Advances in shop-floor data management systems give manufacturers real-time views of machining and other operational metrics for fast digital analysis.

Patrick Waurzyniak
Senior Editor

The pace of the march toward the digital factory and smart manufacturing depends on just how fast manufacturing owners and shop operational managers can be convinced of the need to fully leverage the vast amounts of digital data available from the shop floor. Data available from fully networked machines provides insights on machine uptime, product quality, tooling status and even the effectiveness of individual operators on the shop floor.

Shop-floor data collection and monitoring systems aren’t cheap, with installations costing $2000–$4000 per machine, but the benefits are invaluable for any shop aiming to be competitive in today’s global manufacturing markets. Initial implementation costs are higher for legacy equipment—machine tools needing extra hardware to add full networking capabilities—but the costs are typically considerably less with newer machine tools like a Mazak Integrex or an Okuma equipped with the royalty-free, open-architecture MTConnect data-collection protocol. With lower-cost options, monitoring software...
and even cloud-based solutions, more shops are seeing the advantages of leveraging real-time machining and tooling data from the shop floor.

The Digital Factory Advantage

“There is a global move toward smart manufacturing,” said Mohamed Abuali, CEO of Forcam USA (Cincinnati, OH). “As we are based out of Europe, there is the Industry 4.0 movement that’s called Fourth Industrial Revolution. In the US, some people have been pushing Digital Manufacturing.”

Working with the Digital Manufacturing and Design Innovation Institute (DMDII; Chicago), Forcam is developing new shop-floor management solutions with Lockheed Martin, and the company’s Forcam Force shop-floor data management software systems are installed at many large companies, including GKN Aerospace (Irving, TX). Manufacturers are exploring this technology in many ways, Abuali said, citing Lockheed’s Digital Thread program. Forcam will hold its second Smart Factory World Symposium on June 2 at the DMDII’s headquarters in Chicago.

“Lockheed’s direction in shop floor management is what they call Digital Tapestry or the Digital Thread,” Abuali said. This means the digitization of machine, part and labor efficiency, he said. “Those are the key elements of the shop floor that make up the Digital Tapestry, and then they define what’s like the DNA of the factory. The DNA they call the Digital Thread.

“Imagine every part coming off the shop floor, every part has a DNA, or the genealogy of that part. You could easily trace back what happened to the part during the process on every operation by every person who touched that part and on every machine where that part has been produced.”

Several elements are key to shop-floor management, including the machines or assets, the parts being produced on the machines, and the communications of machines and the machine operator, he added. “A critical element is the operator...
running a part on the machine, and the future of shop-floor management really lies in modeling and tying these three elements together in a cohesive manner,” Abuali noted.

A technology like Forcam Force or other shop-floor systems can digitize information exchange on the shop floor, and could facilitate human-machine communication.

“Those are the two key levers for the future—digitizing information exchange on the shop floor by marrying machine data with part data, which means shop floor to top floor, and human-machine communication, because as you know the operator is a key lever to the success of shop floor systems,” he added.

The inclusion of legacy equipment is an important trend, as shops that appreciate the impact of plant-floor monitoring look to bring more and more machine tool assets under the monitoring umbrella to optimize efficiency, noted Pete Tecos, executive vice president, 5ME (Cincinnati). “Our Dashboards software module and new Freedom Digital Interface [FDI] with an integral MTConnect adapter allow users to create a one-screen view of machine-tool performance data, including older CNC or manual machines that do not have Ethernet ports.”

The system can be set up to monitor a single machine, a cell or a mix of various machines on the shop floor. “This is important as shops see the benefits of monitoring software and want to bring these benefits to older equipment,” Tecos said.

“In addition to Dashboards and eMONITOR, our eLOG software now includes the e$CORE module that monetizes machine tool performance based on the six span-time categories as defined by the Association for Manufacturing Technology [AMT],” Tecos added. “It provides full transparency into manufacturing gains or losses in terms of dollars, putting the amount of money being saved or wasted in the plant at management’s fingertips.”

The software includes burden, monetary and summary reports that can be customized by users based on an assigned hourly value for each machine. “Users assign the percentage weights based on the AMT category, such as plant shutdown, scheduled downtime, delay time, repair time, not-in-cycle process time and in-cycle time,” he added, “and the e$CORE value is calculated by summing the daily values in each category.”

