

Step 1: Design of Experiments. DOE helps to understand the entire working of a process through experiments. It is one of the many statistical problem-solving tools used to find the significant factors in a process, discover the effect of each factor on the outcome, troubleshoot machine problems, select process or design parameters, and model processes. In short, when applied appropriately, it can enhance both process and product quality.

The concept first emerged in 1919, when British statistician Sir Ronald A. Fisher devised a strategy for systematic experimentation. This strategy, thanks to certain developments and modifications by Genichi Taguchi (the father of Experimental Design), is now universally known as Design of Experiments.

Step 2: Aim of the improvement program. Every program that aims at improvement must have a clear goal in perspective. The program must clearly define the desired target and the means to achieve it.

For instance, the goal might be to reduce scrap produced, nonconformities, or repair work during the warranty period. Furthermore, performance metrics must be initiated to measure performance at every stage.

Step 3: Experiments and analysis. In order to study or monitor the factors in a process, one factor should be studied at a time while all other factors are kept fixed. However, this method leads to many calculations and results. Therefore, it could prove to be difficult to determine the effects of one variable over another.

The second method is to study the effect of all the variables/factors at a time using experimental techniques such as DOE, which is more effective than traditional methods.

Step 4: Use Orthogonal arrays to experiment. DOE helps in designing experiments that check process performance and the conditions and factors affecting the process. After the process to be tested is decided upon, the layout of the experiments is considered. The approach to the DOE program is extremely critical. If the experiments

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are incomprehensive, then the process cannot be understood, and necessary corrective measures cannot be initiated.

The best approach to initiate a DOE program is to create orthogonal arrays.

Orthogonal arrays are nothing but a series of numeric tables that display different test conditions that must be initiated to test a process. In short, the tables give the different circumstances that the process is subjected too. The orthogonal array can help to devise experiments for examining different test conditions.

It is easier to conduct a DOE program with the help of orthogonal arrays since it helps put focus on every possible condition that the process goes through.

Step 5: Experiments must be based on two-level factors. Experiments conducted with first-level factors may not always yield indicators that can help improve performance. Therefore, it is necessary to include two-level factors in the orthogonal arrays. These help to scrutinize the process/product more efficiently.

Step 6: Experiments must take into account three and four-level factors. Having seen the need to initiate two-level orthogonal array factors, experiments with three and four-level factors need to be understood. Experimenting with two-level orthogonal arrays is ideal if the experimental result is linear in nature because in such cases, two-level factors are enough to check for variability.

However, it is different for non-linear performance characteristics. It is recommended that three-level and four-level orthogonal array factors be used for improving the accuracy of more complex experiments

Step 7: Take into account the analysis of variance (ANOVA). ANOVA, or analysis-of-variance, is a statistical model used to analyze performance-related data. It helps determine the source of variability and therefore is used to iron out potential problems that might occur in the production process. ANOVA is used when the variables in the process can be categorized and are non-continuous.

There are two types of ANOVA (for different applications or circumstances) - the one-way ANOVA and the N-way ANOVA. The former is used when there is one independent variable and one dependent variable. The latter is used when there are two or more independent variables and only one dependent variable.

ANOVA is advantageous because it helps in the perception of the effects of variance on the process, thereby allowing better understanding of the process.

Step 8: Experiments must understand the interaction amongst variables.

Experiments must reveal the effect of one factor over another. For instance, a vibration analysis must not merely focus on the equipment vibration, but must also aim at determining factors such as heat, load conditions and operator ignorance that might fuel vibration. Such approaches help iron out all variations that eventually lead to non-conformities and defects.

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As discussed in step 6, the need for three-level and four-level factors is very important, especially in complex experimental set-ups. The complexity of the experiments depends directly on the interdependence of factors, i.e. the influence of one factor over another. The more interdependent the factors, the more complex the experiments can be. Therefore, it is absolutely necessary that experiments be designed with three-level and four-level orthogonal arrays to reduce complexity and increase the awareness of interdependent factors.

Step 9: Mixed-level factors. With regard to single or one-level factors, it is easy to create a standard array. However, some experiments involve frequently changing characteristics. In such cases, mixed-level arrays are recommended. Mixed-level arrays help upgrade or downgrade the columns in an orthogonal or standard array and help deconstruct the array whenever necessary. Thus, a two-level array can be converted into a three-level array and vice versa, depending on the requirement or experiment.

Step 10: Comprehensive and robust design. Non-conformities result in inconsistent quality. These non-conformities/variations disrupt the production schedule. Often, organizations aim at reducing the variations. Reducing variations implies that a quality-consistent product is delivered to all the customers.

However, some variations are impossible to eliminate because preventive measures are very expensive or uncontrollable. Such uncontrollable variations are called noise factors. Robust experimental design aims at reducing the influence of uncontrollable factors or noise factors using controllable factors. In short, by altering or adjusting controllable factors, the uncontrollable factors can be reduced.

Step 11: Use the mean square deviation to find optimum variable levels. Every variation is fuelled by a variable or a factor. To control the variation, the factors responsible for it must be set at a specific level, called the optimum level. This ensures minimum variation and maximum process performance. To determine the optimum level for a certain factor, experiments are conducted repeatedly, and then the average of the experiments is considered the optimum value. Calculating the averages to determine the optimum value is easy, but is it the best approach?

The mean square deviation (MSD) is a better approach. The MSD combines the advantages of averages and standard deviation. Therefore, unlike the average calculation, MSD encompasses the variability of the result within a single experiment, thus improving the accuracy of the experiment.

Step 12: Check the monetary advantages of improvement. Improvement is crucial. However, what good is an improvement if it is not commercially/monetarily viable? Therefore, if an improvement reduces rework, defect or scrap, it is important to quantify the profit. Taguchi loss function can help achieve this objective. According to the Taguchi Loss Function, the greater the variation of a value from the standard, the greater the costs incurred.

Step 13: Review previous case studies and work in the order of complexity. Prior case studies give substantial information on areas requiring improvement. They also



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provide vital insight into matters that must be avoided to prevent failure. Above all, case studies provide the perfect learning ground for organizations. Every case study should be adequately documented for future reference.

Always begin improvement programs with simple and straightforward projects. This provides the perfect launch-pad for future complex improvement programs. On the contrary, starting with a complex project might cause boredom and disappointment.

Summary

Improvement is not a one shot activity. It requires dedication and an urge to fight all odds to achieve enhanced performance. These 13 steps provide an opportunity to achieve enhanced performance. Needless to say, enthusiastic participation from the entire organization is an imperative.