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Applying Lean to the Machine

Lean-manufacturing concepts have permeated all corners of many a shop floor—except within the machining center.

By **Tim Heston**
Editor

Anyone tackling lean manufacturing has heard the "wastes" probably more than they can remember. Traditionally seven, now most lean gurus identify eight wastes on the modern shop floor: overproduction, waiting, transporting, inappropriate processing, unnecessary inventory, excess motion, defects and—the latest addition—underutilization of employees.

During kaizen events held with all stakeholders to gather input and develop solutions, the focus stays where many agree the drastic inefficiencies occur: between operations.

Nevertheless, the actual manufacturing cycle shouldn't be overlooked. Machine-tool sales have soared, representing huge investments, and using them inefficiently takes away their benefits. Why spend so much money on a new machine if a shop doesn't squeeze all available efficiency out of it?

That's according to Michael Gugger, a project engineer at Cincinnati-based TechSolve (www.techsolve.org). "The eight wastes of lean apply very much to inside the CNC machine," Gugger explains. Lean concepts should be applied at every level of an organization, from material flow and supply-chain issues to Z-axis moves inside a milling machine.

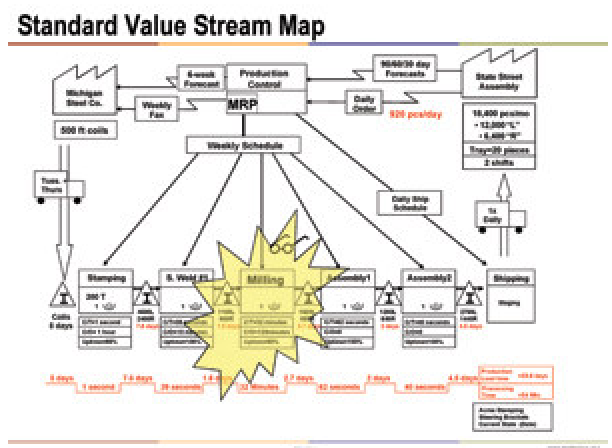

Figure 1. Value stream maps should consider efficiencies inside the machine work envelope.

Against the "Lean" Grain

Traditionally, says Gugger, the lean effort has regarded machining as an immutable element that, according to many a value-stream map, always adds value.

True, those maps helps streamline work processes, identifying value-adding and non-value-adding time. The ratio between them is a principal lean metric.

One mistake, Gugger says, is "treating machining time as 100-percent value-added time." With this perspective, reducing machining cycle time actually hurts the ratio by cutting supposed "value-added" time.

The solution lies in extending that value-stream map inside the machining center and realizing that not all machining adds value (Figure 1, see page 28). He recalls one shop that machined 50 parts per hour. The company implemented lean tools, held kaizen events and developed value-stream maps. They identified non-value-adding items, like excess motion between work stations, excess inventories, inefficient use of employees on the shop floor, and so on. In the end, the company boasted an enviable value-add ratio—yet it saw no improvement to the bottom line.

"That milling process still cut only 50 parts per hour," Gugger says. Efficiencies may have been gained in other areas, yet because of inefficiencies inside the machining centers, the one metric that really matters didn't change: profits.

A Walk through the Traditional Wastes

Apply lean's list of wastes inside the machine-tool work envelope, says Gugger, and the potential efficiencies become clear.

Overproduction speaks directly to the "keep-the-machine-running" mentality, he explains. Not only does this lead to excess inventory but also produces inefficient side effects, including extra process costs, tooling and, not least, material.

"Steel and titanium prices are through the roof" due to overseas demand, mainly China, Gugger says. With current material pricing, he says, just-in-case inventory isn't too kind to a balance sheet.

Lengthy setup times also contribute, Gugger says. "Many organizations machine more than necessary simply because it's so difficult to set up the machine. Shops keep the same setup running, risking over-capacity," just because of part change-over time. Here, investment in quick-change pallets and other flexible tooling solutions help.

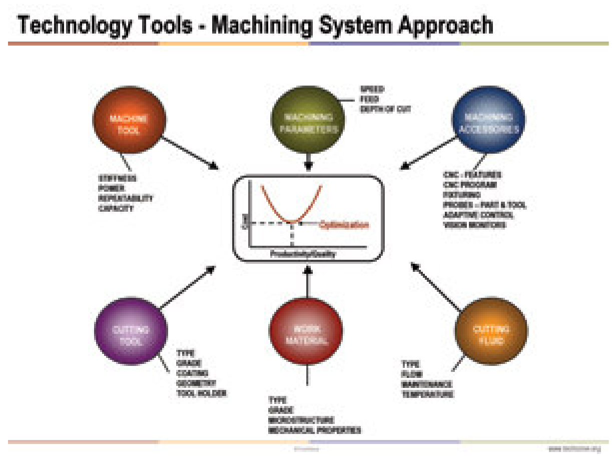

Figure 2. A machining-systems approach to optimizing efficiencies within the machining center, with the resulting trade-off/optimization curve in the middle.

Besides overproduction, excess inventory also comes from improperly utilized tools, reducing tool life and, hence, requiring the need for an extra tool inventory.

As for the waste of waiting, excessive tool wear fits the bill. Shops may use the wrong tool, material or a combination of both, so operators change out tools more often than they should, creating bottlenecks.

Gugger recalls one shop with cutting tools that had to be changed out every few hundred parts. "The machining guy pointed to the tool guy, the tool guy pointed to programming guy," he says. No one took the reigns to solve the problem.

To blame was the interaction between the cutting tool and workpiece. The large casting cooled at different rates in different areas. Hence, it cut through microstructures in different phases, or stages. Each had different levels of machinability, wreaking havoc with tool life.