Tracking for Traceability

Whatever the costs, data collection, monitoring and analysis are becoming musts for many shops of all sizes, and for industries like aerospace, automotive and medical, they’re becoming mandatory due to the traceability requirements of regulatory agencies, including the Federal Aviation Administration (FAA), the National Highway Traffic Safety Administration (NHTSA), and the Food and Drug Administration (FDA).

With Predator MDC (Manufacturing Data Collection) software for machine monitoring and tracking real-time overall equipment effectiveness (OEE), Predator Software Inc. (Portland, OR) helps shops gather and analyze every imaginable metric coming off the shop floor. Predator has 10 software modules, including Predator MDC, PDM (Product Data Management), Tracker, Traveler, and RCM (Robotic Cell Management) software.

“We have software and products that can handle anything from the two-machine job shops just getting started out, to the Fortune 100 level—GE Aviation, Boeing, Northrop Grumman,” said Mike Rogers, director, Automation and OEM Relations, for the 30-year-old software developer.

“The MDC software’s real-time database gives users the accountability needed for ISO and FAA oversight,” Rogers noted. “If they show up on your doorstep and need to know where a landing gear was made, and when and out of what batch of material, our Predator products can help document that in a database for full charting and recording for those requirements.”

Automotive recalls also are a growing concern for manufacturers regarding traceability for expensive parts involved in recalls, he said, noting one Predator Software customer in the automotive industry has a 100% inspection requirement. While not dealing with mission-critical systems like many...
aerospace parts, automotive customers won’t want to have an engine part fail and result in the manufacturer covering warranty costs on a new engine. “Having something that’s able to track all that, in a system that gives them some data on how many parts were made, where they made them, what the true machining time was, right out of the machine tool, that’s what our software products are capable of doing for those customers,” Rogers said.

**Shop-Floor Management’s Big Payoff**

Investing in shop-floor management can give companies a leg up on those not actively monitoring the shop floor. “Manufacturing companies craving a competitive advantage are actively seeking ways to implement machine-to-machine connectivity on their shop floors,” said David McPhail, CEO of Memex Inc. (Burlington, ON, Canada).

By 2030, Accenture estimates capital investments in the Industrial Internet of Things (IIoT), and productivity gains that should follow could add US$6.1 trillion to the US cumulative GDP, he said.

“That’s a huge number, and IIoT represents no less than the next Industrial Revolution. IIoT is powered by the Internet and software applications capable of connecting, collecting, and analyzing streams of manufacturing data,” McPhail added. “And it’s not a fuzzy vision of what could be. It’s totally achievable now.”

Memex’s flagship product, the MERLIN (Manufacturing Execution Real-Time Lean Information Network) communications platform, offers manufacturing analytics in real-time. “MERLIN delivers a 10%–50% average productivity increase, earns 20%-plus profit improvement based on just a 10% increase in Overall Equipment Effectiveness, and achieves payback in less than four months with an Internal Rate of Return greater than 300%,” McPhail noted.
MERLIN offers a “no machine left behind” bonus, he added. “It connects to any machine, utilizing MTConnect, other protocols, or MERLIN hardware adapters for older equipment, so that every machine and related asset on the plant floor can take advantage of IIoT productivity today.”

Manufacturing leaders around the world are taking MTConnect very seriously, McPhail added. “MTConnect has become the de-facto standard for discrete manufacturing. The reason is simple. It is far and away the most elegant yet simple protocol that encompasses a common dictionary of terms and is supported by the thought leaders in manufacturing. Boeing has publicly stated that no machine tools will go into its factories that do not support MTConnect.”

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MTConnect is an absolute necessity for shops looking to track and improve sustainability and productivity, added 5ME’s Tecos. “Our eMONITOR software module monitors and analyzes machine health, and can actually stop issues before they happen,” he said. “The software detects small anomalies before component failure and determines whether a component or process is within specified parameters. The software looks at vibration, temperature, pressure, current and fluid condition and allows rapid detection of process variation prior to production of poor quality parts.”

The MTConnect-compliant 5ME software also can be used with smartphones and tablets, so alerts are sent and received in real time from virtually anywhere. “Software’s universal connectivity and intuitive interfaces give management and machine operators single-point access to machine status, for assets numbering from just a few to hundreds,” Tecos said. “Real-time information improves maintenance response times, processes, and decision-making on asset purchases.”

