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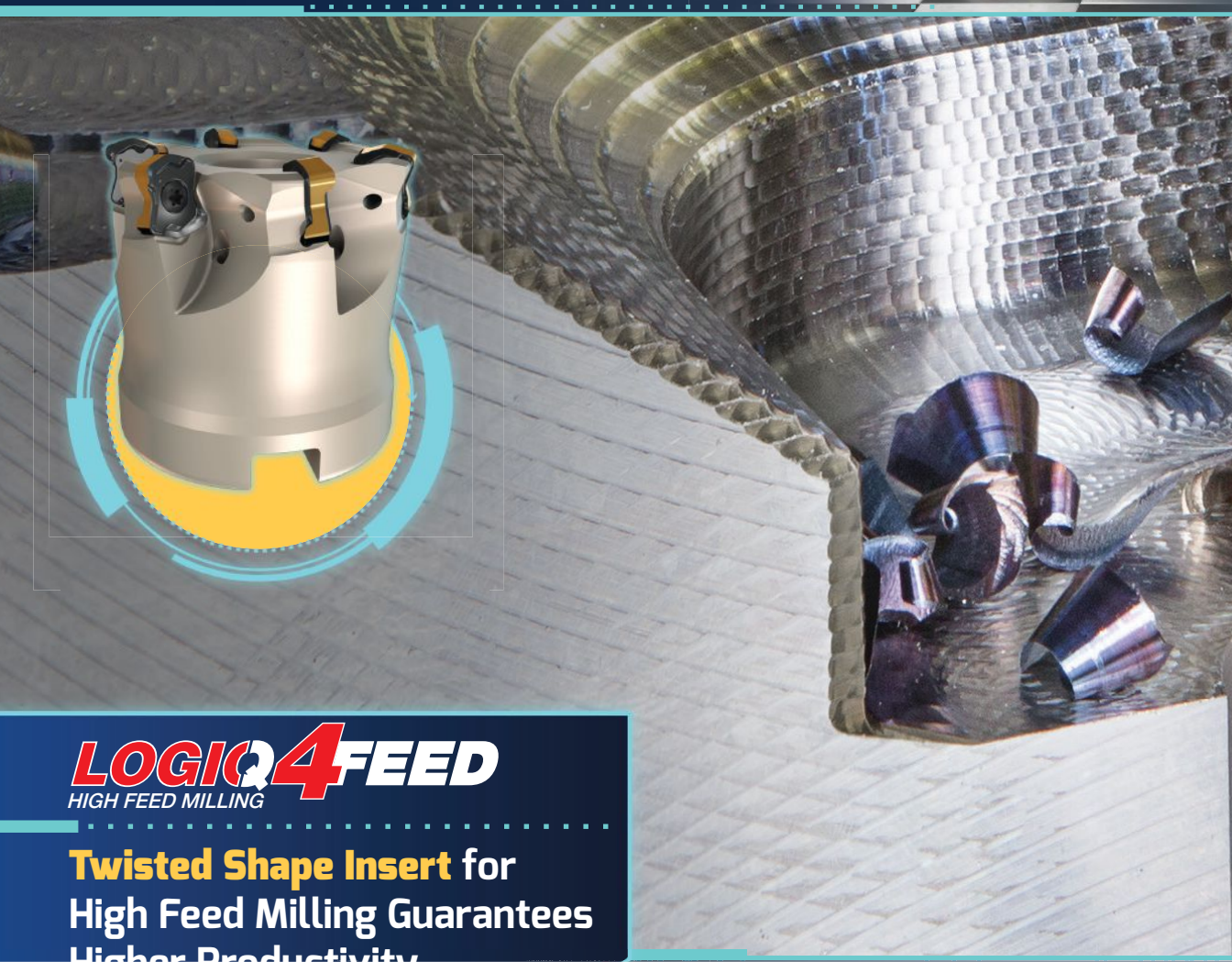

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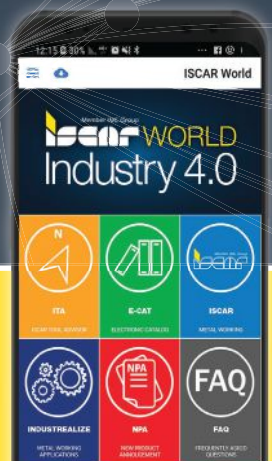

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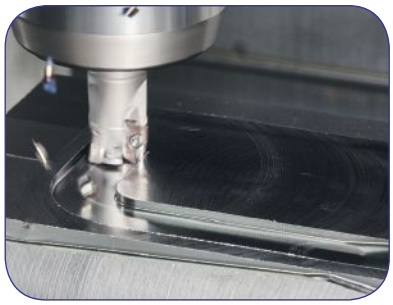

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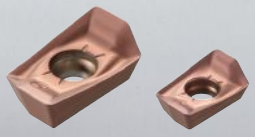

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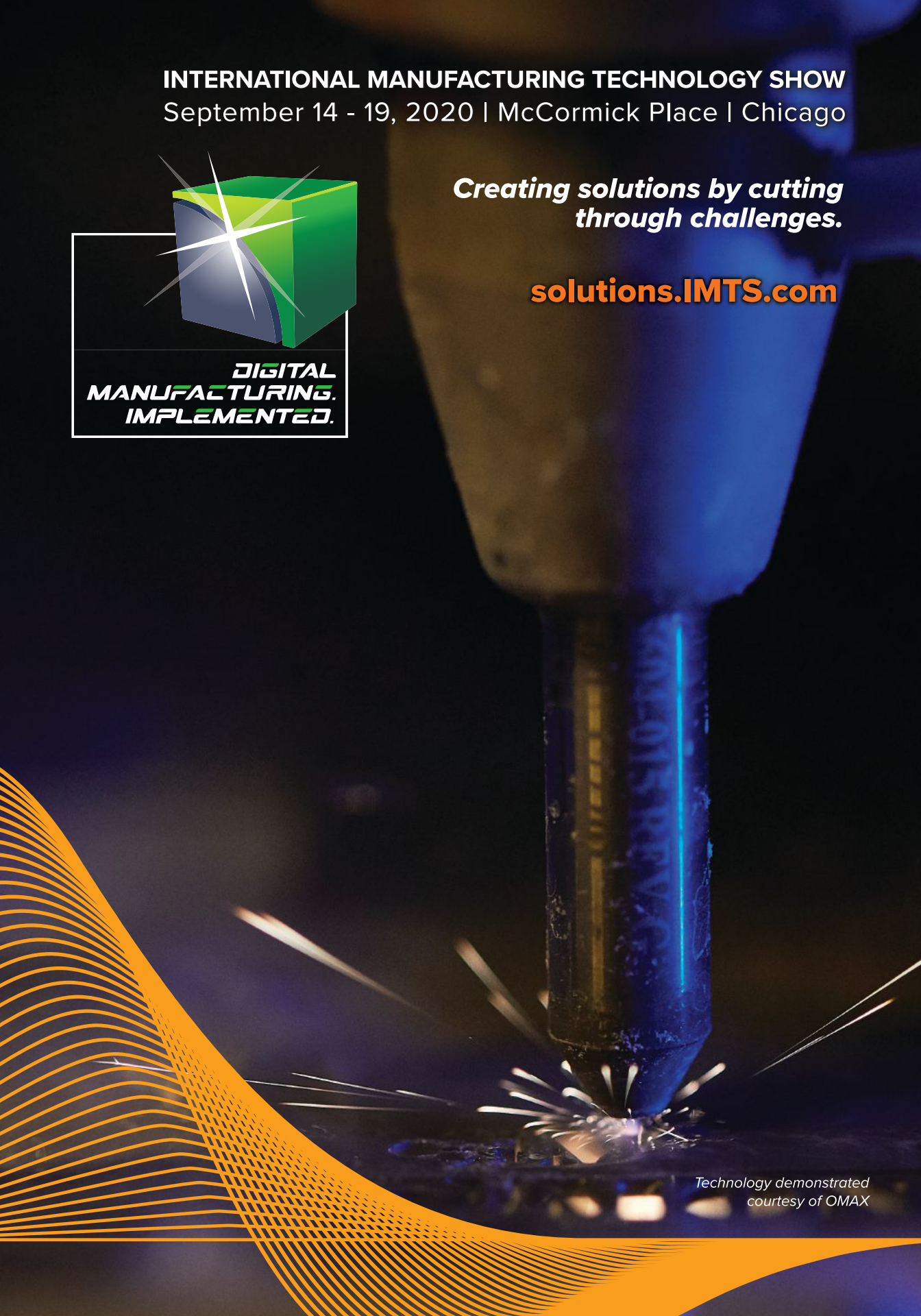
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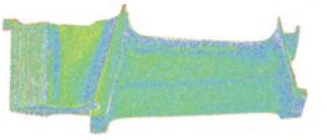

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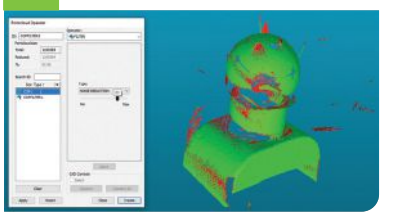

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While tough economic conditions tied to the coronavirus lie ahead for many small manufacturers in the near term, the opportunity for a sustainable domestic manufacturing surge has perhaps never been greater. Read the story on page 70.

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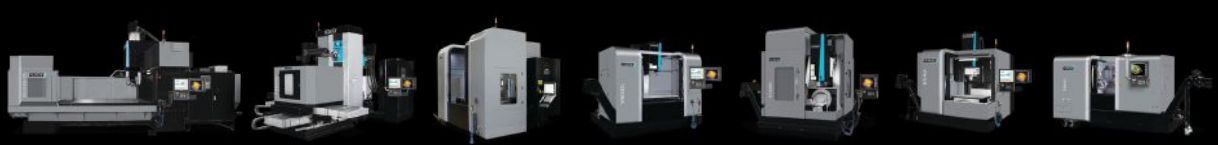

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This is how our staff meeting looked as we planned this issue. We took a tip from many of our readers and pivoted. The May issue was almost complete when we started over in order to bring you coverage of how the manufacturing industry is responding to the coronavirus. (See page 62.)

Trending: #coronavirus

Ruby the Riveter and a Reminder for the Times

Our country has been in crisis many times. The coronavirus pandemic is the latest to test our mettle. We are reacting to it as we have to earlier crises: by working together, finding new strengths, taking new jobs and making sacrifices. During WWII, Ruby Shuman helped repair bombers. Her memories have a lesson for a country facing a crisis today. gbm.media/ruby

Protect Your Employees

ERP systems facilitate remote work for many employees and social distancing for those who must be in the shop. Here are some steps to think through before implementing these policies. gbm.media/coronaerp

Additive Developments

At the intersection between the COVID-19 crisis and additive manufacturing, developments are coming fast. Here, Peter Zelinski and Stephanie Hendrixson from sister publication *Additive Manufacturing* try to make sense of it. More video posts like this to come. gbm.media/covid-am

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14 MIN.

SHOP STORY

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SPECIAL COVERAGE | Manufacturing in the Time of COVID-19

Our own coverage of the coronavirus' impacts on manufacturing is joined with that of our sister publications in this special content feed. This is the place to find out how manufacturers and trade events are reacting to efforts to contain the spread of the virus. Stay informed and #StopTheSpread.

BROWSE: gbm.media/covid19

13 MIN.

PROFILES | Women in Manufacturing Share Their Stories

A young welder, an experienced machinist and a shop owner share what it is like to be a woman in manufacturing, showing that a more inclusive workforce helps the industry thrive.

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What Comes Next: How to Begin a Reshoring Policy

The current crisis is a reckoning. Right now, the challenge is saving lives. But once we are free to look ahead, let's learn the lessons and prepare ourselves better for the next crisis that comes.

We are hoping for manufacturing to save lives. That is the situation as I write these words. As we send this issue to press, we are still in the very midst — perhaps still in an early stage — of the coronavirus crisis. A question still unanswered: Will there be enough ventilators to meet the needs of the most serious COVID-19 sufferers? We do not know. Machining suppliers are doing their part, with many shops now devoting much or all of their attention and capacity to ventilator component production, and many more will likely enter the effort soon (see page 62). In the race between production and infection, we are all rooting for production, and our champion might yet win.

But still, there is a sense in which we have already accepted a sort of defeat. I am writing these words from my home. Most businesses have closed or vacated their facilities. We have shut ourselves in, cancelled our activities, sworn off the joys of a free, open and advanced society, all because of a legitimate fear. We are hiding from a virus in order to slow the spread because we know we are short on supplies to treat the sufferers, and we fear our manufacturing capabilities might not actually be able to keep up.

Did it have to be this way? To an extent, yes. The race to produce more ventilators would have been an unprecedented challenge no matter what. However, certain aspects of the response reveal our vulnerabilities. The reinvention of the supply chain did not have to be as drastic as it appears to have been. In the future, our ability to respond can be what we would have hoped for it to be this year.

Manufacturers of essential products would define and certify how production will be protected or expanded in a time of crisis, or when the normal rate of production is suddenly too small. This obligation would tend to necessitate domestic sourcing.

