DFM Crucial for Gear Industry Success

John P. Walter and Georges Assimilalo, Precipart Corporation

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"Design for manufacturability" (DFM) is a well-established practice, essential to realizing the successful transformation of concepts into mass-produced gears and motion control devices. And yet, all too often issues that could have been avoided are identified very late in the process that impact production costs and schedules. This suggests that key DFM principles are often underutilized in practice and are not applied consistently—or to the degree necessary—to avoid these negative results.

By considering in detail three DFM-based best practices, we can offer insight for improving the conditions for success as manufacturing partners work together towards a common goal. Engaging key stakeholders in an organized team from the very start of a project, conducting a thorough feasibility study, and implementing the proper quality assurance tools will help ensure that the final product is reliable, manufacturable and acceptable to the original equipment manufacturer (OEM) andend user.

Integrated Product Development Teams

For DFM to be successful, it is vital to create a truly integrated multi-disciplinary design and product development team from the beginning. This team should include representatives from key departments that will be involved—from design through production—including engineering; product management; manufacturing; quality; sales and marketing; supply chain; and others appropriate to a given project.

In addition, it makes sense to include representatives from outside your business, such as key suppliers and other design and manufacturing specialists who may be needed on a specific project. Good collaboration here can help ensure that an elegant gear or motion control design is practical to manufacture and meets the cost targets and performance goals set by the end user. An integrated team also reduces the risk of a "silo" approach where one element may be overemphasized while other design considerations are overlooked.

All critical customer requirements must be clearly established during initial team meetings, as total project lifecycle costs and speed to product launch are often defined early in the process. A good multi-disciplinary team looks at details such as materials selection, degree of manufacturing difficulty, supply chain issues and market/industry-based requirements such as regulatory stipulations.

Consulting early on with key suppliers can help in avoiding costly rework later. For example, Precipart recently reviewed the design of a tight tolerance gear assembly for a medical imaging device, and we identified a potential performance flaw early in the design phase. As a result we recommended bench assembly and light run-in to create the contact pattern on a helical gear to reduce

A DFM approach can produce significant benefits even from the smallest details; for example, where a change to a gear tolerance by .002" can significantly improve the performance of a device.

backlash by approximately .002", which would significantly improve the durability, performance and lifecycle of the device.

The dynamics and open communication of a multi-disciplinary team are crucial to ensuring successful DFM processes. A senior staff engineer from a medical device manufacturer recently told us, "The level and degree of DFM teams vary, but from the design phase perspective, suppliers who are critical to the project's success should be included in the discussions, and the sooner the better. We receive great input from our suppliers in their fields of expertise, and having a good partnership with them ensures the launch is successful."

Feasibility Study

A comprehensive feasibility study is part of an effective DFM process and it should examine key specifications and potential design issues that may occur throughout the life of the gear or motion control device; it should also offer recommendations to address any performance issues in various environments and conditions.

Application-specific requirements are fully evaluated in the feasibility study. For example, some aerospace applications may focus on torque and speed, while others focus on accuracy. A gearbox which controls the positioning feedback system of an aircraft's landing gear must utilize anti-backlash gears to avoid inaccuracies in the system. Envelope size and weight may be other key considerations for aerospace applications, due to space and weight constraints on the aircraft. These critical design and application requirements must be captured up front as inputs for the integrated product development team.

A thorough feasibility study will also help identify concerns about production tooling – i.e., whether existing tooling is sufficient or if custom tooling is needed. It can also assess the tolerance of materials for post-fabrication treatments such as deburring.

Poorly finished parts are frequently a cause of order rejection and production delays. The feasibility study can help identify areas of dimensional inaccuracies and rough surfaces that can lead to noise, excessive wear and backlash between the pair of gears in mesh, which can result in inefficient power transmission. After reviewing these factors, the DFM team can implement design or manufacturing alternatives that prevent these problems from occurring.