Engineers solved the issue by tailoring the cooling process for the casting and adjusting feeds and speeds to match the metallurgy. With open communication between engineering and design, they found that a different, more-machinable grade of A300-series aluminum would not change product quality and downstream manufacturing processes (e.g., welding). The result? "The shop met its takt time and produced 1,800 parts a day," Gugger says, adding that the processes were tailored so well, they could even push another 600 a day out of the machining cells if needed.

Programming practices also enter in, including what Gugger calls "just-in-case programming." For one shop, standard practice involved bringing the tool within an inch of the work surface at rapid and then feeding in Z toward the cut—cutting air. "They stopped the tool because there had been errors in programming," he says. Stopping the rapid short gave a chance for operators to halt the operation if the program was incorrect, saving the tool. Yet when initiating lean, he says, companies should tackle the problem at the source—that is, bad programming.

Outdated technology creates a waiting waste, too. In the past, machines would stop as slow CNCs processed their next move. "Now, with computing time much quicker, that stop time doesn't exist," he says, particularly with high-speed-machining and look-ahead control capabilities.

Like all wastes, extra processing can be solved with proper communication. Problems here crop up with what Gugger calls "Xerox design," where designers, asked to improve quality, copy the old design and write in tighter tolerances. Those tolerances now may require inefficient, or even impossible, processing inside the machine-tool work envelope.

Extra processing may even come from the most elegant designs. Gugger recalls one shop that machined vacuum chambers for microchip production. The side of one part involved slot ends rounded and angled in such a way that required a five-axis move. "The machine had to come from the side of the cam ... at 45 degrees and sweep through an arc to create that feature," he says. Engineers asked designers how necessary that feature was. It turned out that, though it was aesthetically pleasing, the feature wasn't worth the extra processing time. So it was nixed, and machining time and costs plummeted because of it.

Excess motion applies within the machine tool just as it does elsewhere on the shop floor. Poor clamping techniques can lead to unnecessary tool motion (i.e., inefficient toolpaths). Using the "picture frame" approach, making workpiece elements part of the fixturing, works well here. Leaving plastic-model-airplane-like tabs, the technique allows the operator to crack the tabs off after the operation. While it does add a little material cost, "it produces zero fixturing costs," Gugger says.

Another intertwined waste, transportation, can also be applied here. Consider the unnecessary transport of fixtures and tools throughout the plant, for example.

The Keystone

Of all wastes, the underutilization of people serves as a keystone, according to some. Underutilize employees, and all seven other wastes step to the footlights.

"Lean" for the machining center involves the operator. Here, short-term solutions abound, Gugger says. If wait time can't be avoided, for instance, operators can conduct 5S activities or simple maintenance. Nevertheless, much of this won't solve long-term pains of unqualified or unmotivated employees. What can help, he says, is proper hiring.

Today's shop sees two types of management structures, he says. One has "centralized skill" at the programmer or setup-person level and above, and relatively unskilled labor at the machines. ("In one Pacific Rim shop—extremely well lit, clean and with new equipment—one person asked the operator what his job function was," Gugger recalls. "He said, 'When a certain light turns red, I push this button.'") The other extreme involves shop-floor expertise, where "the operators are true machinists and know the intimate details involved in the machine," he says.

Both management structures work, he says, but either way needs investment. The centralized-skill model requires automation while the latter takes more training and personnel investment. Shops should choose the model that requires the least investment, matches employees' needs and personalities, while also meeting product quality and delivery.

Without the right model, Gugger says, "rampant turnover can result."

Kaizen Event for the Machine

Armed with knowledge of the eight wastes, engineers can sit down and identify inefficiencies within the machine tool. Enter the kaizen event.

At TechSolve, Gugger has hosted such events for the "lean machine," and they mirror traditional kaizens in many ways, with key distinctions.

For example, most conventional events start with brainstorming sessions, which work wonders for management. But "technical people are much more right-brained," he says, adding that they thrive on careful technical research. So here the "lean champion" presents general technical articles and data that serve as groundwork. "They then assimilate from the general and direct this [general technical knowledge] to the specific," Gugger says.

All stakeholders—be they machinists, manufacturing engineers, even suppliers—break into groups of two. They present solutions, giving arguments like an academic thesis. Then they present their agreed-upon results, which are again argued among the entire group. In the end, the whole group arrives at a carefully measured solution.

No Hunches

To make a lean-for-the-machine approach really work, Gugger adds, requires a science-based strategy involving real calculations that anchor efficiencies to time (or how long an operation takes). This requires validation tests in metal cutting, which produces numbers that can be applied to "trade-off" curves. Any productivity increase has some kind trade-off (less machining time can also decrease tool life and add tool cost, for instance), and the curve measures which trade-off combination produces the greatest efficiencies (Figure 2). Such tests may be done in-house or outsourced to labs like TechSolve, says Gugger.

Driven by Talent

From a broader perspective, most do not doubt that lean's popularity comes from industry's need to be more competitive, Gugger says. He adds, though, that a part of it spawns from the lack of skilled labor. "At last count, [much of the industry] has seen 64-plus quarters of recession," he says. For some, business just started to pick up earlier this year. "The view of the industry is so dismal that no one is coming in," he adds.

Talent is retiring, particularly at the machine-tool/shop-floor level. What used to be "normal" questions (Is this the right fluid? Are we using the right tool? Can we build more efficient fixturing?) quite often just isn't asked anymore, he says. This is made worse in an environment where technology advancements emerge faster than ever.

In short, Gugger concludes, the "lean for the machine" concept makes shops asks these questions again, tweaks them to account for modern technology and lean-manufacturing principles, and ensures lean efficiencies reach down to the machine-tool work envelope.

Editor's Note: Illustrations and artwork courtesy of TechSolve. For more information, visit www.techsolve.org.