The challenge here and now is to meet the urgent medical need. Ignore and delay everything else. Yet nearly all of us in manufacturing can sense the bigger, broader, farther-reaching challenge coming next. The current situation is a reckoning, one that many have foreseen and sought to warn against. In manufacturing, we have allowed buffers and margins to become too lean, supply lines to stretch too far, and pennies to be pinched too tightly. Another crisis is coming at some point. And while we don't know what it will be, we »

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know it likely will have this much in common with the crisis today: Some vital object will be part of the answer — a tool, a machine, a piece of technology — and our ability to produce that item quickly and in large quantities will determine the success of our response. We support manufacturing in part because, in extreme times, manufacturing saves us.

Seeing this, it is time for the United States, as a matter of policy, to recognize the importance of domestic manufacturing. To support, value and encourage not just manufacturing in general, but the development of a sophisticated manufacturing base is a vital matter of national security and — as we are seeing — national health.

This is not a new idea. Words like these have been written before. What is new are the fresh lessons we will bring out of this time.

So how do we begin?

The contents and priorities of a U.S. domestic manufacturing policy in the wake of the lessons of 2020 are an area I want to weigh in on and discuss with others. Soon. For now, the question I want to explore is simply how and where to begin. And I think this crisis has given us the clue.

It happened at the state level. It happened as we began to shut ourselves in. Within the different states, as one governor after another issued different shadings of stay-at-home orders or recommendations, many of us learned for the first time of the notion of "essential" versus "non-essential" businesses. Plenty of businesses have gone dark during the crisis, but plenty also have remained open, their employees still showing up, because someone made a list (however imperfect) of the categories of business that needed to keep operating.

Essential, non-essential — I believe the starting point is a definition like this at the federal level around manufactured products. We cannot predict the next crisis, but we can imagine scenarios. We can imagine what devices we might need if one perilous scenario after another comes upon us. We can therefore imagine which stocks of equipment we never again want to see depleted, and which supply lines would be the worst to have cut.

For the manufacturers of products deemed essential, things would change. The designation would be privileged; it would come with support, benefits or protections. It would have to do so, because the designation would also bring a burden. Manufacturers of products classified as essential would be required to define and certify how production will be protected or expanded in a time of crisis when supply is interrupted, or when the normal rate of production is suddenly too small. This obligation would tend to necessitate domestic sourcing. This designation would thus be the start of an official policy of reshoring vital U.S. manufacturing. It means low cost (or a low visible cost) could no longer be the ultimate determinant of where production occurs or how it is organized. This would amount to a deep and fundamental shift — and this change alone might do a great deal to stimulate and provide context for all the other changes to U.S. manufacturing that ought to come (see page 70).

While we can't predict the next threat, we know it likely will have this much in common with the crisis today: Some vital object will be part of the answer and our ability to produce that item quickly will determine the success of our response.

Other changes worthy of discussion may or may not suggest policy choices. For example, a reshoring strategy must be coupled to a digital manufacturing strategy, because our energy has to flow toward cultivating nimble and competitive manufacturing rather than protecting legacy facilities and methods. And additive manufacturing in particular should be embraced, because this could bring us a nationwide distributed manufacturing network that would be the most responsive manufacturing resource of all in a time of crisis. Let's explore this soon. Let's hope the chance to do so comes quickly.

For now, we look to manufacturing to help allow as many as possible to join us in that discussion. And we extend our gratitude toward the physicians and healthcare professionals who are working even harder than manufacturers, putting to good use all the tools manufacturing is able to provide.

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ERP Leads Top Shop to Paperless Initiative

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Derek Korn
EXECUTIVE EDITOR

Enterprise resource planning software is not only enabling Chapter 2 Inc. to better manage its range of capabilities, but also to help it go paperless.

Amanda Johnston, marketing specialist for Chapter 2 Inc., says the contract manufacturer has expanded and implemented a number of changes to become more efficient since it was named a Top Shops winner in 2015.

The Lake Mills, Wisconsin, company has a range of in-house manufacturing capabilities including CNC machining, welding, assembly and painting, as well as workholding device and tool-and-die manufacturing. In the last five years, it has added new capital equipment including turning centers, HMCs, a new side-down-draft paint booth, a urethane molding process and a coordinate measuring machine (CMM). It has also expanded its facility by 20,000 square feet, bringing total floor space to 100,000 square feet.

The shop also has added a couple robots to create two cells producing flywheels for small engines. Each cell features two CNC lathes. This enables one person to tend two machines, whereas before adding the robots, one person for each of the four machines was required. The cells increase throughput and also eliminate the repetitive motions formerly required of these employees to maneuver 20-pound workpieces by hand.

Chapter 2 has also made significant changes on the software side of things. It moved away from basic accounting software to an enterprise resource planning (ERP) system in 2016. The issue with the accounting software was that it lacked the work order and shopfloor control capabilities the company felt it needed. That software worked fine for inventory management but had no job tracking capabilities. Plus, one part number could have a variety of spreadsheets tied to it. All this was exacerbated by the fact that »

ERP is especially helpful for tracking jobs at Chapter 2, given that the shop has so many different manufacturing departments jobs might run through. Here is the shop's paint department.

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the shop had so many different manufacturing departments through which a job might run.

With the ERP system, all job information is tracked in one place, and the shop can easily see the status of every job on the shop floor. "It also has eliminated a lot of paper use, as employees used to hand in a printed timecard at the end of the day where they listed what jobs they ran, how many parts were produced, run time and so on," Ms. Johnston says. "Now, the ERP system captures all the information for us when employees log in to a job within the system."

With ERP, all job information is tracked in one place, and the shop can easily see the status of every job on the shop floor.

Chapter 2 has also developed its own computer application that has further reduced its reliance on paper documentation. "Previously, we printed hard copies of all work instructions and inspection logs that employees then filled out by hand at the end of their shift," she explains. "Those logs were then filed in cabinets and stored. Today, employees use our app, and all that information is stored in a database."

The first job for which Chapter 2 implemented this paperless process was the flywheel part mentioned above, which required many inspection logs. The process is also helpful when employees' time is split between multiple jobs, because it can track true labor cost for each. In addition, it is a customer service tool. For example, if a customer were to call asking for immediate delivery of parts for a given job, a manager could see how many parts have been completed and can be delivered, then provide a good estimation of delivery time for the remaining parts.

This aligns with Top Shops benchmarking results over the survey's 10 editions. Successful shops are more likely to have an ERP system than lower-performing shops. And those that participated in this year's survey, our 10th edition, should be getting their custom reports soon.

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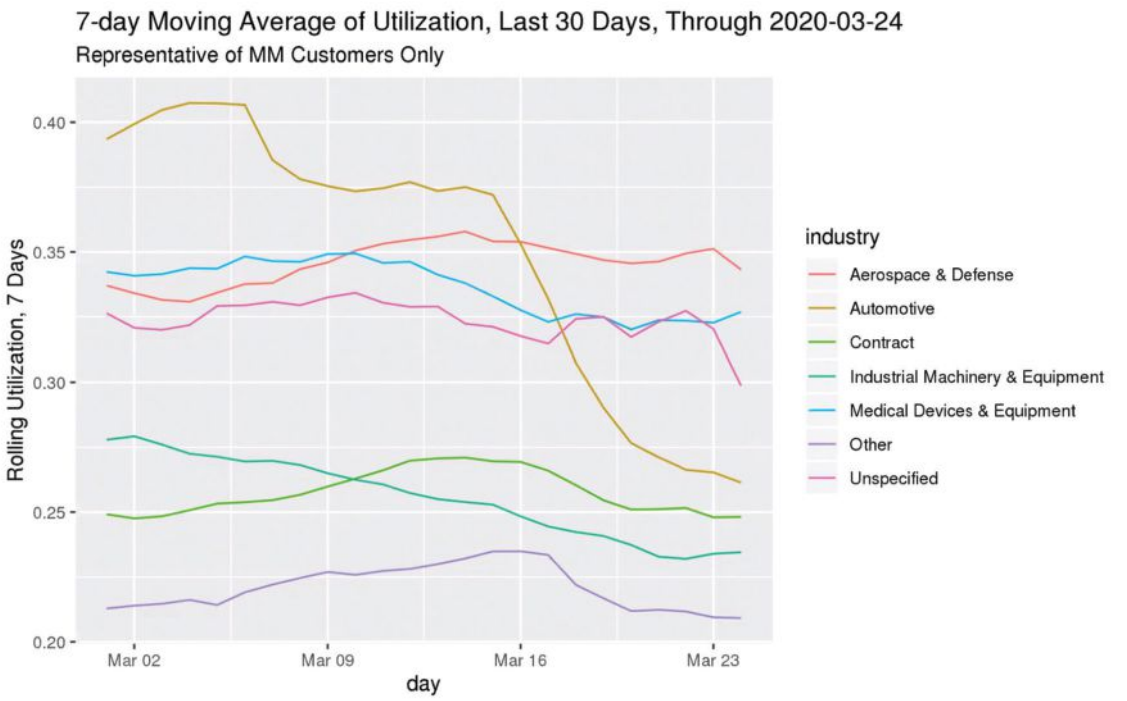
I'm writing this column a week after attending a March 25 webinar about the effects of the coronavirus on the manufacturing industry. Although the presented data will be out of date by the time this is published, the pandemic was not the point, at least not for me. The broader takeaway was the potentially vast power of widely shared machine utilization data for improving business planning and benchmarking, whatever the economic situation.

The power of this dataset is that it is available in real time, in this case through webinar host MachineMetrics' multi-tenant cloud platform. Taken from thousands of machines in every sector of the industry, the anonymous, aggregated data often reveals trends and insights prior to leading economic indicators such as industrial production and the Purchasing Managers' Index (PMI), says company co-founder Bill Bither.

He went on to show graphs of utilization and downtime data illustrating steep declines in the automotive industry after the "Big 3" automakers shut down only days before. "We have the real-time element — the pulse of manufacturing," he said.

Quarantined at home, my first reaction was that anyone could see things are changing, and that the pandemic's grip on the economy has only begun to tighten. Other insights are still coming »



A snapshot of utilization data on March 25, by which point the automotive sector had declined steeply.

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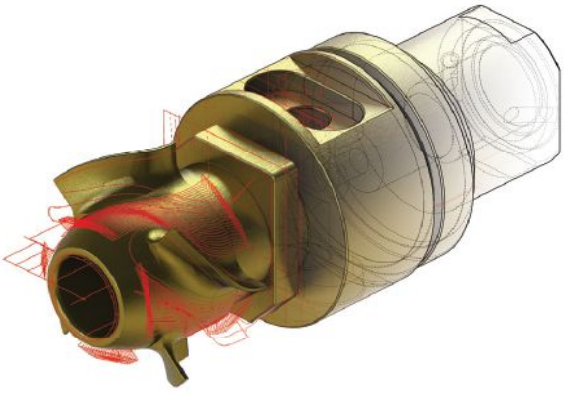

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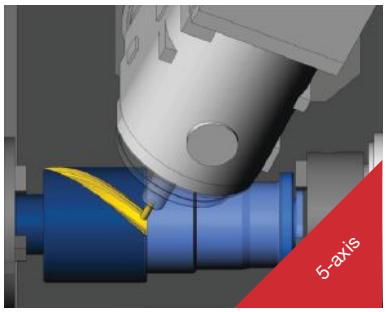

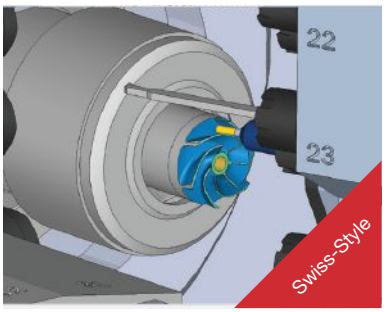

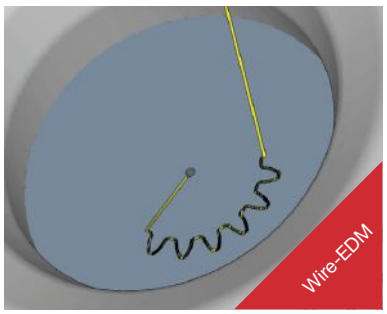

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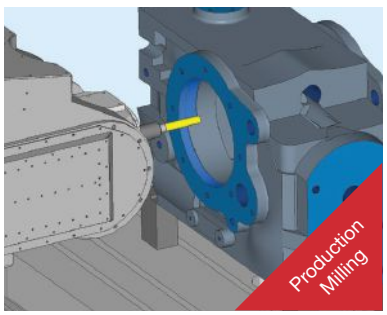

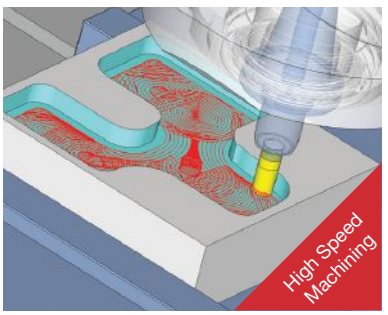

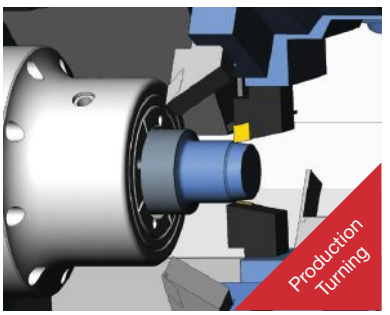

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into focus. For instance, during a phone conversation a week after the webinar (which was the first in a planned series of presentations on the impact of the virus), Mr. Bither speculated that an uptick in automotive utilization might be a result of manufacturers retooling for medical supplies. Pandemics aside, less obvious correlations and trends that might guide manufacturers' planning are likely to show up here first.

