Process improvement encompasses a wide range of tools, techniques and strategies. When properly deployed, shop-floor data collection and monitoring systems can help factory-floor managers leverage key data metrics including overall equipment effectiveness (OEE) and total effective equipment performance (TEEP) that measure machine uptime and pinpoint bottlenecks or other problems in order to improve machining performance.

OEE metrics quantify factors including machine availability and operating time, part production performance, and quality. With OEE, manufacturers get the latest information on machine availability against planned uptimes, performance against target values, and quality data for comparing good versus scrapped parts.

With improved factory data collection, manufacturers can get a more accurate view of manufacturing processes.

Patrick Waurzyniak
Senior Editor
Monitoring the Shop Floor

Without shop-floor monitoring systems, manufacturers cannot effectively employ OEE metrics and lean manufacturing, said Dave Edstrom, president and chairman, MTConnect Institute (McLean, VA). At the MTConnect conference last April, the new MTConnect Challenge was presented, aiming to spur development of advanced manufacturing intelligence applications using the MTConnect standard. Edstrom said shop-floor monitoring is a must for both OEE and lean. “I think a lot of people are kidding themselves, because if you don’t have the data, you can’t be doing OEE or lean,” Edstrom said.

MTConnect is an open-source, royalty-free protocol for sharing machine data using the XML and HTTP standards which Edstrom said allows manufacturers to easily get data from machines, including older legacy equipment, through MTConnect agents and adapters. The read-only protocol has gained many converts, with major machine builders, controls developers and manufacturing software companies supporting it to more seamlessly share manufacturing equipment data. The protocol now supports the ISO 13999 standard for specifications for tooling data, which simplifies sharing of standardized tooling information between manufacturing companies.

“The myth among machine tool builders is that it doesn’t benefit them, but when you talk to them, they’re differentiating themselves by being open, and it’s saving these machine tool builders direct money,” Edstrom said. Most builders supporting MTConnect have included agents and adapters for the protocol with newer machines for free, he added, or charge for a nominal fee on adapters for older legacy equipment.

To date, shop-floor monitoring hasn’t really taken off in the machine tool industry, with estimates that only 4% of shops monitor machines, though that number could be much lower.

“Knowing what your machines are doing is the first step,” said Brian Sides, director of technology, Okuma America Corp. (Charlotte, NC). “That means are they running or not?”

“We’ve been a proponent of machine monitoring for years,” Sides added. “I’m seeing more interest. It’s really taken hold in the last couple years or less. The most mature part of MTConnect is the machine monitoring, and some big customers are putting it in their bid spec.”

OEE, TEEP Keys to Lean Process Optimization

OEE and TEEP are similar machine performance metrics but TEEP is measured against total calendar time. Each provide key views into how manufacturing processes are performing and provide critical data for manufacturers to improve operations. “From my perspective there are always two ways for any manufacturer to improve their processes. One is by implementing lean manufacturing and the other is to innovate their existing manufacturing processes,” said Sri Atluru, senior manufacturing engineer, process integration, Sandvik Coromant (Fair Lawn, NJ).

“There is a fine line between lean and innovation—lean management is mostly concerned with targeting the elimination of wasteful content or resources in your process flow, and improving the existing productivity of your shop floor,” Atluru noted. “Innovation is different in the sense that it has the capability to redesign your whole manufacturing process.

“Metrics like OEE and TEEP are very critical because management always wants a way to quantify the whole manufacturing process,” Atluru added. “OEE and TEEP provide a metric that quantifies the whole production flow in your shop floor. And it’s not just OEE or TEEP, you could also use something like SPC to also monitor your process flow and see what is the variability in your process flow.”

OEE provides a way to trace back the whole process flow and find out which part of the process flow is actually contributing to this wasteful content, he noted. “There is a fine balance when you say that, because OEE depends on the way that you collect your data. If you collect very accurate data, it is possible to trace back your problem or trace back your bad OEE to this particular source. But if you do not have accurate data, if you do not do real-time data collection, it becomes very hard to trace back why your OEE or your TEEP is very low. It’s like ‘garbage in and garbage out.’”
Another issue is that most manufacturers have a tendency to not collect data real-time, or automate their data-collection process, Atluru said. “When you manually collect the data, there is always a possibility to introduce more variability, or more errors, into your data.”