A comprehensive assessment will utilize computer-aided modeling and analysis techniques to determine load values and directions, life expectancy, heat treatment specifications and tolerance areas such as stack-ups, backlash and hysteresis. Collaborating with partners that have both high-precision manufacturing capabilities and design services to conduct feasibility studies throughout product development lends itself to a more successful product launch.

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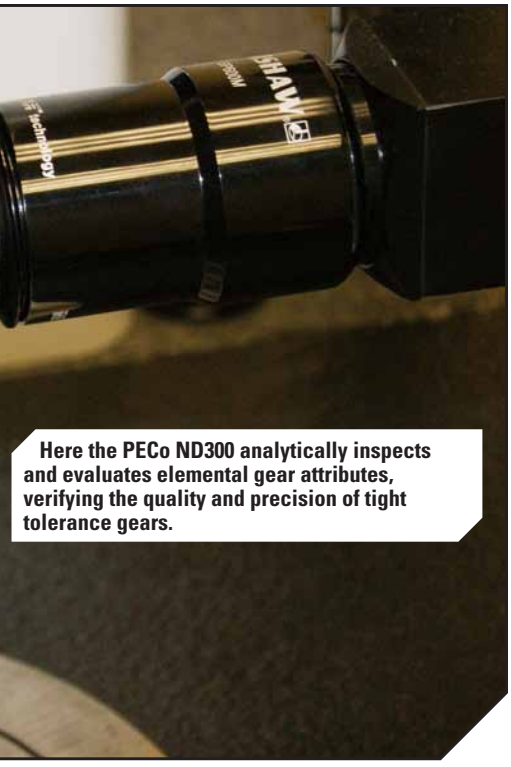
Building in Quality to Support DFM

Quality initiatives such as risk management and Six Sigma can help reduce variation and remove waste from the manufacturing process. An effective DFM process takes these types of quality initiatives into account up front to help build quality into the design and mitigate risk in the production of new gears or motion control devices.

Risk management utilizes several techniques to identify all the critical-factor project elements. The "design of experiment" (DOE) is one example. As a methodology for systematically applying statistics to experimentation, it is used to identify the source of variation in processes such as manufacturing. DOE is critical in evaluating or validating a component or procedure and helps ensure that a product functions as intended, without costly testing and revision while in production. Despite its high value, DOE methodology is often overlooked in the rush to get a project moving.

Another key risk management process is the "failure mode and effect analysis" (FMEA). It is difficult to have a success-



Here the PECo ND300 analytically inspects and evaluates elemental gear attributes, verifying the quality and precision of tight tolerance gears.

ful DFM process if FMEA is skipped or minimized; as part of the planning phase, it helps guide the team in troubleshooting and in working through worst-case scenario factors during the design process.

Whenever possible, providing component suppliers and partners with an overall FMEA system is extremely useful; it serves to identify the most important product features and design tolerances in order to determine how to control them and document the process, including all changes. The FMEA system provides the direct inputs for the supplier's "design failure mode and effect analysis" (DFMEA).

Having a culture of continuous improvement that utilizes lean manufacturing and Six Sigma techniques, such as kaizen, ties in well to designing for manufacturability. These initiatives require "on-the-floor" presence by designers, engineers and other team members who, after participating in discussions on quality and observing production processes, incorporate their lessons learned into the product design. One kaizen team at Precipart helped triple throughput by changing a component finishing process to minimize the time spent in prepping parts for assembly.

Conclusions

Successful delivery of gears and motion control devices requires more than a sophisticated design. Design for manufacturability ensures that innovative technology delivers true economic value while guiding the development process, as well as the teams responsible for achieving success, so that the new gear or motion control device can be produced cost-effectively, brought to market with minimal delays, and perform reliably.

John P. Walter is president and chief executive officer at Precipart, where he has worked for 25 years.

Georges Assimilalo is vice president of engineering and chief operating officer at Precipart, where he has worked for 18 years managing the engineering and design teams.