Perhaps more importantly, revealing broad economic trends is only a beneficial byproduct of the company's data collection. "The real benefit for the machine shop is how this data correlates to their own operations," Mr. Bither said.

For instance, MachineMetrics' regular reports reveal that having a "case of the Mondays" is a very real phenomenon. The aggregate data show that, in general, machine utilization tends to be lowest on that day before peaking by Wednesday and dropping again into the weekend. This can also be narrowed to hours of the day, and extrapolated to the entire calendar year. In one case, proving a gut instinct with real data led one MachineMetrics customer to eliminate Columbus day and extend the Christmas holiday instead.

Finding surprises in the data is even more valuable, Mr. Bither said, pointing out that shops' actual average machine utilization, which is generally around 25%, pales in comparison to the 60% or greater that most users assume prior to implementing company's machine monitoring system. Where does a shop stand in relation to other businesses in machine utilization as a whole, or, more specifically, time lost to changeovers? Which machine types experience more downtime on average, and why is that? Are shops in the Northeast experiencing higher utilization rates than those in other regions? MachineMetrics aims to make such insights available at any time to everyone via regular "State of the Industry" reports published online, Mr. Bither said.

These reports would not be possible without the system's users, all of which must opt in. Beyond being willing to share data, they are obviously comfortable with machine monitoring generally, as well as cloud computing and, if that is any indication, other tools of data-driven manufacturing. Data democratization, and the benefits all stand to share, begins with individual shops understanding that in many ways, they're all in it together.

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There's No Way Around Auditing Your Shop Improvements

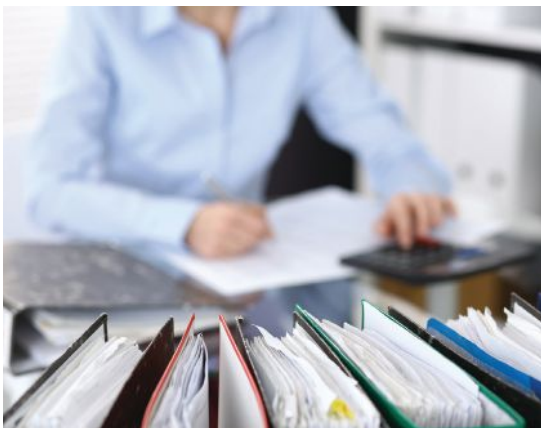
Here are a few practical approaches for auditing your manufacturing initiatives.

WAYNE S. CHANESKI | COLUMNIST

Often, companies do some pretty impressive things that make their operations better. Unfortunately, in too many situations, these impressive initiatives fade out. The improvements start to wither and the gains eventually disappear. It happens in more cases than we'd like to admit. Why?

We can point to many possible reasons, such as changing priorities, excessive effort required to sustain improvements, limited resource availability and more. Yet what is at the heart of these failures is often a lack of follow-up or willingness to audit the changes made.

Unfortunately, the word "audit" conjures up visions of extensive reviews and multi-page reports that put everyone on edge. But audits do not have to be overly complicated; they are simply a comparison between what is supposed to be happening and what is actually happening. The audit can be as easy as reviewing a key process metric and comparing actual results to planned results. If the comparison is favorable, that can be the end of the audit. If the comparison is not favorable, then action needs to be taken — but that is a good thing if you are truly committed to continuous improvement.



Auditing a manufacturing initiative is as simple as comparing the results at the time of implementation with current results.

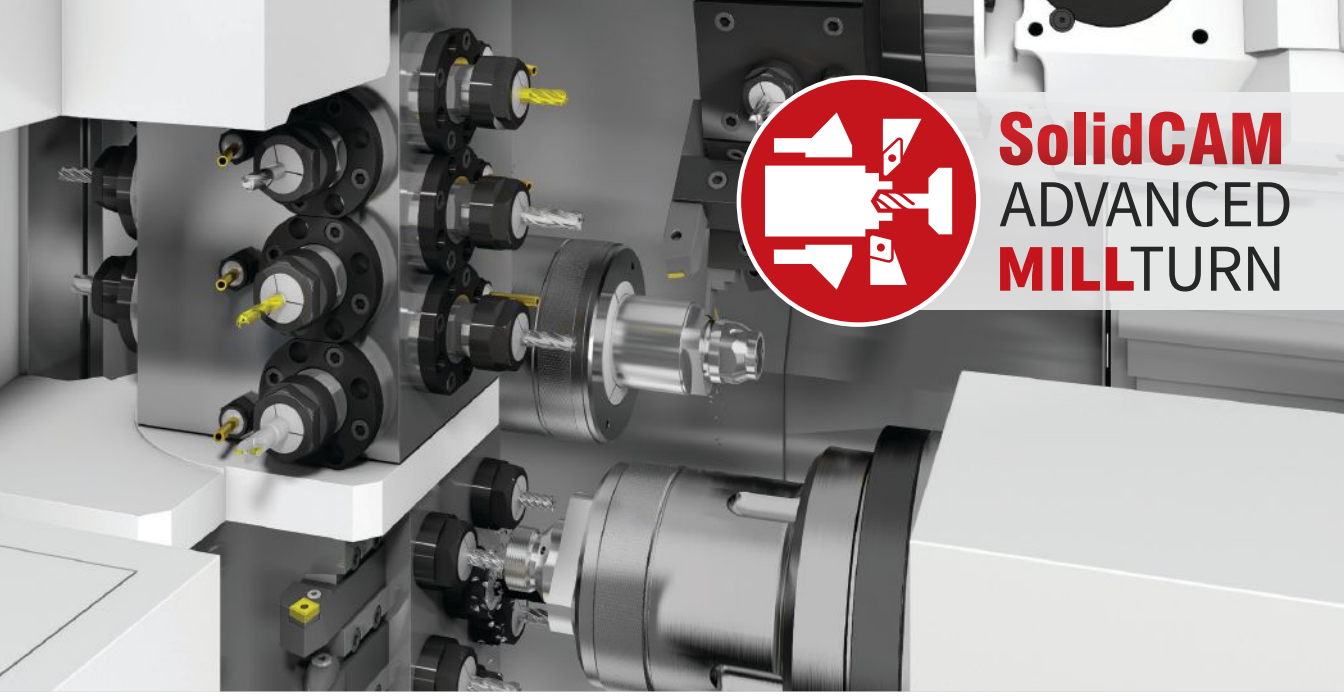
Here are some ideas for auditing your process improvements in three areas of the business:

Auditing Workplace Organization

If you have invested time in improving the organization of a specific workplace, you want to be sure the organization is sustained (one of the elements of the 5S system of workplace organization). An audit should consist of a comparison of the workplace condition currently to the condition achieved immediately after the improvement was made. This comparison can be done using posted photographs of the well-organized condition; a numerical score on a list of organization-related questions (for example, "Are all tools stored in properly identified locations after use?"); or even a brief observation of workers in the area to see how much time they spend searching or waiting for what they need. Any of these auditing techniques can be completed pretty quickly and provide an indication of whether the workplace organization effort made things permanently better.

Auditing Production

Among the most obvious ways of auditing an improvement is with a performance tracking metric. If time-per-workpiece data was available for the former process, then it's just a matter of comparing this to the time per workpiece for the current process. Color coding (green = good, red = bad) can provide an effective visual for this comparison, as can charts (up = good, down = bad). The idea is to be able to determine on a regular basis the effectiveness of the new process at a glance. In the event these results are not as »



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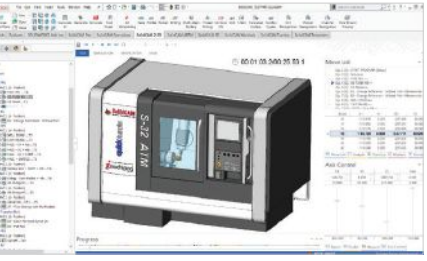

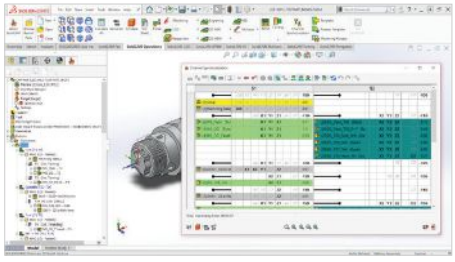

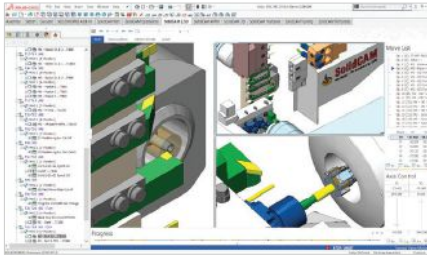

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expected, the first thing to do is to verify that the new process is being followed. Too often, we find the reason for not achieving expected results is not that the new approach is bad, but that it is not being followed as planned.

At the heart of failures in operations improvements is often a lack of follow-up or willingness to audit the changes made.

Auditing Administrative Throughput

If you have taken steps to improve any type of administrative process, such as order entry, accounts receivable, purchase order processing, customer returns and so on, you will want to know if the throughput time (overall time from receipt to completion) has been reduced. The easiest way to audit such a process is through a review of inputs, outputs and backlogs. In very simple terms, inputs – outputs = backlog. An improved process should reduce the average backlog over time, barring unforeseen spikes in inputs. Therefore, the major focus for an audit is the backlog number, whether it be customer orders received but yet not entered; open orders or dollars to be collected from customers; purchase orders to be placed with vendors; or customer returns received but not yet processed.

An accurate accounting of a backlog requires a means of knowing what was received and what was processed. Whereas any ERP system can capture what was processed as this is "seen" by the system, calculating what was received may require a little effort to count what came in each day. Once input is captured, the point-in-time backlog is a simple calculation. Unusual spikes or dips in the backlog may warrant further investigation, but for the most part, a regular audit of the backlog should provide sufficient information about whether an improved process really is better.

Your willingness to audit the improvements made in your organization is a great indicator for how those improvements will stick long term.

AUTHOR | Wayne S. Chaneski
President, Smart Manufacturing Solutions

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Cord Cutting and Code Reading Make Gaging Smarter

Many companies have "cut the cord" to streamline metrology operations and data management. Barcode scanning is an additional option.

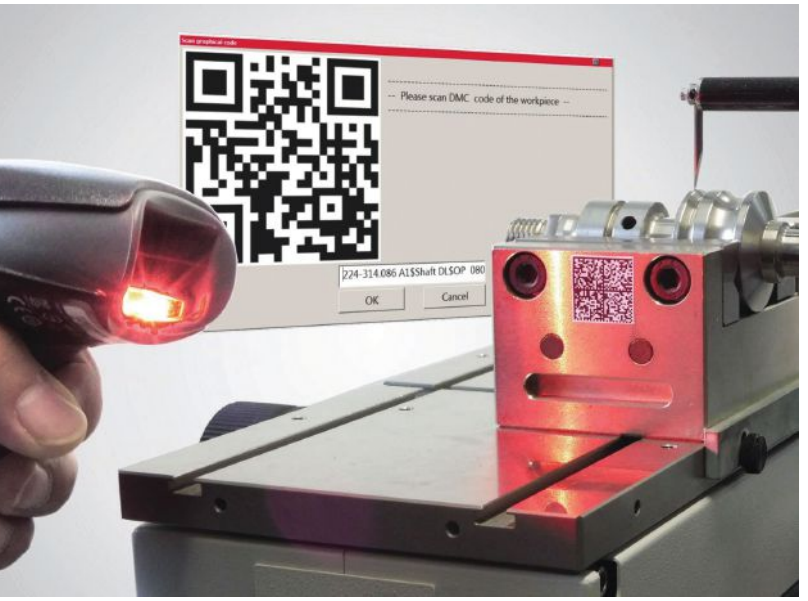
GEORGE SCHUETZ | COLUMNIST

Over the last few years, many companies have "cut the cord" by adding integrated wireless data transmission to their digital gaging. This eliminates the cable nest, frees users to move gages around the shop and ensures accurate data collection. The goal is to enable the user to seamlessly collect accurate data and make good decisions about the quality of the part and the process. When the data is sent to a file locally, on the network or up to a cloud server somewhere, it can be made available to anyone who needs it. This provides useful information and is helpful once the gaging tools are running.

But what about the front end, before the gage is set up and ready for the user to start measuring parts? Most gaging systems today are computer-based, capable of flexible gaging routines. Often the gage is relatively universal and can perform many measurement functions — it just has to be told what to do. Instructions could be as simple as what tolerances to use for the part measurement or as complex as what parameter and sequence to use when measuring the new shaft coming down the line. With data storage in the cloud, a gaging routine could be created for a machine in a facility on the opposite side of the world and used in a different plant with the same machines and measuring equipment.

Another idea for streamlining measurement functions is to enter or start measuring programs with a laser scanner. Surprisingly, you don't even need PC-based gaging systems to do this. Bench-style amplifiers are available that can interface with a barcode scanner and read text from a scan code. Imagine a worksheet that accompanies the next batch of parts to be gaged. Rather than sitting down with the electronic column gage or bench amplifier and manually entering the next set of tolerances, the operator could scan the process card that contains all the gage setup parameters and, within a second, the gage would be ready to start measuring the new part. The result is significant time savings and reduced errors.

