Optimize

Roadmap for Optimized Machining Processes

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Customer Satisfaction Depends on Reliable Machining Processes

When planning and implementing machining processes, manufacturers generally focus on manipulating elements of their internal operations and may lose sight of the end goal: ensuring customer satisfaction.

To a great extent, customer satisfaction is based on minimizing the time between the customer's order and the delivery of the finished product. In the past, manufacturers minimized lead times by machining thousands of identical parts and building large inventories to be able to ship products immediately. This low-mix, high volume production (LMHV) scenario enabled manufacturers to meet customer needs in a timely manner throughout gradual development of the machining process and unanticipated production errors and interruptions.

Today's market requirements, however, are radically different. Customers increasingly order small batches of products tailored to specific needs. As a result, manufacturers rarely make long production runs and production batches are much smaller. This high-mix, low-volume (HMLV) scenario leaves no room for ongoing process development or unanticipated interruptions. Manufacturers are under pressure to develop machining processes that are totally reliable from the start. Immediate speed, consistency and predictability are paramount.

Nevertheless, many manufacturers continue to focus on what they call "efficiency," developing manufacturing processes aimed nearly exclusively at maximizing output and minimizing cost. They unintentionally ignore "the elephant in the room" – the crucial priority of satisfying their customers, especially customer demands for timely delivery.

QRM

Developed in the early days of the HMLV era, a concept called Quick Response Manufacturing (QRM) highlights the critical role of time in the manufacturing process. QRM strategies, along with zero-waste and process optimization efforts, provide a roadmap that can put manufacturers on a path to minimize lead time and thereby maximize customer satisfaction.

Rajan Suri, a professor of industrial engineering at the University of Wisconsin-Madison in the 1990s, recognized looming changes in manufacturing markets, particularly the trend towards HMLV production. In 1993 he founded the Center for Quick Response Manufacturing. The Center's purpose is to create partnerships between the university and manufacturing companies to develop and implement ways to reduce lead times. QRM strategies are often applied in addition to lean, Six Sigma and similar process improvement initiatives.

The Traditional Approach

Production managers in traditional machining environments seek maximum machine utilization above all. The goal is to produce large batches for inventory. Parts in stock buffer fluctuating customer demand.

In HMLV manufacturing, however, a job is put into production to fulfill a customer order for a limited number of specific components. There is no buffering inventory.

Further complicating the situation are factors such as so-called "hot jobs" that arrive unexpectedly in response to emergency circumstances or special requests from key customers.

Another issue is that manufacturing operators tend to concentrate on finding ways to meet internal goals, such as achieving 100 percent on-time delivery. Planning often is carried out with those internal goals in mind. For example, shop personnel may know that completing a certain job takes one day but will allocate two days to account for interruptions by hot jobs or other possible delays.

Roadmap for HMLV Production

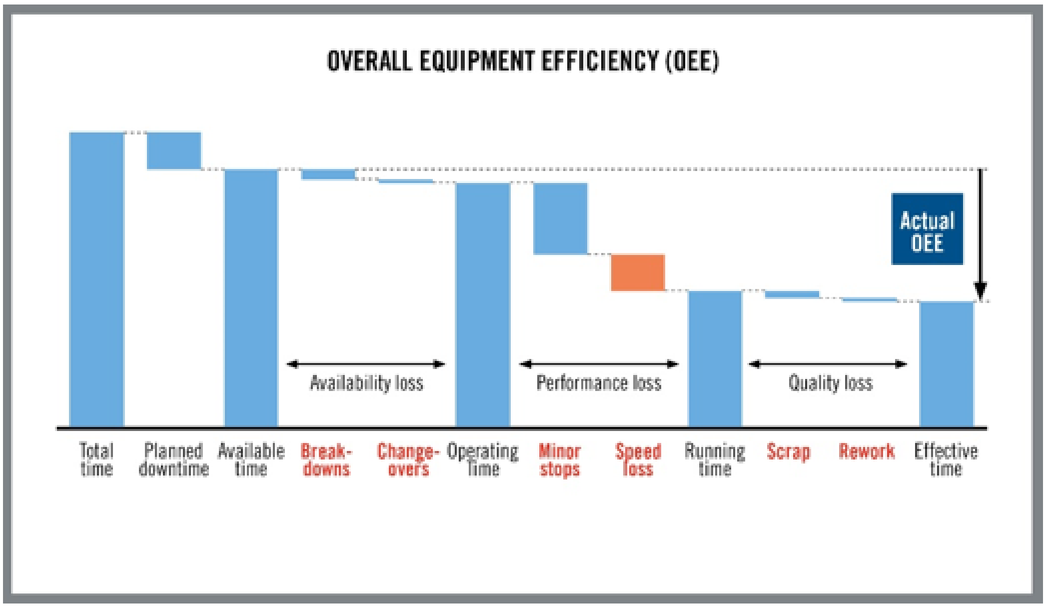
In a HMLV production environment, first time part yield and consistent quality in production of non-identical workpieces is key. The objective is to provide customized products where the part in a one-piece batch costs the same as a part in a million-piece batch and immediate delivery is achieved.

Producing good parts from the start requires establishing a trouble-free and reliable machining process. The current trend is to point to the newest production techniques and digitalization technologies as solutions to machining problems. However, speed, consistency and flexibility always have been, and still are, based on a foundation of operational excellence as well as an educated manufacturing staff with a positive mindset and motivation.