Lowering Costs of Entry

What does every part cost? The expense of data monitoring is dropping, making the question of whether to monitor machines more feasible even for smaller manufacturing shops, Rogers noted. “Believe it or not, whether you’re a small company or a Fortune 100, every owner would love to know more about what’s going on on the shop floor and what every part truly costs,” said Predator’s Rogers. “The other side that data management is really bringing to the forefront is how well am I utilizing what I already own?”
Before investing in a new machine tool, shop owners really need to know the productivity of their existing machines, he said. “Am I getting the hours and the productivity out of my people and the machines and the equipment I have? If not, the data management software lets you identify where the weak links in the chain are, because we’re going to show you that this machine that you think is running 24/7 is actually only running 25% of the time.”

It’s not a cheap investment, Rogers added, with costs of monitoring installation at about $2000–$4000 per machine. The cost is lower for new machines with a modern control from FANUC, Okuma or Mazak. With these types of controls, Rogers said Predator’s monitoring software can easily add data collection and monitoring. It’s less to install just the software, but the high end of those costs would be for machines requiring additional monitoring hardware. “If you have a 1987 machine with a FANUC 11M control on it, it’s going to need $1200–$1500 more in hardware,” he said, “and it may take two days to diagnose what it needs.”

Machine tools equipped with MTConnect, or with proprietary controls like FANUC’s FOCAS, Okuma’s THINC, or protocols from Siemens or Heidenhain, are all relatively easy to connect, Rogers added. “Those protocols will give us a wide variety of information, and tell you things like spindle speeds, which aerospace is very fussy about because of the very expensive alloys they’re using and worry about scrapping an expensive part,” Rogers said. “Aerospace companies want to know that the operators are running at the right speeds and feeds. Those new protocols will let us get that data.”

New solutions include Forcam’s “Smart Factory in a Box,” which was introduced last November for cloud connectivity for up to three machines. Priced at $24,950, including full installation and training, it aims at getting smaller manufacturing companies connected.

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Even with new protocols and new connectivity solutions, many shops still lag in monitoring assets, with estimates of under 10% of shops monitoring machine tool performance. “It appears as though the average factory is still obtaining shop-floor data manually, compiling paper data and Excel sheets giving management insight that is 24–72 hours delayed,” said Keith R. Magnant, ShopFloorConnect sales manager, Wintriss Controls (Acton, MA). “We have seen a push towards obtaining real-time data, with a focus on the reasons for downtime, as well as amount of downtime.”

Wintriss’ ShopFloorConnect uses the company’s new SMI 2, a data-collection device that’s been redesigned for greater flexibility that connects to any machine in a factory using simple electrical signals to monitor runtime and part counts, Magnant said. “Our hardware has the ability to inhibit a machine operation, ‘forcing’ the operator to enter in a downtime reason,” he said. “It has the ability to accept a schedule directly from any ERP/MRP system or using a simple Excel sheet.” The system also has an Alert feature that sends an e-mail or text when ShopFloorConnect detects a machine is down for any period of time, Magnant added, allowing for real-time reaction to any problems arising on the shop floor.

Tracking Key Tooling Data

Another key element of shop floor management is tracking of tooling inventories, both through cloud-based services like those offered by MachiningCloud GmbH (Stans, Switzerland) and through tooling suppliers. “There are many terms but just one trend: Industry 4.0, smart factory or the Industrial Internet of Things. The future of machining will be a more networked one,” said Alexander Zoller, CEO of Zoller GmbH.
(Pleidelsheim, Germany). “That is because the future of the machining sector is becoming a more challenging one: Not just in terms of high volumes—even a batch size of one has to be produced to a high standard of quality and the procedures must be documented.”

For processes to be safe, manufacturers need to be able to call up ever-greater volumes of tooling data from any location in order for machine and software systems to work together effectively, Zoller noted. “All of this of course is under conditions of rising pressure on time, cost and quality,” he said. “Parts must move through production more rapidly and leave in better quality than ever before.”

To meet those needs, tooling developers need the Internet of Things to arrive on the shop floor, Zoller added. “With the new version 1.15 of Zoller TMS Tool Management Solutions, consistent compiling of inventories is now possible, right down to the level of individual components. Tools and individual components can be represented individually and detailed information saved and traced along the entire production process. This unique identification of components, with reference to the serial number, facilitates real transparency in the tools department, and lays the foundation for systematic tool management and smart manufacturing processes.”

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