With more complex measuring systems that can be programmed »



Using barcodes and scanners to send setup parameters to the gage can result in significant time savings and fewer errors.

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to a virtually endless number of dimensions and parameters, entering a new part program or searching through a list of hundreds of parts can be a time-consuming process. Again, with the aid of a handheld scanner, measuring programs can be started easily and conveniently by scanning the DMC code. In addition, the information contained in the code can be used for logging or exporting data. Importing component information digitally eliminates errors in the log and export data because the operator simply scans the component's data, and the associated measuring program is simultaneously started.

Once the scanner is available and the part program is ready to go, this is the best time to start logging the measured data against the specific part being measured. A scan code on the part can be read as the part is being measured so that every measurement on that part is tied to the data being stored — not only to measure and qualify its good or bad condition, but to document the part being measured, the operator, the time and the machine that was used to measure the part. Even the machine's calibration data can be tied to this data file, ensuring that this information is available long after the part has been shipped.

Scanning a barcode can save operators time they would otherwise spend checking data requirements, deciding on a measuring program, choosing which features to check and figuring out associated tolerances.

Allowing the measuring system to read the data saves operators time they would otherwise spend checking data requirements and deciding what measuring program to use for a particular component, what features need to be checked, and associated tolerances. This allows the machine operator to optimize time and workflow. Using the scanner instead of manual data entry can improve the entire process.

AUTHOR | George Schuetz
Director of Precision Gages, Mahr Inc.

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6 Steps To Take Before Creating a CNC Program

Any time saved by skipping preparation for programming can be easily lost when the program makes it to the machine. Follow these steps to ensure success.

MIKE LYNCH | COLUMNIST

The success of a CNC program is a direct result of the preparation done prior to its creation. While an ill-prepared programmer may be able to create workable programs, such programs will often be prone to error, inefficient, unfriendly to the user or difficult to verify. Any time saved by skipping preparation steps can be easily lost when the job arrives at a CNC machine.

Here are six planning steps to complete before producing a new program.

Step 1: Determine the machining operations to be performed.

For simple workpieces, required machining operations may be easy to ascertain. But as complexity increases, so does the difficulty in isolating everything that must be done during a given operation. A company's routing sheet, which commonly gives generic instructions like "complete all milling and hole machining," is unhelpful. It is left to the programmer to find all surfaces that must be machined. This is no easy task when complex drawings have multiple views distributed among several pages.

AN OUNCE OF PREPARATION

Implementing data-driven manufacturing is an exercise in preparing your shop to take advantage of whatever comes next: gbm.media/dm1.

One way to identify machined surfaces is to use colored pens and mark up a working copy of the engineering drawing. Another is to create a list of machined surfaces and the related cutting tools. Either technique will keep you from omitting something when it comes time to create the program.

Step 2: Decide the machining order.

The order of machining operations is of the utmost importance. One general rule of thumb is to rough everything before finishing anything. If this rule is broken, it may be impossible to consistently produce acceptable workpieces. It is easy to forget something in a complex process.

I recommend using a sequence of operations planning form. Headings for this form can include:

- Step number
- Operation description
- Cutting tool name (with cutting tool components listed separately)
- Cutting tool station number
- Spindle speed
- Feed rate
- Notes/issues for the step

A completed form becomes the written version of your program. Anyone seeing it in the future will know exactly what the program is doing. If you question whether your chosen process will work, you can share it with others in your company for confirmation. Use it as a checklist while developing your program to keep from forgetting something.

Step 3: Do the math.

The idea here is to avoid breaking your train of thought while programming to perform a calculation. During manual programming, you must calculate coordinates needed for the program. There will also be cutting conditions (speeds and feeds) to calculate, even if using a CAM system. Coordinates can be documented separately or written on your working copy of the engineering drawing. Speeds and feeds can be documented on the previously mentioned planning form as well.

Step 4: Consider the workholding device.

There may be things about the workholding device that affect how you create the CNC program. Examples include the orientation of a fixture »

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on a table, clamps that must be avoided, location surfaces and jaw configuration for three-jaw chucks. Only with a clear understanding of how the workpiece will be held in the setup can you create an acceptable CNC program.

Step 5: Consider the cutting tools.

Cutting conditions are directly related to the cutting tools you'll be using and, as mentioned, should be documented on the planning form. There may also be rigidity or clearance issues. If you know a milling cutter will be performing powerful roughing operations, it must be kept as short as possible. Conversely, a drill may have to reach deep into a casting to get to a surface into which a hole must be machined. Notes included on your planning form can highlight any special considerations you should remember when programming and when providing setup instructions.

At some point, you must come up with a list of components that make up each cutting tool. This information will be included in setup documentation. Doing this before programming may expose an issue that affects what the program must do.

Step 6: Write the documentation.

Develop setup and production run documentation as if the CNC program has already been created. Thinking through what setup people and operators must do when they run the job may expose something that you can do in the program to help them. Will the workholding setup be qualified? If so, can you include G10 commands in the program to retain/enter program zero assigning values in fixture offsets? Will trial machining be necessary? If so, could a probe be used to automate the process? Developing documentation in advance could help answer these questions for employees.

While these preparation steps take time, skipping them can be reckless and wasteful, especially when you consider the machine (down)time that will be required to correct issues that should have been handled during the preparation stage. There is no excuse for wasting machine time for something as basic as not being truly ready to create the program in the first place.

AUTHOR | Mike Lynch
Founder and President, CNC Concepts Inc.

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Additive Manufacturing in the Age of COVID-19

From the front lines of the fight against the coronavirus, here's how my journey began.

TIMOTHY SIMPSON | COLUMNIST

Like many around the world, my life, work and travel plans were upended as the coronavirus made its way to the United States. All of Penn State's classes were told to move online, and I had a weekend to figure out how I was going to teach the undergraduates in my additive manufacturing (AM) and reverse engineering course how to operate 3D printers and gain hands-on experience with 3D scanning.

Like many other faculty and teachers facing similar situations, I started searching online for new ideas and materials for my course. As I was reconnecting with folks on LinkedIn, I started seeing posts from my connections around the world who were already battling the coronavirus. First on this list was probably the duo in Italy who saved lives by redesigning and 3D printing replacement parts for ventilators in their local hospital. Around the same time, Materialise started sharing its 3D printed hands-free door opener, which circulated quickly on Twitter and other social media. Its design soon found its way to HP's newly launched 3D printing website to help with COVID-19 as the company was collecting cool ideas to help nurses, doctors and other healthcare workers on the front lines. Meanwhile, the team from Prusa in Prague released the 3D printed face shield design that they had quickly developed and prototyped.

Figure 1: Zachery Smith in Penn State's Applied Research Laboratory (ARL) wears a prototype of the Prusa 3D printed face shield.

Photo: Charlie Tricou, ARL

By the time I stumbled on the 3D printed foot pedal door opener from Professor Olaf Diegel and his students at the University of Auckland, I knew it was time to redirect my class project and challenge the students in my AM class to design, develop and prototype their own ideas to help contain the spread of the coronavirus. Having my students make and test a bunch of random 3D printed parts on some material extrusion systems in an AM lab to quantify variability just did not seem important anymore — plus they could no longer access the AM lab anyway. Luckily, a lot of engineering students have their own 3D printers on hand these days; so, my immediate project and lab challenges were solved, and I migrated my lectures online with little hassle.

Figure 2: Matt Parkinson, a faculty member at Penn State, shows off the "Billings" filtration mask that he 3D printed for testing.

Photo: Matt Parkinson, Penn State

Meanwhile, as I read these articles and online posts for my class, I started sharing them with friends and colleagues in our 3D printing network across Penn State University, Penn State's Applied Research Laboratory (ARL), and local companies and industry partners. At the same time, I also reconnected with colleagues at Penn State' College of Medicine at the Hershey Medical Center, »

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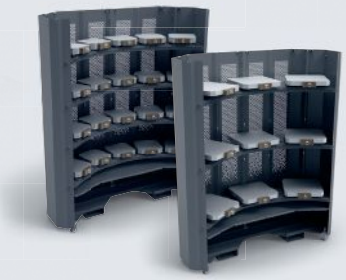

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knowing that they were likely preparing for the onslaught that was coming. Within a day, hundreds of emails started flying around, numerous new connections were formed, and some semblance of priorities were established. Within two days, the team at the ARL had 3D printed, laser cut, and fabricated the Prusa face shield (see Figure 1). The team at Penn State's Hershey Medical Center loved the effort and the result, and we quickly started identifying other areas where AM could help.

Ventilators, filtration masks, and other personal protective equipment (PPE) immediately joined the list. We then 3D printed and tested the filtration mask (see Figure 2) that was posted online by the group in Billings, Montana.

The feedback from the doctors at Penn State's Hershey Medical Center, which tested our 3D printed filtration masks, has since led to modifications to improve comfort and fit while reducing printing time. This rapid feedback was only made possible through AM, but we all quickly realized that the demand was going to outstrip the supply — and that was just for one hospital. After joking that we would need to fill Penn State's Beaver stadium with 3D printers in order to meet the demand that was being projected, we pivoted and started redesigning the 3D printed face shields, filtration masks and other PPE for fabrication with more traditional methods (for example, injection molding, vacuum forming). These methods could be performed within an ISO-certified, GMP-compliant facility to help meet FDA regulations, and the resulting PPE could be more easily sterilized.

AM is great, but you can imagine all of the nooks and crannies that a virus could hide in on a 3D printed object. Worse, many of the sterilization protocols that were being proposed for decontaminating PPE for reuse (such as heating to a high temperature in an oven) would melt and deform many of the polymers people were using on their 3D printers. So, like many, we are now building out a network of companies that can help us meet industry standards and comply with FDA regulations. The fight has only begun, and we hope we are not too late.

AUTHOR | Timothy Simpson

Professor of Engineering Design & Manufacturing
Pennsylvania State University

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How To Practice Stage Two Thinking in Your Machine Shop

Responsible decision-making requires thinking beyond the initial benefits to consider how a change ripples throughout the machine shop's operations and culture.

JESSE SCHELITZCHE | CONTRIBUTOR

In "Applied Economics: Thinking Beyond Stage One," the economist Thomas Sowell argues that "stage one thinking" is when a decision-maker considers only the immediate result of an action without determining what happens next.

On the shop floor, stage one thinking could encompass hiring decisions, capital equipment purchases or strategic initiatives. Here are five areas in which I personally failed to look past stage one when I decided to purchase a machine shop, and what stage two thinking would've involved in each scenario.

Existing Customer Base

Stage One Thinking: Since I was familiar with the current customer base, I made some basic assumptions regarding the shop's current workload. I thought the business had strong customer relationships, steady business and consistently profitable work.

Stage Two Thinking: If I had peeled the onion back one more layer, what would I have found? What market segments were these customers in? Were there long-term growth opportunities, or were these flash-in-the-pan moments we were taking advantage of? What was our average customer size? Was I working for large corporations with deep pockets and more work than I could provide, or was our customer base smaller, niche products that could rarely keep my machines busy?

When looking at a customer network, be sure to ask what customers fit the business best.

Workforce

Stage One Thinking: The business had several long-term employees and high retention rates, and most employees seemed happy with their jobs. There was a mix of older talent with the wisdom to train the younger employees.

Stage Two Thinking: Why were there so many long-term employees? Did they truly love their jobs, or had there been a lack of management that led to employee complacency? Were company policies and an employee handbook in place? Were all employees aware of them? Were company rules and expectations enforced when need be? What were the accepted norms at this company that might not be tolerated elsewhere?

When I purchased the business, I was impressed by several of the long-term employees, a few of them having been with the shop over 20 years. I also realized that one of them should have been let go 20 years ago.

Equipment

Stage One Thinking: Yes, there were several aged pieces of equipment, but they did their job dependably and held tolerance. Our newer equipment kept the shop competitive and added to its capabilities. The company was using the current equipment to deliver quality products to customer specs.

Stage Two Thinking: How did changing technology affect our current equipment? How did the equipment handle our current mix of work? What maintenance should I expect in the coming years? Did I have the ability to grow with my current customer base with the same equipment? What impression did our shop floor give customers?

In the ever-changing technology landscape, it is more important than ever to understand how your shop might look in five or 10 years. Understand what investments may be necessary to stay competitive. »

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Process/Organization

Stage One Thinking: The business had an ERP system in place with good shopfloor organization and sound flow and execution from start to finish.

Stage Two Thinking: Was the ERP system being used to its full capabilities? What company metrics were being tracked, and was the information accurate? What was the continuous improvement history and culture within the business? Were there constant fires to put out or was there a drive for improvement?

When evaluating the processes and organization of your shop or potential purchase, it's critical to understand what you are inheriting.

Technology

Stage One Thinking: The company was functioning as it should with limited internal issues. The business had a general understanding of how technology benefits the company.

Stage Two Thinking: How was the company using existing technology to improve or grow? What opportunities were visible that could streamline process or replace unnecessary labor? What investments were needed to get the most from the technology available?

Technology has improved or replaced what previously required hours of labor. How can the business offer the most to your employees while staying productive and profitable?