Using financial OEE tied to manufacturers’ lean efforts also is important, noted consultant Robert Hansen, owner of R.C. Hansen Consulting LLC (Fort Collins, CO) and author of “Overall Equipment Effectiveness: A Powerful Production/Maintenance Tool for Increased Profits.”

“Lean is the bigger umbrella, but OEE in my mind is the engine,” Hansen said. “In the flow stream, I envision it as the pistons in the engine. I contend that OEE Value Stream analysis is extremely important to learn, and it can harmonize that engine.”

The key to his approach is that all inventory is a loss, although necessary, said Hansen, a 29-year veteran of Eastman Kodak Co. “Financial OEE is the crystal ball that tells you just what the impact on the bottom line is,” Hansen said of OEE. “What it has is all the operating cost of the inventory. There are those who do it well, and others that have way too much inventory. Financial OEE just looks at whatever your current results are, from an income/profitability standpoint. The question is how much could you do if you did best practices?”

An organization’s financial OEE is really a question of how well it’s doing currently, as opposed to how well it could do if the company was operating at world-class quality levels, he added. “If you use all that improvement in time, you’d be astounded that operations that are in the 60–70% at each shop workstation could be much better,” Hansen said. “There’s a complete hidden factory within the assets you already have. Most people don’t ask the question, ‘How much did I leave on the table?’ But they should be.”

**Taking the Pulse of the Factory**

To enhance process improvement, manufacturers can leverage MTConnect to more easily view operational performance, noted Surya Kommareddy, business development manager, DMG / Mori Seiki USA Qualified Products (DMGMSQP)-software, DMG / Mori Seiki (Hoffman Estates, IL). “If you don’t measure, you cannot manage,” Kommareddy said. “OEE is helpful, but probably as it stands it’s taking a broader view more focused on quality, availability and performance. That’s not enough. You need to have more insight into what’s going on to improve the process.”

MTConnect gives manufacturers access to a lot of information in real time, he added. DMG / Mori Seiki recently announced it would offer MTConnect Standard V1.1-compliant adapters with all new machine tools equipped with the company’s MAPPS control. The MTConnect adapter solution includes the adapter, an agent and web services to let customers monitor machine status.

The effectiveness of OEE and charts depends on who looks at the metrics and how the data is used, Kommareddy said. “The shop manager may be interested mainly in OEE data,” he said, “but others are interested in that data on a detailed time chart. How many parts are being produced? And how many are being scrapped and why?”
Production workers on the floor are likely more interested in part-production data, for example, if a tool is running out and they need a new one from the tool crib in time, he added. “These are also part and parcel of process improvement. You can look at these data to find bottlenecks in your process—anything that is green is productive time, and anything other than that, yellow or red, it’s all downtime, which is waste.”

OEE gives manufacturers a lot of data on factors including quality, showing good parts and bad parts, noted Neil Desrosiers, application engineer/developer, Mazak Corp. (Florence, KY), who also serves as chairperson for MTConnect Institute’s Machine Tool Workgroup. “Anyone who’s not measuring their factory today, they implement the low-hanging fruit,” Desrosiers said. “You usually see a 10% improvement and then after that you start seeing targeted improvements. It’s surprising to me how many people are not using machine tool monitoring.”

A longtime supporter of MTConnect, Mazak has included MTConnect compliance on both its machine tools and Mazatrol CNC controls, supporting the current third release of MTConnect v1.2 including mobile assets in the manufacturing process that can be associated with multiple devices in the
lifecycle. Mazak makes the MTConnect adapters available at a cost of $500 per machine, he said.

Employing shop-floor monitoring solutions gives manufacturers a way to visualize what’s wrong with their processes, noted Ron Pieper, program manager, Viz Products, TechSolve Inc. (Cincinnati). With TechSolve’s MTConnect-compliant Web-based ShopViz monitoring application, users can easily see what ails a process on the factory floor.