Before discussing digitalization and optimization, it is necessary to look at the overall operation, determine where waste of time and resources occurs, and develop methods to minimize it. Then the emphasis shifts to process quality or reliability.

A Zero-Waste Operation

Reducing lead times requires eliminating waste in the manufacturing process. Wasteful and time-consuming activities in the machining process itself include production of burrs, bad surface finishes, long chips, vibration, and machining errors that create unacceptable parts.

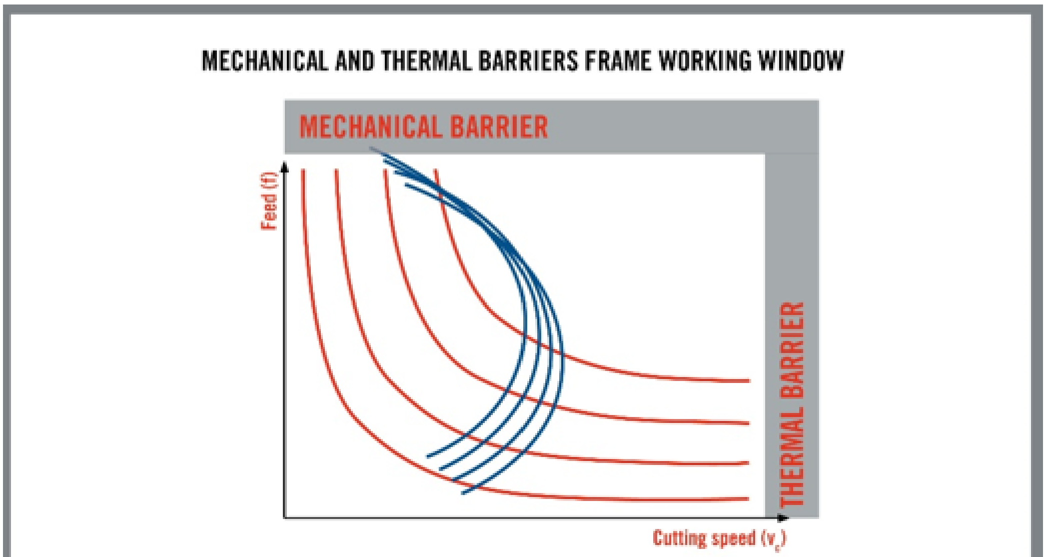


Even producing parts that exceed customer requirements represents wasted time and money. Shops must realize that it is necessary to achieve only the lowest possible workpiece quality that meets customer specifications and functional requirements.

If a part tolerance is five microns, achieving three microns is wasteful. Higher quality tooling and more precise operating processes will be required to meet the tighter tolerance, but a customer will not pay for the unrequested higher quality. The job will end up costing money.

Respecting Constraints

The first phase in establishing a balanced machining process is choosing tools with load capacity that meets or exceeds the mechanical, thermal, chemical, and tribological loads present in the metal cutting operation.



The red lines represent metal removal rate and the blue lines represent tool life.

Phase two involves selecting cutting conditions that account for the constraints put on a machining process by real-world factors. Cutting tools have broad capabilities, but specific elements limit the range of effective application parameters.

For example, tool capabilities change according to the power of the machine being used. Machining characteristics of the workpiece material may limit cutting speed or feed rate, or complex or weak workpiece configurations may be prone to vibration. Although a vast number of cutting condition combinations will work in theory, reality-dictated constraints will narrow trouble-free choices to a certain selection of parameters.

Applying cutting conditions outside the constraints of a specific situation will have negative consequences, including higher costs and lower productivity. Most of the problems experienced during machining come from disregarding the constraints of the cutting process. When cutting conditions do not exceed real-world constraints, the operation is safe from a technical perspective.

The third phase of achieving a balanced machining process involves determining the optimal combination of cutting conditions for a given situation. It is essential to set up combinations that provide the desired levels of productivity and profitability. After the combinations are put into production, troubleshooting to solve specific problems is usually required, as well as ongoing process analysis and optimization.

Versatile Tooling

While high-performance, specialized tools can boost output speed, recognizing process constraints may prompt the choice of tools developed for versatility. When tools are selected for maximum productivity and cost efficiency in machining a specific part, a change from one workpiece configuration to another may require emptying the machine turret completely and replacing all the tools. In HMLV situations where smaller runs of different parts change frequently, that changeover time can consume all productivity gains.

In cases where tool performance is stretched to the maximum, some operators will reduce cutting parameters in fear of tool failure and disruption. Versatile tooling, on the other hand, is applicable across a wider range of cutting conditions, although at less aggressive parameters. When versatile tooling is applied to process a variety of different workpieces, actual machining may be somewhat slower or more expensive, but the reductions in setup time, scrap, and lead time fully make up the difference.

Conclusion

Customer satisfaction is the goal of any business relationship, and a key element of customer satisfaction in manufacturing is timely delivery of machined components. HMLV production scenarios put pressure on manufacturers to optimize their operations to reduce lead times and speed up delivery. Applying the concepts of Quick Response Manufacturing and zero-waste and optimization initiatives enables manufacturers to achieve the speed and reliability needed to fulfill customer demands for timely delivery while also assuring manufacturing profitability.