Taking the Next Step

The first step is to get a 10,000-foot view of the company. Identify areas that function and flow well, then areas that need upgrades and attention. Next, do some stage two thinking within each area that needs improvement. Diagnose the most pressing issues and produce an action plan.

ABOUT THE CONTRIBUTOR

Jesse Schelitzche is the owner of Imagineering Machine Inc. in Minneapolis, Minnesota. In addition to focusing on high-mix/low-volume machining in the medical device, aerospace and semiconductor markets, he also serves on the board of the Minnesota Precision Manufacturing Association (MPMA).

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Rick Kline Jr. is a fourth-generation co-owner of Gardner Business Media, which publishes *Modern Machine Shop*. He argues in a *Wall Street Journal* op-ed that manufacturing is rising to the challenge of the coronavirus pandemic.

Gardner Business Media President Featured in *Wall Street Journal*

An opinion piece by Gardner Business Media President Rick Kline Jr. was featured by the *Wall Street Journal* in March. The op-ed argues that American manufacturers are rallying to produce vital equipment to aid in efforts to respond to the coronavirus pandemic.

Mr. Kline is a fourth-generation co-owner of Gardner Business Media, which publishes *Modern Machine Shop*.

The appearance of the op-ed marks the *Wall Street Journal*'s recognition that the coronavirus crisis brings attention to, among other things, U.S. manufacturing. The opinion piece claims that manufacturers are creatively rising to the challenge of meeting emergency production needs. It also criticizes government intervention on the matter. Mr. Kline draws on examples from Gardner brands like *Additive Manufacturing*, *AutoBeat*, *Plastics Technology* and *MoldMaking Technology* to tell stories illustrating his point.

"American manufacturing is nimble and strong," says Mr. Kline. "An event »

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- Head ram travel: 18½" (front to back)
- Head tilt: 90° left & right, 45° front & back
- Turret/column swivel: 360 degrees left/right
- Max. distance spindle to table: 19¼"
- Table travel (longitudinal): 30"
- Table travel (cross): 14"
- Table travel (vertical): 15"
- Table size: 10" x 50" x 4⅛"
- Base footprint: 48" x 33"
- Spindle speed: Variable, 60-4200 RPM
- Approximate shipping weight: 3021 lbs.

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- Motor RPM: 1725
- Power transfer: Cogged belt
- Spindle taper: R-8
- Spindle travel: 5"
- Table size: 9" x 48"
- Table travel (longitudinal): 29"
- Table travel (cross): 12"
- Knee travel (vertical): 16"
- Tram travel: 13"
- Head swivel: 90° left & right
- T-slots: 3 on 2½" centers, ⅝" wide
- Ram swivel: 360°
- Max. dist. spindle to table: 18"
- Spindle speeds: Variable
- Range of speeds: 60–5000 RPM
- Table size: 10" x 50" x 4⅛"
- Base footprint: 26" x 24"
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- Horizontal spindle motor: 2 HP, 220V, single-phase
- Spindle taper: R-8
- Spindle travel: 5"
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- Vertical spindle speeds: variable, 100–2000 RPM
- Horizontal spindle speeds: 8, 72–1300 RPM
- Approximate shipping weight: 2050 lb.

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- Swing over saddle: 12"
- Spindle bore: 3⅛"
- Spindle nose taper: MT#7
- Spindle nose: D1-8 camlock
- Cross slide travel: 12¾"
- Spindle speeds: 12, 25–1600 RPM
- Bed width: 13¾"
- Range of threads (metric): 47 @ 0.2–14 mm
- Approximate shipping weight: 5758 lbs.

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- Motor: 10 HP 3-phase
- Swing: 22-1/2"
- Distance between centers: 59-1/16"
- Spindle bore: 3.125"
- Spindle type: D1-8 Camlock
- Speeds: 25 - 1600 RPM
- Tailstock taper: MT#5
- Tailstock barrel travel: 7"
- Shipping weight: 5930 lbs.

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like the coronavirus is putting the industry to the test, but the solidarity and ingenuity of our nation's makers is still shining through."

Mr. Kline's op-ed argues that the next step will have to be consolidating the lessons from the pandemic in order to ensure that U.S. manufacturing is prepared to respond to the next crisis that comes.

Readers can find the full article at gbm.media/mfg.

Additive Manufacturer Green Trade Association Hires Executive Director

The Additive Manufacturer Green Trade Association (AMGTA), a new green trade group created to promote additive manufacturing, has hired Sherry Handel as its first executive director.

The AMGTA was launched in November 2019 to promote the environmental benefits of additive manufacturing (AM) over traditional methods of manufacturing. The AMGTA is a non-commercial, unaffiliated organization open to any additive manufacturer or industry stakeholder that meets certain criteria relating to sustainability of production or process.

"We founded the AMGTA because too often in additive manufacturing we focus on the cost and time benefits of the technology, and do not equally consider the very real environmental benefits of AM over traditional manufacturing. These benefits include improved end use design utility and improved industrial ecology of the fabrication process itself. The AMGTA's purpose is to raise awareness of these benefits within end market segments in order to accelerate the adoption rate of the technology," says Brian Neff, chairman of the board of directors. "Sherry brings the talent, passion for sustainability, as well as the background and experience required to execute on AMGTA's mission and grow the organization. In her short time here, she has really hit the ground running."

Ms. Handel has board-level experience scaling nonprofits in the sustainability and tech startup education and training sectors. As executive »

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director of the AMGTA, she will focus on educating the public and the industry about the positive environmental benefits of additive manufacturing, promoting the adoption of additive manufacturing as an alternative to traditional manufacturing, developing best practices for additive manufacturing, and helping the organization's members grow their businesses and acquire new customers.

Additive Manufacturer Green Trade Association
amgta.org

Hexagon Offers Free Software Licenses for Manufacturing Personnel Working from Home

Hexagon's Manufacturing Intelligence division is offering a range of free offline licensing and remote access options designed to enable efficient home working for manufacturing professionals facing new productivity challenges during the coronavirus pandemic.

Home working options will be provided for Hexagon's production software and metrology software offerings, as well as the MSC Software range of computer-aided engineering (CAE) solutions, at least until June 30, 2020. Manufacturers running metrology equipment in factories can remotely monitor and analyze how key assets are performing for free with HxGN SFx | Asset Management. Users will also have access to additional online learning resources.

Details on how to access the home working packages can be found at hexagonmi.com/wahs. The offering includes:

- Extension of licenses for work-from-home support or alternative access options for MSC Software CAE solutions
- License move, remote access or additional temporary home office licenses for Hexagon's CAD/CAM software
- Free offline licenses of the latest versions of PC-DMIS and other metrology software
- Free remote machine monitoring via the HxGN SFx | Asset Management asset performance management solution
- Free access to online learning for Hexagon's metrology and MSC Software solutions

"The purpose of our smart manufacturing solutions is to improve quality and productivity, and this challenge is especially acute during this time of extensive home working," says Paolo Guglielmini, president of Hexagon's Manufacturing Intelligence division. "So, to support the industries we serve, we're offering special access to our »

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software and learning tools for both current customers and non-customers who can benefit from our technology."

"Like many businesses in the manufacturing sector, we have many employees working from home at the moment and we appreciate that giving them the right tools to work remotely is essential to their well-being and success," he adds.

Hexagon Manufacturing Intelligence
800-283-3600 | tesatechnology.com

Exsys Tool Celebrates 25th Anniversary

Exsys Tool Inc., the exclusive importer of Eppinger toolholders, adapters and specialty products, is celebrating its 25th anniversary in June 2020.

Originally a play on the phrase "expert systems," Exsys was established by President and CEO Stewart Bachmann and Craig Campbell, who served as vice president of sales until 1998. However, it began as a business run by Stewart Bachmann's father, who had served as a director of manufacturing planning and had experience with the production of special tooling.

"My father started his business out of our house in California, with boxes of toolholders stacked up on the washing machine," recalls Mr. Bachmann. "But he did some significant volumes with that infrastructure and his knowledge of working with Eppinger to develop specialized manufacturing solutions. So when Craig and I moved out to the Eastern time zone to start our branch of Exsys, I used what I learned from him to push our sales and applications expertise even further."

Initially, this new branch focused on the sale of axial and radial toolholders, products the company has refined and optimized over the years. The company increased its capacity year after year, eventually forming an exclusive distribution partnership with Eppinger. Today, in addition to its current headquarters in San Antonio, Florida, the company has Canadian and Mexican distribution centers in Ontario »

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and Monterrey, respectively, as well as factory representatives in Colombia, Costa Rica, Peru and Chile.

"We've been successful for 25 years for two reasons," says Mr. Bachmann. "First, I've always insisted that our telephone is answered by a real person within three rings. Second, we always answer our phone, and we treat every call seriously, whether it's an order for $30 or $30,000. "

Exsys Tool Inc. | 800-397-9748 | exsys-tool.com

Comau, Exechon Collaborate on Machining Center Design

Comau, a manufacturer of advanced industrial automation products, is partnering with Exechon, a developer of technology for parallel kinematic machine solutions, to design and produce a new Comau machining center. The machine will be able to handle lightweight framing and structural components for multiple sectors, with a particular focus on automotive, aerospace and electrification. Comau says that the move is in response to the expanding use of lightweight components that reduce fuel consumption and CO_2 emissions; the growing importance of electrification for automotive manufacturers; and the increasing degree of production complexity within the aerospace sector.

"The importance of this project extends through to Comau's ability to offer a 360-degree service connected to electrification, with new lightweight machining centers as a central link," says Luca Ferrero, COO of Comau Machining. "Coupling a lightweight approach in machining with our body assembly competencies and battery assembly knowhow, we can now complete the value chain and deliver advanced solutions for battery case machining and more."

"It has been an amazing year, as Comau and Exechon have jointly engaged in the extremely fast transition from conventional cars and planes to electrical and lightweight design," says, Karl Erik Neumann, CEO of Exechon. "We've shown how combining »

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Precision Cutting Technologies Acquires Supermill LLC

Precision Cutting Technologies Inc., holding company of Bourn & Koch, has acquired Supermill LLC, a Connecticut manufacturer of high-performance carbide end mills.

"We are excited to partner with Tom Hale, founder and president of Supermill, as well as his talented and experienced team of associates," says Terry Derrico, president of Precision Cutting Technologies. "The acquisition of Supermill enhances Precision Cutting Technologies' portfolio of cutting consumables and strengthens its position in the Northeastern United States. As in our past acquisitions and reflective of our strategic partnership approach, Tom will continue to lead the company post-transaction, and Supermill's day-to-day operations will not be impacted. »

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However, we believe that Supermill will now be able to take advantage of the infrastructure and national sales reach of the Precision Cutting Technologies platform."

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MTConnect Institute Trustees Elected to National Academy of Engineering

MTConnect Institute board of trustee members Dr. Stephan Biller and Dr. Tom Kurfess have been elected to the National Academy of Engineering (NAE) in recognition of professional excellence in engineering. Members of NAE are elected by their peers for outstanding contributions to research, practice, education, technology, advances in engineering, innovative approaches to engineering and leadership.

"The harmonization of standards is a critical step in the advancement of IoT in the manufacturing industry," says Tim Shinbara, MTConnect Institute board officer.

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MAY 5, 2:00 P.M. ET

Metal 3D Printing for the Production Line - Using Binder Jetting

ExOne | gbm.media/exmet

MAY 12, 2:00 P.M. ET

Digital Machine Shop: Boost Your Productivity with High-Performance Milling

Siemens | gbm.media/siemdig

In light of the COVID-19 pandemic, we are doing our best to keep the event calendar updated with the latest information we have available. That said, you should confirm event plans with the organizer while the pandemic continues.

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The seventh annual Additive Manufacturing Conference + Expo will be located at IMTS this year. It focuses on industrial applications of additive technologies for making functional components and end-use production parts. This year's event will again offer a dynamic conference program covering processes, applications and materials the deliver practical knowledge on how to implement AM in your facility.

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cmsc.org/conference

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SEPTEMBER 14, 15, 17
MMS Top Shops Workshops @ IMTS 2020
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pmpa.org

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SPECIAL REPORT:

Machine Shops Race To Meet the Need for Ventilators

Ventilator production is underway. Machining suppliers have joined the effort to produce ventilators fast enough to save the lives of COVID-19 sufferers. Here are some of their stories.

BY THE EDITORS

The most important manufacturing story of 2020, perhaps the most important manufacturing story many of us will see for years to come, relates to ventilators. In the COVID-19 pandemic, the most serious sufferers from the virus need the aid of this respiratory device, leading to what is already proving to be an enormous shortage of the lifesaving machines.

In hopes of reducing the demand on medical resources, people around the world are isolating themselves to slow the illness's spread. Meanwhile, within the small window of delay provided by these stay-at-home measures, manufacturers are racing ahead. Tens of thousands of additional ventilators will be needed in the United States alone — a level of immediate demand far surpassing what ventilator makers can meet without assistance. So other manufactures have entered in. Major automakers, for example, have turned to ventilator production. And large and small companies across the manufacturing landscape are now working rapidly to produce ventilator components. The editors of *Modern Machine Shop* filed these reports of machining suppliers involved in the ventilator effort.

