TenStep Supplemental Paper

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Understanding Robust Quality

For years, manufacturing engineers and managers have associated losses due to poor quality with the squandered value of products not shipped, the cost of rework and material waste. Losses owing to poor quality may even exceed the cost of manufacture, but no amount of money can repair the damage done to the company's reputation.

A 'Robust' Product

Taguchi methods emphasize that quality is a virtue of design. The 'robustness' of a product depends more on good design than on on-line process control, no matter how stringent it is. Companies often tend to believe that losses are low when they ship most of the products they manufacture. They often believe that manufacturing products within specifications is a sign of good quality. However, for a customer, the proof of a product's quality is its performance level under varying operating conditions. Don't we all expect our vehicles to be designed for safety even when driven on wet or bumpy roads, with tires slightly under- or over-inflated? Don't we want our music systems to perform consistently, even during low voltage conditions? Likewise, wouldn't we prefer photocopiers whose copies are clear even under dim lights? Such products are termed 'robust.'

Varying Variations

Design engineers try to counter variations in external forces, like low voltage and rains (for the cases above), by methods like insulating wires, adjusting tire treads, sealing joints, etc. But what about performance degradations occurring due to the interactions among parts and not due to external forces? Most products generally contain parts that do not work in perfect harmony. This can be due to misconceived designs or faulty meshing of a component with the corresponding components. Consider the case of a drive shaft of a car whose vibrations cause premature wearing out of a universal joint. Higher vibrations of the drive shaft could be either due to a misaligned lathe used during manufacture, poorly conceived design or negligent handling by the customer.

In simple terms, a product may be subjected to wide variations during factory processes as well as during customer use. But it has been observed that the ambient or process variations that the product has been subjected to in the factory may not be as striking as the variations in customer use.

Zero Defects versus Taguchi Methods

As per the principles of Zero Defects, any effort to reduce process failure during manufacturing operations simultaneously reduces product failures in the field. Nevertheless, one principle derived from the Taguchi Methods emphasizes that efforts to reduce product failures simultaneously reduce the number of defects in the factory.

Going by the theory of Zero Defects, quality initiatives are considered in most manufacturing plants only after the designs are finalized. Hence, performance degradations resulting from the failure of parts to pair perfectly and interface are grossly neglected.

Robustness and Consistency

Unquestionably, no two parts/components or products can be made exactly identical. Engineers, using the logic of Zero Defects, presume and allow a certain amount of variation during the production of parts. They set targets for a part's dimensions and specify tolerances, which allow for trivial deviations from the target. For instance, a shaft whose diameter is 9.998 (within specified tolerances) is acceptable though the target is 10. This deviation does not result in serious performance degradations. The actual problem arises when the issue of tolerances and deviations evolves into a virtue. That is, engineers, managers and production personnel grow accustomed to working with acceptable deviations from the target instead of making consistent efforts to meet the target. Moreover, designers prefer wide tolerances, assuming that the cost of narrowing them would prove expensive for the company. However, what they don't realize is that even when parts are within specifications, small deviations from the target can really 'stack up,' causing problems that will cost the company to fix.

Catastrophic Stack-ups

The same logic, when extended to factory performances, proves that aiming for the target results in robust products. Missing targets with perfect consistency is better than hitting them haphazardly and staying within specifications. When consistency exists, adjusting performance by paying attention to details of design and processes to meet targets is easier. For instance, if every drive shaft manufactured misses the target 0.005mm, operators can work to adjust the same to zero by adjusting the position of the cutting tools. Consistency also helps to eliminate the 'stack up' effect. Catastrophic stack-ups are more likely to occur due to scattered deviations within specifications than consistent deviations outside.

Understanding the Quality Loss Function

The greater a manufacturer deviates from targets, the greater the losses; quality loss (loss incurred after products are shipped) also increases at a tremendous rate. This can be quantified based on the Quality Loss Function (QLF), a simple quadratic formula. Based on this, loss increases by the square of deviation from the target value.

$$QLF=D^2C,$$

where C is the constant which is determined by the cost of the countermeasure the company has to use to get on target. By identifying what is required to meet targets, a company can determine the cost of the action per unit. If a company hesitates to spend the money required to meet targets, the more components deviate from the target, the greater the compounded costs will be.

For instance, a car manufacturer decides against spending $50 per transmission to get a gearbox exactly on target. Based on QLF, it would then spend $200 for two deviations from the target, (2^2 X $50), $450 for three, $800 for four and so on. This is a very simple approximation and actual field data might or might not prove the QLF to be precisely correct. Nevertheless, QLF can prove to be extremely important in the initial stages of new product development when tolerances are set and quality targets are established.