Predicting Cost of Quality Essential to DFA

For years, many industries have been using a formal design for assembly (DFA) process to develop new design approaches. The central emphasis of DFA is reducing product complexity, and many organizations have been brought back from the brink of extinction using DFA.

Other companies have pursued world-class quality by attacking defect sources in every part and process step without questioning the level of complexity of the product. Although this approach has shown impressive results, typically among Japanese companies, it may force an organization into significant amounts of unnecessary and costly improvement activity that DFA may make unnecessary.

Recent news articles indicate that some Japanese organizations are now developing fundamentally different approaches to fulfill customer needs. The search is characteristic of DFA. An integrated strategy to reduce product complexity and support a drive toward world-class quality would be a formidable competitive weapon.

This push for "world-class simplicity" would ask a fundamental question: do we really need every part and process step to meet the customer's need? Answering that question requires a way of assessing the cost of quality of a product early in its design cycle. Most methods of predicting quality are difficult and time-consuming, however, and are not easily accessed in early conceptual design activity. Design teams also are often reluctant to make quality predictions about new designs due to inexperience and distrust of estimating.

A fast way to address these concerns relies on a concept called rolled yield. Rolled yield (also known as rolled throughput yield, first-time yield, and first-time through) is the percentage of production that will have no incidence of defects anywhere in the part, process step, or performance parameter. Historical evidence shows that rolled yield improves along with total cost when DFA techniques are applied.

What's needed is a method to estimate the cost of poor quality (COPQ) of a product quickly using a minimum amount of data and time. A basic building block of such an analysis is a measurement called defects per unit (DPU). For attributes data, DPU is a simple average of the number of defects found divided by the number of units inspected for a particular defect type. For variables data, DPU is the tail area(s) of a curve beyond specification limits.

We calculate DPU for all possible sources of defects including parts, processes, and performance parameters. We can then calculate total defects per unit (TDU) by summing all DPUs. TDU in turn lets us calculate COPQ, rolled yield, and the "sigma" level for organizations that use the six-sigma process for benchmarking. To calculate rolled yield, we apply the Poisson formula:

$$P(x) = \frac{\mu^x * e^{-\mu}}{x!}$$

where μ is the average incidence of defects, x is the specific number of defects we want to predict in a unit chosen at random, and e is the engineering constant, which is the base for natural logarithms.

We substitute TDU for x:

$$P(x) = \frac{TDU^x * e^{-TDU}}{x!}$$

then look at the case of $x = 0$ to predict rolled yield:

$$P(0) = \frac{TDU^0 * e^{-TDU}}{0!} = e^{-TDU} = \textit{rolled yield}$$

By recording a different cost for each source of defects, we can calculate total COPQ by summing all the totals based on our prediction of defects.

We can also come to a rough first estimate of COPQ even if we have not completed a detailed defect analysis. First, we must estimate rolled yield using a simple formula that uses complexity as a factor. This formula assumes that we can estimate a normalized yield for each part and process step, which we'll call Y_1, then raise it to a power, the complexity factor z, which is the number of parts and steps.

$$P(0) = \text{Rolled Yield} = Y_1^z$$

Then, we can use the inverse of the rolled yield equation to calculate TDU:

Since $P(0) = e^{-TDU}$, then TDU = -ln [$P(0)$]

If we can estimate the average cost of a defect ($\$D$) to an organization, we simply multiply TDU by $\$D$ to get a rough estimate of COPQ per unit: COPQ = TDU * $\$D$. Again, this method is used only when a detailed defect analysis has not been completed.

Quality analysis provides additional measurements that support and enhance the traditional DFA process. With early quality information, we can develop the best design strategy to achieve ease of manufacturing, lowest total accounted cost, rapid development, profitability, and total customer satisfaction.

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