Team Thinking Helps Donson Machine with Nickel Alloy Ventilator Part Production

MARK ALBERT | EDITOR EMERITUS

The picture below might look ordinary: a bunch of guys standing around. Not so. The setting is the concrete apron to the high-bay loading area near the front entrance of Donson Machine, a contract manufacturer in Alsip, Illinois. The picture shows the company's management team considering its options to meet the urgent needs of its customers for ventilator components to respond to COVID-19. Normally, the group would huddle indoors, but meeting in fresh air to obtain as much distance as the group practically can was the appropriate alternative.

Leading the meeting are brothers Joe and Jim Bettinardi, president and CEO respectively (only Joe is visible, with his back to the rollup door). Donson Machine was a recent *MMS* Top Shops winner in the category of machining technology. Joe Bettinardi says the times right now reinforce an important point about technology and this shop's application of it:

"You can have the most flexible, capable and productive CNC machines on your shop floor, but you need a shop floor workforce with the flexibility, capability and productivity to match," he explains. Donson Machine was tasked with producing some of the most complex and critical ventilator components in a high-nickel alloy, a workpiece material familiar to the shop because it is frequently encountered in the medical equipment, orthopedics and food processing part production that is its specialty in normal times.

However, the ventilator components are just different enough from past work that the shop wanted to be sure it brought the best collective thinking to bear for ramping up production and deploying its most valuable asset, a cadre of skilled CNC programmers and machinists.

"We couldn't afford missteps or miss out on a workflow built on optimized machining strategies that maximized our capability for manufacturing complex parts in one path on a single machine," Mr. Bettinardi says. He also adds that his company is committed to keeping all of its employees as safe as possible, and the group discussed the best course of action in keeping with national health guidelines.

Although details about the ventilator parts are confidential, Mr. Bettinardi could share this much: "The parts we make for ventilators are mostly done on multi-axis equipment, so everything comes out complete. Hundreds of parts go into a ventilator, and we need to make sure we send perfect parts to our customer so that we never slow down another ventilator getting shipped to a hospital."

Mr. Bettinardi offered one more comment, which reflects his own company but probably many other American job shops too: "I always knew we had great employees, but what I have seen the last few weeks makes me so proud of the spirit of our team members. These are people of extremely high character. At least once a day, someone comes into my office and asks, 'What else can I do to help?'"

Company leaders discuss the shop's strategies for both efficient machining and employee safety in providing the urgently needed parts.
Photo: Donson Machine.

Aerospace Supplier Shifts to Tight-Tolerance Ventilator Parts: "We Weren't in This Business Two Weeks Ago"

EMILY PROBST | SENIOR EDITOR

"We're not doing this to make money, we're doing this to save lives," says Dodd Russell, CEO at Skilled Manufacturing Inc. (SMI), a Tier 1 aerospace and automotive supplier located in Traverse City, Michigan.

Mr. Russell got the call from one of his major automotive customers on a Saturday morning asking if his company could help churn out 6061T aluminum parts destined for ventilators. Within an hour, he had 12 of his aerospace employees at the plant, ready to make it happen. After looking at the 2D blueprints of four parts, they went to work on the easiest one first, producing a prototype by Saturday night for submission. By Sunday, they had made a prototype of the second part; and by Monday, they had prototyped the third and fourth parts.

"At that point, I didn't even have a purchase order. I told my customer that we would donate the parts if we were not chosen as a supplier. Luckily, our customer did choose us, but that's not why we did it," Mr. Russell says.

According to Mr. Russell, his entire supply chain has "really ponied up" to support the work. For instance, the general manager of SMI's aluminum supplier went in by himself Sunday morning to load the aluminum and deliver it to the plant. His tooling supplier sat in the parking lot calling suppliers Saturday night and was able to deliver tools by Sunday. There was a 72-hour turnaround time on all specials, Mr. Russell says.

"We weren't in this business two weeks ago, but this is what Americans do when stuff like this goes on," he says. "We didn't plan on this. In fact, we just laid off 150 people in our automotive division the night before we got the call. Now, the 150 people in our aerospace division are working to support our main customers. This is our new reality."

Mr. Russell commends job shops and certain other manufacturing facilities for wanting to do their part to make ventilators, but he can't sugar-coat the reality that there is a certain baseline of tolerance requirements and cleanliness standards that must be achieved for some of these parts. SMI's aerospace division was already set up to handle this new kind of work. According to Mr. Russell, the ventilator parts are similar in surface finish and tolerance to the aerospace parts, which the company is accustomed to holding at 2 tenths.

In the midst of this, SMI is also working to keep its employees safe. The plant is completely locked down — no outside visitors or suppliers can enter. Mr. Russell says they are following full CDC protocols using face masks, social distancing and thermal scanning. "It's an effort for our employees just to get into the plant," he says.

At the end of the day, Mr. Russell and the employees at SMI are just trying to do their part. "We live in a small town. We've known each other for a long time, and we all take a lot of pride in our work and workplace. This ventilator work is a testament for my employees. They want to stand up and be counted. We're all just small-town folks who are working hard to save the lives of those in our town and our friends."

Die Maker Describes Five-Day Build for Tool Urgently Needed for Coronavirus Ventilator Production

PETER ZELINSKI | EDITOR-IN-CHIEF

William Berry, president of Die-Tech & Engineering, says its process for rapid die building (which we have covered before) proved essential for building and delivering a die urgently needed for making ventilator components within five days.

The customer now using the die is Minnesota die caster Twin City Die Castings. The die makes ventilator pistons. Twin City's request for quote demanded a delivery lead time for die tooling of five weeks — much tighter than typical tooling

lead times. Mr. Berry phoned the company to say, “You don’t have five weeks. You need the die basically now.”

Die-Tech’s process for streamlining die lead times involves beginning machining before engineering is done, setup using self-locating workholding, and five-axis machining. For maximum speed in this case, the shop devoted as many resources as possible to producing different components of the die in parallel.

“We put four lead engineers and 50 other guys on it,” he says. “At one point, we had 11 five-axis machines all working on different parts of it at once.”

Mr. Berry believes this crisis illustrates the importance of having this kind of capability in the United States.

“If die making had all gone overseas, there would have been no way to respond like this,” he says. There would have been no way to get the ventilator components into production so quickly.

Eleven five-axis machines and more than 50 employees delivered this die in five days.
Photo: Die-Tech.

Shop Starts Work on Custom Drill for Ventilators Before Purchase Order Came

ELI PLASKETT | ASSOCIATE EDITOR

This step drill is used to manufacture ventilators.
Photo: NPW.

It’s not every day that the shopfloor workers decide to run a job before the owner has gotten the purchase order, but the coronavirus pandemic makes for interesting times. “My guys had started putting the job together before I finished filling out the quote,” says Mark Delaney, operations manager at Nicholas Precision Works (NPW), an Indiana toolmaking shop. “I just said, ‘Okay, I guess we’re making the parts whether we get paid or not.’”

The order came in early April. When Mr. Delaney received a request for quote (RFQ) for step drills, he learned they were for manufacturing ventilators for COVID-19 patients. “When we saw the RFQ, the young guys on the floor got really excited,” Mr. Delaney says. “Everyone wants to do their part, and this was the perfect opportunity for them.” Programmer Ryan Alderfer asked to start work on the step drills immediately. “Who was I to say no after all the stupid stuff I’ve done?” Mr. Delaney asks.

By the time the purchase order came in the next morning, Mr. Alderfer had programmed three machines, two of them already running. All three machines were running in less than an hour at a tighter tolerance than the job had called for. When the distributor — S&S Industrial Supply out of Potage, Michigan — phoned to see if the shop could rush the order, Mr. Delaney let him know the step drills were already packed for shipping.

With schools closed, several of NPW’s employees had their children on site, learning remotely in a conference room. “I got to tell the kids that their parents were making tools that would help save lives,” Mr. Delaney says. “Really, we were just doing a toolmaker’s job, but it felt good to know we could help.”

Manufacturing Association Aids Shop's Pivot to Ventilator Parts

JULIA HIDER | ASSOCIATE EDITOR

Wolfram Manufacturing in Austin, Texas, usually uses its multitasking machines to produce parts for oil and gas and heavy industry, but the coronavirus pandemic had the company wondering if it could produce parts for much-needed ventilators. It started reaching out to different organizations, including the Austin Regional Manufacturers Association (ARMA), to see if it could help. "I don't even know if there are parts that we can make in ventilators," Wolfram Manufacturing President Nathan Byman said to ARMA's executive director, Ed Latson. "But if somebody has a need, please let us know. Pass it on to us." Within three days, the shop had an order for ventilator parts that needed to be complete by the next evening.

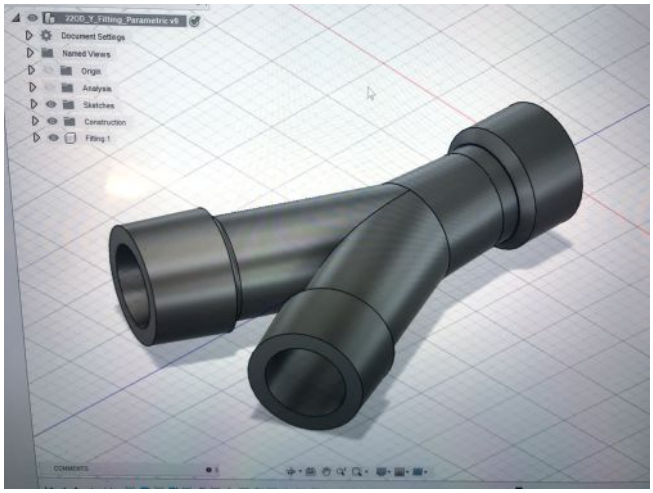
Wolfram got the call on a Sunday afternoon, and the parts needed to be ready to meet a critical shipping deadline at midnight on Monday. The order for 60 of these parts (each of which is roughly the size of a cell phone) came from Sisu, an engineering firm that is helping to design a ventilator. Wolfram quickly mobilized five employees to open up the shop and start setting up to run the parts. "We got our setup done, we worked with raw material that we had in the shop, brought the part online and worked through the day, and then hand-delivered the parts to them Monday night," Mr. Byman says.

While the timing was unusual, the parts themselves weren't a challenge for the shop. "Our inspection requirements are very high, so that made the tolerances and everything on the parts very easy for us," Mr. Byman explains. What did pose a problem was material, which led to the shop using its own stock. The customer managed to find a vendor that could get material to the shop by Monday morning, but it was all square. This wasn't ideal, as the shop was using its Okuma Multus B400 — a lathe — to produce the parts. Fortunately, Wolfram had some 5-inch round drops in inventory from a project that was finished. The company worked to figure out how it could nest as many of the parts as possible into the barstock, around the turning and milling that had already been performed on the material. "We figured out how to stack them so we could do half of what they needed. And then we figured out how to stack more," Mr. Byman says. By densely packing the parts, the shop was able to fit all 60. According to Mr. Byman, the ventilators with the parts Wolfram Manufacturing produced were deployed in New York, one of the areas hardest hit by the pandemic.

Five Wolfram Manufacturing employees quickly mobilized to produce 60 ventilator parts using an Okuma Multus B400 and material the shop already had. Photo: Wolfram Manufacturing.

At Purdue University, Emergency Production of PPE and Ventilator Fittings

BRENT DONALDSON | SENIOR EDITOR



This CAD model for a Y fitting will double the ventilator capacity at nearby hospitals by splitting the hoses in two. Photo: Purdue University.

Through a herculean display of institutional coordination, the Indiana Manufacturing Competitiveness Center (IN-MaC) — using its new digital manufacturing testbed at Purdue University — has pooled its resources with several other university departments and hospitals to manufacture critical parts needed by healthcare workers to battle the coronavirus, such as personal protective equipment (PPE) and ventilator fittings to increase overall ventilator capacity at regional and state hospitals. The Purdue collective is now involved in designing and manufacturing multiple ventilator fittings, developing a prototype fitting for hazmat suits, and producing up to 1,000 sets of face shields and glasses per day.

Beginning around March 20, (after the university had largely shut down its campus), faculty, staff and students at Purdue University began coordinating with Purdue's College of Health and Human Services, the Purdue Polytechnic Institute, the College of Engineering, the College of Pharmacy and its School of Nursing, as well as six research labs that all have design and production capability.

Dr. Nathan Hartman, Purdue's Dauch Family Professor of Advanced Manufacturing and co-executive director of IN-MaC, now leads a group of more than 50 people who are coordinating with regional and state hospitals to manufacture PPE parts via CNC machining and additive manufacturing technologies located on campus.

Dr. Hartman likens the university's response to the federal Defense Production Act, albeit executed at the county level. "We're in direct connection with four of our hospital systems in the state of Indiana as well as Indiana University Medical Center and the Indiana University School of Medicine, which have been advising us a lot on the technical and clinical details about all of this so that we're making things that can actually be used. We're not just out here winging it as hobbyists."

Jacob Coffing, a senior engineering tech for IN-MaC, says some of the parts being manufactured at Purdue are the result of a local hospital's urgent problem: The hospital had two different types of hazmat suits with fittings that were not interchangeable. With the help of a graduate student, IN-MaC came up with a fitting that could interchange across the different suit types, allowing the hospital to use the same hoses on all 200 of its suits rather than only half of them. IN-MaC is machining the fittings on a Haas VF-2 VMC.

