Closed-Loop Quality Management Minimizes The Cost Of Quality

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Quality itself is no longer a differentiator among manufacturers. High quality is expected and achievable. With enough time and money, any manufacturer *can* turn around a high-quality product. The focus of manufacturing quality has shifted to a discussion about the cost of quality (CoQ) and how to manage it. The manufacturer that can minimize CoQ, while producing products the fastest, is the one that will win in today's market.

The "closed-loop" approach to quality management, utilizing virtual simulations and tolerance analyses, can link cost factors with tolerance adjustments so users have the data they need to achieve a strategic balance between quality and cost. With such an approach, users determine how to precisely meet their quality requirements by identifying and focusing on the key points that affect quality and avoiding unnecessarily tight tolerances.

CoQ Defined

CoQ includes four components:

1. **Prevention costs** involved in preparing and implementing a quality plan.
2. **Appraisal costs** involved in testing, evaluating, and inspecting quality.
3. **Internal failure costs** of scrap, rework and material losses.
4. **External failure costs** at customer site, including returns, repairs/rework and recalls.

The Value of a Closed-Loop Quality Management Process

The most successful organizations use simulation-based dimensional engineering processes as part of their quality management program in order to prevent design problems that might not otherwise be discovered until manufacturing finds them or the customer experiences them as quality issues. Using tolerance analysis linked to actual measurement results, engineers and quality professionals can quickly pinpoint sources of variation and perform root-cause analyses to solve problems.

Most complex, assembled products built today are subjected to simulation-based dimensional engineering processes which help product design and manufacturing engineers understand dimensional fit characteristics and quality statuses. Engineers

use this type of analysis before they start a product launch and continually through production. In a “closed-loop” quality management process, several built-in steps enable users to define and refine their plans and objectives early in the process, and through ongoing checks and balances, in order to achieve the precise quality required by the customer at the least possible cost. There are seven steps involved:

1. **Establish Build Objectives:** A team analyzes the quality levels of competitor products to determine appropriate levels of variation allowable. The balance between build requirements and cost will vary based on planned quality levels.

2. **Set Build Strategies:** A build strategy defines the way parts will be located and held within an assembly. There is always more than one way to manufacture and assemble a product; the goal is to find the best approach given quality and cost objectives.

3. **Establish GD&T Requirements:** Geometric dimensioning & tolerancing (GD&T) is applied to parts driven by the build objectives and strategies. Data locators are set, and related dimensions are measured based on their locations relative to the locators.

4. **Analyze Tolerances:** The “assemblibility” of a part is ensured before production. In production, possible product and process changes are optimized before expensive tooling changes are made.

5. **Establish Measurement Plans:** A measurement plan includes the critical quality characteristics that have been identified through tolerance analysis, noting limits for each part. The plan is a roadmap of which critical features to monitor through simulation-based analysis during production.

6. **Generate Dimensional Data Reports:** As a product enters pre-production and initial runs begin, quality inspection data is collected and reports are generated to ensure measurement plans are followed and endproducts achieve expected tolerances.

7. **Conduct Root Cause Analyses:** As is the case at most other stages, if end-products are not achieving the tolerances expected, engineers can “loop back” to see where problems originated and either resolve issues or adjust build objectives, strategies, or tolerances.

The closed-loop approach is referred to as such because it closes the loop on product and manufacturing. It enables engineers to use comprehensive virtual simulation to analyze variation and tolerances in product design from initial product development through production, ensuring that the value of the analyses is maintained across the full product lifecycle.

Through this process, dimensional quality data reports are generated as the product

enters preproduction and initial runs begin. Engineers refer to the reports and check key points to ensure that measurement plans are being followed and that end products achieve quality targets. If the end-products are not achieving quality targets, engineers can “loop back” to see where problems originated and fix them.

Minimizing CoQ

A closed-loop quality management process enables the manufacturing enterprise to avoid unnecessary costs by addressing all four components of the CoQ as follows:

1. **Prevention Costs**: A “closed-loop” process includes development of quality plans for each product and program enhancement using tools and processes that are well-established, speedy and efficient.

2. **Appraisal Costs:** Testing, evaluation and inspection of quality are included as critical components of a “closed-loop” DE process – again, through a highly effective, resource-efficient process.

3. **Internal Failure Costs:** With the capability for users to “loop back” and make process, measurement and design corrections and adjustments during the “as-built” phase of a product’s lifecycle, the closed-loop quality management approach minimizes internal costs associated with scrap, rework and material losses.

4. **External Failure Costs:** The use of a “closed-loop’ quality management process, with its many checks and balances, minimizes the number of quality defects or issues that may slip through to the customer – minimizing the costs associated with returns, repairs and recalls.

In short, the use of a “closed-loop” quality management process, including tolerance simulation tools and techniques, enables engineers to optimize CoQ.