Pieper compares MTConnect with a mechanic using the On-Board Diagnostics (OBD) standard for automotive maintenance. “When we hook up ShopViz to a machine, we really don’t care what kind of machine it is. You get the same data for the same reality,” Pieper said. “Say I drive an old Saturn, and you probably drive a newer Lexus or a Ford, when I hook up an OBD code scanner, it has the language it needs for communication. If we can apply this OBD concept to machine tools, we can truly learn what’s wrong with the process, and we can look for losses—I call them OEE detractors.”

Even with the tools available, a major impediment to optimizing processes is that so few shops use monitoring. “AMT has estimated that about 4% of machine tools out there are monitored,” Pieper said. “I believe that’s an over-estimation! There are a huge amount of machines in the small shops that are not monitored.”

The number of machine tools being monitored is under 1%, Pieper estimates, with that figure skewed toward larger manufacturers that more likely have internally developed systems. “Because they can afford it, what they tend to do is to create their own monitoring systems,” he said of companies including Ford, Chrysler and GE.

Many machine tool builders such as Mazak, Mori-Seiki and Okuma have done a good job supporting MTConnect, and Makino Inc. (Mason, OH) is using an adapter that was co-written by TechSolve that will work with Makino’s Pro3 and Pro5 controls, he said. “MTConnect works easily with newer controls,” Pieper said. “One of the big trends is to have
the CNC front end be driven by a PC. That makes an easy platform. For example, Mazak’s Fusions, Matrix, and Matrix II controls all are able to be made MTConnect-compliant, even the controls dating back to the Win95 days.”

With ShopViz, customers get a relatively simple solution that is Web-based and resides either on the cloud or locally, Pieper said, depending on customer preference. “The importance of a metric like OEE or TEEP is based on who’s using it and what they’re doing with it,” he adds. “Really the most important metric comes down to utilization, simple as that. Is the machine running or not?”

Tuning the Process

Implementing process improvements can entail taking simple steps such as ensuring machines have properly tuned servosystems before delivery to customers, said Mark Brownhill, manager, strategic marketing, FANUC FA America (Hoffman Estates, IL).

“It really depends on where they are in the process journey,” said Brownhill. “If they haven't even implemented 5S, they need to. When it comes to process improvement, you’ve got to start with something basic. A lot of people are still in what I call the fire-fighting mode.”

MTConnect is a protocol that is still trying to gain ground, said Brownhill, noting that FANUC has its own native protocol, FOCAS (FANUC Open CNC API Specifications), that runs on its CNCs. FANUC and FANUC Robotics (Rochester Hills, MI) are MTConnect members and Technical Advisory Group participants in the consortium. “MTConnect at the end of the day is a communications device that is designed with web-enabled data to tell you if your machine is running.”

Data-driven process improvement helps and manufacturers should fix things that have the biggest impact, he advises. “Focus on adopting best practices,” Brownhill said. “Until you fix the root cause, the problem will repeat itself. Very few manufacturers dedicate people directly to process improvement. It takes leadership to get process improvement to work.”

Manufacturers can make vast process improvements with tuning machine servosystems. “Your typical machine tool delivered to an end user is never optimized,” Brownhill stated. “Even if you didn’t add one thing to it, if you were to tune the servos it would go a long way toward optimizing machine performance. The majority of improving speed is improving the path accuracy. It can be any part of the servosystem. With a bell-shaped acc and dec, it is knocking off the linear acceleration corners to reduce vibration. A properly tuned machine with an AI Contouring Control can climb the path and you can cut your cycle times in half—we call it improving dynamic accuracy. That’s a big deal.”

Several elements of manufacturing systems—better CAM systems, workholding, and tooling systems—can dramatically affect performance, but deploying a high-pressure coolant system may have the greatest return on investment, noted Okuma America’s Jeff Estes, director, Partners in THINC and Okuma Technology Centers. “What we see is there’s really eight groups of technologies. One of them is CAM systems,” Estes noted. “CAM systems have come a long way, allowing shops to optimize cutting time, and simulate when undesirable things like a crash can happen.

“If I only had $15,000 to spend on something on the machine and I had to increase my productivity in the cut by 20 or 30%, the first place I’d look would be high-pressure coolant,” Estes added. “The biggest bang for the buck is putting in high-pressure coolant. It’ll allow you to get faster cutting speeds, longer tool life, and better surface finish.” ME