Meanwhile, Purdue is producing ventilator fillings — specifically smaller, straight inline fittings — at a clip of 60 per hour. More advanced fittings like elbow and Y fittings that require certain profiles to be milled can take anywhere from a minute to five minutes apiece in machining cycle time. Mr. Coffins says that all of these fittings are being produced via lights-out machining on a bar-fed Haas ST-20 lathe; some parts are moving on to a Haas VF-2SS machining center with an add-on fourth axis for final operations such as 3D profiling.

Overall production at Purdue ramped up quickly in mid-April, although Dr. Hartman warns that acquiring materials is already beginning to be a challenge as the materials supply chain begins to tighten.

Protolabs Offers Quotes in Minutes, Parts in Hours

MATT DANFORD | SENIOR EDITOR

Though the company's machining capacity is extensive, software automation able to quickly get parts into production has proven important for the coronavirus-related work. Photo: Protolabs.

Two recent projects demonstrate the potential of digital manufacturing in translating life-saving ideas to real-world products, both at scale and in enough time to make a difference.

The first is a ventilator designed by a team of researchers at the University of Minnesota to be easy to use and, of more immediate concern, easy to manufacture quickly. The second is a face mask from Zverse, a 20-employee design firm. Both relied on the same manufacturing partner to bring their ideas to fruition: Protolabs, a Minneapolis-area provider of CNC machining, injection molding and 3D printing services where automation extends beyond the shop floor. "Once an order is received, our software automates much of the manual engineering and skilled labor that is normally required to manufacture parts," a company representative explained via email.

Whether parts are CNC machined, injection molded or 3D printed, Protolabs' process begins the same way: the submission of a 3D CAD file via the company's website. Within minutes, its software assesses manufacturability and returns a quote, along with suggested modifications.

Injection molding is the process in highest demand right now, the company reports. However, getting molded parts into production requires producing a tool first and, prior to that, significant back-and-forth among all parties involved to finalize designs and terms. With a process designed to streamline these latter tasks, Protolabs was reportedly able to begin molding face masks for Zverse within 48 hours of receiving a CAD file. Along with the efforts of other partners, this has been critical to increasing production enough to produce 20 million face shields by July.

For the ventilator, the primary value of Protolabs' software automation was getting the design the FDA approved in the first place. According to the university web site and recent news coverage, the system is not meant to replace models found in modern medical facilities. Rather, it is intended as a backup — a tool hospitals can build on their own when more sophisticated equipment is not available. With the concept proven by models built from scavenged parts, the researchers turned to Protolabs to finalize a prototype built from a set of standard, easily fabricated components.

Aerospace Machine Shop Uses Past Prototype for Quick Ventilator Part Turnaround

EMILY PROBST | SENIOR EDITOR

Win-Tech Inc. of Kennesaw, Georgia, is a build-to-print AS9100-certified aerospace manufacturer now busy churning out medical parts. Recently, a customer called Win-Tech because a supplier could not meet the increase in demand for aluminum ventilator components, says Allison Giddens, director of operations. In this case, the groundwork was already laid. Win-Tech had made the corresponding prototypes a few years ago, which has led to quicker-than-average turnaround for this work.

According to Ms. Giddens, most of the tooling and milling operations will take place on its Haas CNC machining centers, and the turning operations will take place on CNC lathes from Mazak and Okuma. She says that there isn't anything done differently to this part that isn't done to any part made at Win-Tech. "There is a sort of pride, though, that comes with making parts that you know are immediately necessary to save a life."

Recognizing change as a constant, aerospace manufacturer Win-Tech Inc. has had to rely on its flexibility to quickly fulfill an order for 2,000 ventilator piece parts.

When finished, the shop will have made more than 2,000 ventilator piece parts on this order.

There are, of course, new challenges and risks to consider. For example, will COVID-19 cause a workforce shortage if employees get sick? How can the shop plan for that? Will its vendors be impacted by the pandemic in the short term? How will that affect current work in progress?

To answer some of these questions, Win-Tech has living game plans, Ms. Giddens says. "We recognize that our plan today may change tomorrow, and again the next day, and again the next. We wouldn't be in manufacturing if we didn't recognize change as a constant."

To ensure the health of its employees, Win-Tech adopted several thorough cleaning and sanitation practices early in this public health crisis. Not only is each person responsible for specific work-area cleaning, but someone is responsible for on-the-hour cleaning of common areas, doorknobs, flat surfaces and more. The shop has relaxed its PTO policy to allow for employees to be more flexible during family challenges related to school closures. It has implemented social distancing requirements and canceled non-essential site visits. For those visitors who must be on site for product delivery, the shop has enacted new evaluations at the lobby door to ensure that its employees are not exposed to someone showing signs of COVID-19. All pre-planned audits have been rescheduled to be virtual.

"Win-Tech employees are proud to be manufacturing ventilator parts. We recognize that we are a small piece of the puzzle but are proud to be a part of the vital greater good," Ms. Giddens says.

Does Asia's Low-Cost Manufacturing Option Still Make Sense?

As U.S.-based companies try to stay ahead of COVID-19, global supply chains are under renewed scrutiny. Are uncertainties and delays caused by global crises worth the short-term cost savings?

BRENT DONALDSON | SENIOR EDITOR

With broken supply chains resulting from the coronavirus, the opportunity for a sustainable domestic manufacturing surge has perhaps never been greater.

Cost-cutting measures put in place by U.S. companies over the past 20 years have resulted in manufacturing practices that appear regularly in this publication — practices that include automation, lean manufacturing, and increased deployment of enterprise resource planning (ERP) and machine monitoring systems. But the downward pressure on U.S. companies to reduce costs during the past two decades has also resulted in the massive off-shoring of manufacturing operations to plants in China and other countries throughout Asia, a phenomenon that has helped China attain roughly 16% of today's world gross domestic product. For domestic companies that rely on parts produced in China, the result has been a massive supply chain risk, most dramatically seen recently as the coronavirus shut down most of the country.

To discuss this and other disruptions resulting from the pandemic — as well as the potential long-term domestic manufacturing benefits that may result from it — I talked to Randy Altschuler, CEO of Xometry, the Maryland-based online platform that connects customers and suppliers of custom manufactured parts. While tough times lie ahead for many small manufacturers in the near term, the opportunity for a sustainable domestic manufacturing surge has perhaps never been greater.

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MANUFACTURERS REPORT LENGTHENING SUPPLIER DELIVERIES WHILE NEW ORDERS FALL TO ALL-TIME LOW

In the latest Gardner Business Index (GBI) survey, metalworking respondents reported a steep contraction among most elements of business activity. The reading for supplier deliveries moved higher as supplier deliveries slowed due to the massive economic disruption being caused by COVID-19. Read the report on page 136 for more insights from the latest GBI survey.

***Modern Machine Shop* (MMS): I imagine that Xometry has a unique 360-degree perspective on the impact of the coronavirus on U.S. manufacturing, since your company doesn't produce parts but rather connects companies that need parts with a global network of suppliers, including domestic suppliers located in 46 states. What impact of the pandemic are you seeing right now on both the supply and demand sides?**

Randy Altschuler (RA): I would tell you that it's an emerging situation, but the fallout from this — and I'm not talking about just the human or health fallout, which is obviously first and foremost for everybody — but the business fallout will be devastating. I think the impact on small companies, the small manufacturers that make up the bulk of our network, is that there will be very tough times. For these men and women, their machine shop is sort of melded into their lives. They're not working for a third party. It's part of their livelihood, and their family is involved with it. Maybe a spouse works in the financial department or on the machines with them. That intersection of life and business — even for larger machine shops in our network — work and personal life blend together. They're so dedicated to making parts for their livelihood that they're working through this.

MMS: I feel like a "but" is about to happen.
RA: Well, so far from a *demand* perspective, we are surprisingly seeing strong demand. A lot of our industries, like aerospace, defense and robotics, those industries are less sensitive to consumer demand, at least in the short term. So demand has continued to be strong. And for the most part, our manufacturers, despite the headwinds here, seem to be doing well. Some of that demand may be because people are anticipating further shutdowns. And I think some companies, some engineers, some procurement people are trying to get ahead of the curve, fearing the worst. So that's why we are actually seeing surges in some areas.

MMS: That anticipation, do you feel like it will extend beyond this particular crisis? I think it's safe to say that most multinational companies have no idea who manufactures parts for their direct suppliers. What is your sense of how the pandemic will influence supply chain decisions for businesses that rely heavily on parts produced in lower-cost countries?
RA: For companies whose work may have gone to Asia because it was the low-cost option, I think people are rethinking that. I think they are taking into account the risk in which these calamities, in this case a virus outbreak, can cause huge delays and uncertainty of delivery. I think people are rethinking their supply chains and saying, "Hmm, maybe costs shouldn't be the only driver here. Maybe I need to take down all this risk." And that's a serious change for people who have in many instances shifted away from North America and gone to lower-cost areas.

MMS: Part of the reason why I wanted to talk to you was because of Xometry's unique position as a matchmaker between machine shops and customers looking for manufacturing capacity. Are you seeing companies

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that already want to move manufacturing operations back to the U.S. do so because of the coronavirus?
RA: Yes. I mean, even yesterday there was a $50,000 order where the customer said, "You know what, we've done this in China, but everything we've got there right now is simply too far backed up because of the work shortages. We don't have confidence in it. I need to get out of this place immediately. I need do it right away."

MMS: And this company said that they need to make this change because their existing supply chain is not reliable.
RA: Exactly. I should note that Xometry itself has a China option for our customers. And so as the China news unfolded and there were delays, we went back to our customers who ordered from us in China and said, "Hey, we've got a whole domestic network. Are you interested in switching back to the United States?" And we had a bunch of customers do so. I think that trend will either accelerate, or people will run their models and the numbers will no longer be only about cost.

MMS: What about when things settle down? Won't the tendency to revert to the mean — in this case low production costs — go back into play? Do you really see meaningful change happening?
RA: I think absolutely. Look, I think there's a recognition for the security of the United States and for the health of our economy. We need to have capabilities domestically as well, as it's become clear from this terrible event that entire continents can potentially be shut down. You know, in spite of the virus, American people still have to live their lives and have important goods. So if our supply chain shuts down because 20% of it can only be sourced in another continent, that's simply not acceptable. So I think after it's all said and done, there is going to be some reflection and understanding that we have to have redundancy. At the very least, we have to have those capabilities within the United States and people need to start bringing back some of this work so that if, God forbid, there are more outbreaks like this or issues where continents or countries get shut down, we have a supply here and we can amp that up. So I think that is a huge positive for American manufacturers.

MMS: Which opens up a wholly different challenge: workforce.
RA: Yes. The flip side of that is we need to make sure that those manufacturers can operate. That means better investment in our infrastructure. It means we need to train more people to be machinists and operators of these machines. All of us proudly saying that we want our children to go into manufacturing — that's something the government needs to help with now. That's a standard we need to make a reality now. It literally will help our lives.

You know, I think it's very interesting — and rightfully so — that if your child became a police officer or a firefighter or a doctor or nurse, we recognize the social good that they're doing there. Teachers who help all of us — a noble cause. I don't think you have that respect for manufacturers. But if people aren't making things, the rest of us cannot survive. And somebody has to make the trucks that are carrying food that's going to the supermarkets while a lot of people stay home. Our infrastructure, our national security — all of these different things require actual fabrication of parts. We need to trumpet that and make manufacturing a heroic profession. We need it. We need to give it recognition. And we need to excite our girls and boys to grow up and to be manufacturers.

People are rethinking supply chains and saying, "Maybe costs shouldn't be the only driver here. Maybe I need to take down all this risk."

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World Machine Tool Report Shows Manufacturing Shift to North America

After increasing machine tool purchasing for the past two years, 12 of the top 15 machine tool consuming countries decreased in 2019 in the midst of a worldwide downturn. But in a sign of reshoring, the U.S. increased its share overall, and machine tool purchasing in Mexico increased.

STEVE KLINE JR. | CHIEF DATA OFFICER

In 2017 and 2018, the World Machine Tool Survey from Gardner Intelligence, the research arm of *Modern Machine Shop* publisher Gardner Business Media, showed that 12 out of the top 15 machine tool consuming countries increased their consumption. It is relatively rare for this to happen in a single year, and this was the only time it had ever happened in back-to-back years. This worldwide upturn and the extremely cyclical nature of the machine tool market should have been a clue to the fate of machine tool consumption in 2019, which was a worldwide downturn.

According to the latest survey, the results of which have recently been published, global machine tool consumption decreased by $13.1 billion, or 13.8%, to $82.1 billion in 2019. Therefore, 2019 had the lowest level of machine tool consumption since 2010, when much of the global economy was just starting to recover from the Great Recession. And, in an about face from 2018, 12 out of the top 15 consuming countries decreased their machine tool consumption in 2019.

China Leads the Contraction

While there was a recovery in 2017 and 2018, the global machine tool market has essentially contracted since 2011. Much of this contraction is due to China, which most certainly led the contraction in 2019. China's 2019 consumption was $22.3 billion, falling $6.4 billion, or 25.3%. The decrease in China's machine tool consumption accounted for nearly half of the global decline.

The Chinese automotive industry, among others, slowed toward the end of 2019. The Chinese economy was also hit particularly hard by the quarantines to contain COVID-19. As a result, China's machine tool consumption will likely see another significant decline in 2020, perhaps another 15 to 25%, or roughly $5 billion.

China's machine tool consumption accounted for 27.2% of the market in 2019. This was the first time China's machine tool consumption accounted for less than 30% of the global market since 2008. And the country's share of the global market could fall again in 2020 as work moves toward Southeast Asian countries not hit as hard by COVID-19 as well as Mexico, which continues to claim a larger presence in global manufacturing.

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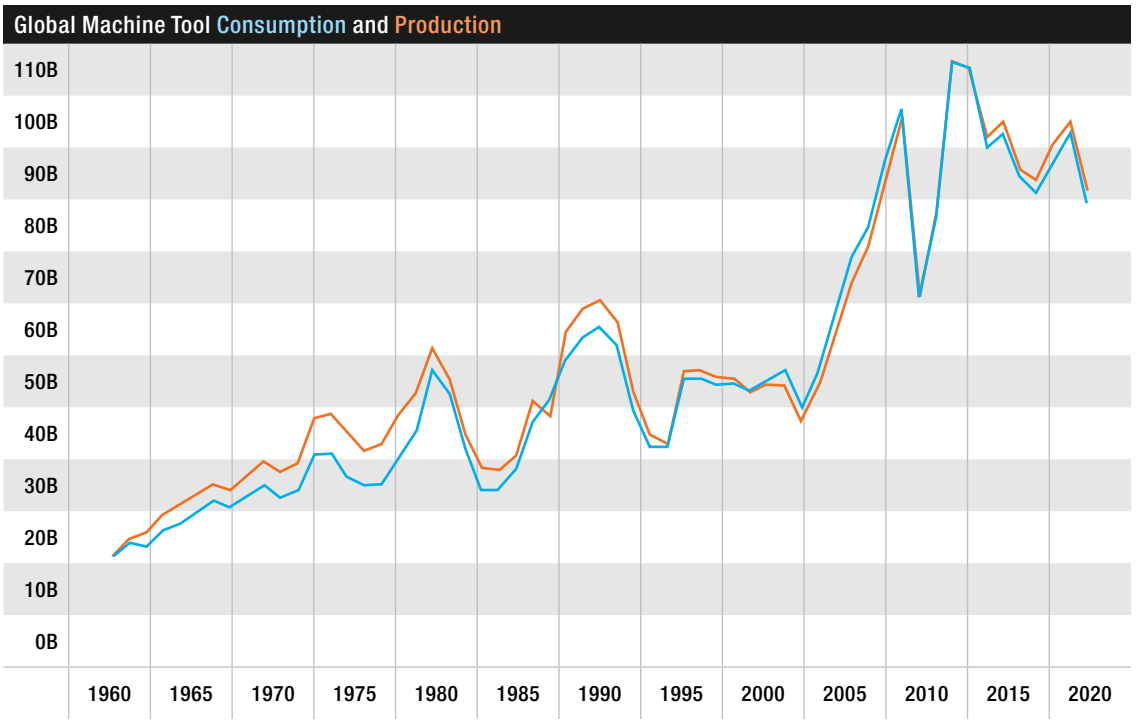

According to the 2019 World Machine Tool Survey, global machine tool consumption decreased to the lowest level since 2010, when much of the global economy was just starting to recover from the Great Recession. Global machine tool production followed a similar pattern, falling to its lowest level since 2010.

Mexican Manufacturing Grows

Mexico consumed $2.5 billion in machine tools in 2019. That was its third highest total ever and its eighth consecutive year with more than $2 billion in consumption. Mexico consumed 9.1% more machine tools in 2019 than it did in 2018. Of the top 15 consumers, Mexico had the second largest increase (only Brazil increased more). Mexico's 2019 growth was also the fifth fastest in the world. Three of the faster-growing countries were significantly smaller consumers, making their higher rates of growth much easier to achieve.

Mexico maintained its ranking as the eighth-largest machine tool consumer in the world in 2019. However, the country significantly increased its share of global machine tool consumption from 2.4% to 3.1%. In 2019, Mexico consumed its largest share of the global machine tool market ever.

Effects of North American Reshoring

The United States, the world's second-largest consumer, bought $9.7 billion of machine tools in 2019, which was down just 1.6% from 2018. That made 2019 the country's third-highest year for machine tool consumption since 1998.

Of the 12 countries that decreased consumption in the top 15 consumers, the U.S. recorded the smallest decline. As a result, the U.S. significantly increased its share of the global machine tool market. In 2019, the U.S. consumed 11.9% of the world's machine tools. This was the country's highest share of global consumption since 2001. This is significant because 2001 was the start of significant offshoring of U.S. manufacturing due to artificially low interest rates set by the Federal Reserve to help the country recover from the bursting of the dot-com bubble.

Since the end of the Great Recession in late 2009 and early 2010, the pendulum has swung back as manufacturing returns to North America, more specifically the U.S. and Mexico. The generally rising share of global machine tool consumption for both countries during that time is evidence of the reshoring or near-shoring trend.

COVID-19 has led several countries to lock down significant portions of their populations, which has led to a significant reduction in economic

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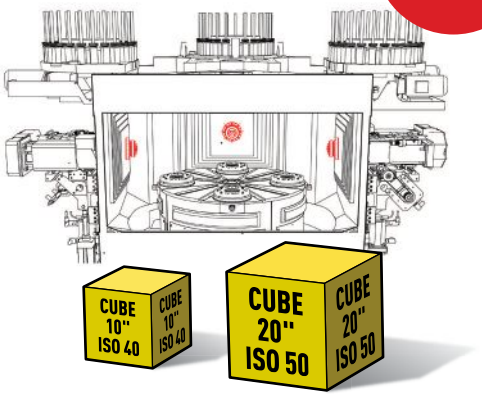

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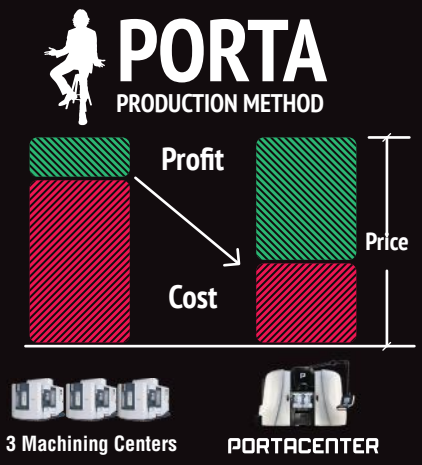

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Top 15 Global Machine Tool Consumers

Rank	Consumption (USD - millions)	% Change	Global Share
1. China	22,290	-25.3%	27.2%
2. USA	9,721	-1.6%	11.8%
3. Germany	7,883	-2.8%	9.6%
4. Japan	6,039	-8.5%	7.4%
5. Italy	4,357	-16.0%	5.3%
6. South Korea	3,171	-18.6%	3.9%
7. India	2,587	-24.1%	3.2%
8. Mexico	2,513	9.1%	3.1%
9. Brazil	1,993	11.1%	2.4%
10. Russia	1,779	-9.1%	2.2%
11. Taiwan	1,693	-18.1%	2.1%
12. France	1,462	0.2%	1.8%
13. Canada	1,364	-12.8%	1.7%
14. Thailand	1,247	-5.7%	1.5%
15. Switzerland	1,226	-7.2%	1.5%

Top 15 Global Machine Tool Producers

Rank	Production (USD - millions)	% Change	Global Share
1. China	19,420	-19.2%	23.1%
2. Germany	14,000	-7.9%	16.6%
3. Japan	12,987	-13.6%	15.4%
4. Italy	6,507	-12.1%	7.7%
5. USA	6,002	-5.8%	7.1%
6. South Korea	4,471	-15.2%	5.3%
7. Taiwan	3,950	-18.1%	4.7%
8. Switzerland	3,211	-20.8%	3.8%
9. Brazil	1,618	12.6%	1.9%
10. Spain	1,234	-14.4%	1.5%
11. Austria	1,196	-5.5%	1.4%
12. India	1,185	-16.8%	1.4%
13. France	964	7.9%	1.1%
14. UK	685	-9.4%	0.8%
15. Canada	671	1.2%	0.8%

China leads global machine tool production and consumption, but had the greatest rate of decline in consumption and nearly the greatest in production. Meanwhile, because the decline in U.S. consumption was so small relative to the declines of other countries, the U.S. increased its share of machine tool consumption overall, providing numerical evidence of reshoring activity.

MMS

HOW WE SURVEY

Learn more about the survey and its methodology at gbm.media/wmts2019.

activity. It is quite possible that global machine tool consumption declines by 15% or more in 2020. If global machine tool consumption declines by 15%, it would drop below $70 billion for the first time since 2009, in the midst of the Great Recession.

Machine Tool Production Also Decreases

Global machine tool production has followed a similar pattern to consumption. In 2019, global machine tool production was $84.2 billion, which was a decrease of $12.9 billion, or 13.3%. Like global consumption, global production in 2019 fell to its lowest level since 2010. Only three of the 15 top producers increased production in 2019: Brazil, France and Canada.

China, the world's largest producer of machine tools, decreased its production by $4.6 billion, or 23.1%. China's machine tool production has decreased six of the last eight years, falling to its lowest level since 2009. In 2019, China's share of global production was 23.1%, which was its lowest share since 2008, when it was 16.4%.

Brazil was the lone country among the top 10 producers that increased its machine tool production. The country increased its production by 12.6% to $1.6 billion. Every one of the other top 10 producers cut its production. Germany and the United States were the only two that decreased their production by less than 10%. As a result, both Germany and the U.S. increased their overall share of global machine tool production. Other countries among the top 15 producers to increase their global share of production include Italy, Austria, France, UK and Canada. Results of the survey show a small but noticeable shift in machine tool production from Asia to Europe.

The World Machine Tool Survey contains much more information, including not only consumption and production data, but also data related to imports and exports of the top 60 machine-consuming countries. To purchase the report and the data supporting it, visit gardnerintelligence.com.

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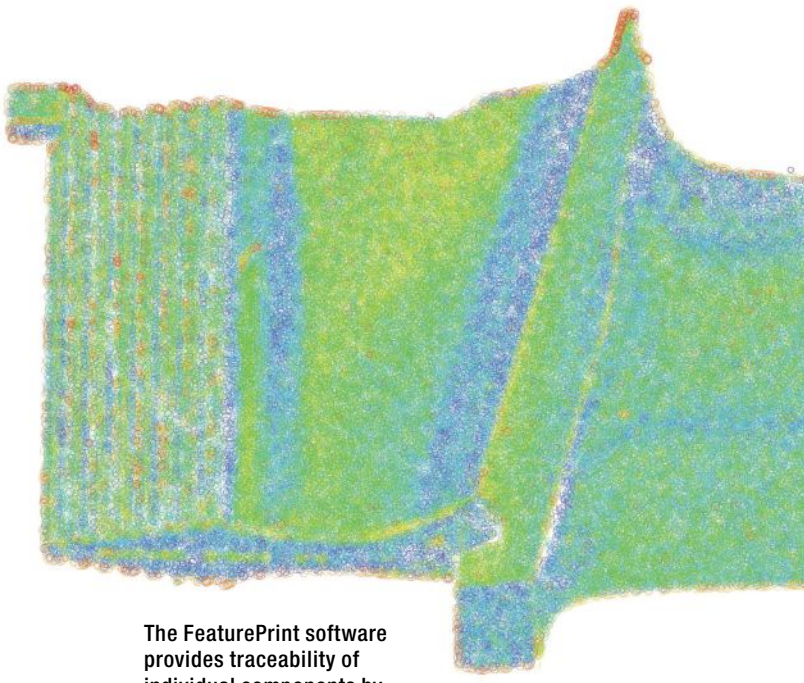
Every Part Is Its Own Identifier

Off-the-shelf imaging technology is now so good it can pick up the distinct surface features of seemingly identical parts. This startup company's technology leverages what cell phones and other imaging devices are now capable of, identifying parts by their unique features so that no serial number is needed.



The FeaturePrint software provides traceability of individual components by detecting the minute surface detail that makes that part unique.

PETER ZELINSKI | EDITOR-IN-CHIEF

Everything needed to trace, track or certify any individual manufactured part is already present on the part itself, according to Brian Crowley, CEO of Alitheon, a startup company focused on object traceability. The surface detail of a manufactured part is unique in the same way fingerprints are, he says. And, importantly, off-the-shelf imaging technology — notably including the cameras in our phones — is now capable of accurately capturing this distinctive surface-level detail. The result is a new possibility for identifying parts, arguably better and more reliable than serial numbers. Alitheon's technology for using this surface detail for part ID is called FeaturePrint.

Mr. Crowley says he and his team often run this demonstration: Playing cards from a new deck are imaged only from the back side, allowing company representatives to show how the FeaturePrint system unerringly identifies each card, even though to the human eye they are identical. At the company's headquarters in Bellevue, Washington, 1,000 crisp $1 bills have been imaged, he says. A scan of the side without the serial number always correctly identifies the individual bill, because of the way the bills are all different at the level of minute surface features.

Applied to production parts, this means the part itself can accomplish every purpose that might otherwise require a serial number, including tracking parts through the process, capturing part history for the sake of liability or recall in the field, and certifying parts to guard against counterfeiting. But where a serial number might

be forged, a part's unique surface characteristics can't be. And where a serial number might be removed or destroyed, the FeaturePrint capability still can identify a part accurately if 90% of the surface is gone, the company says.

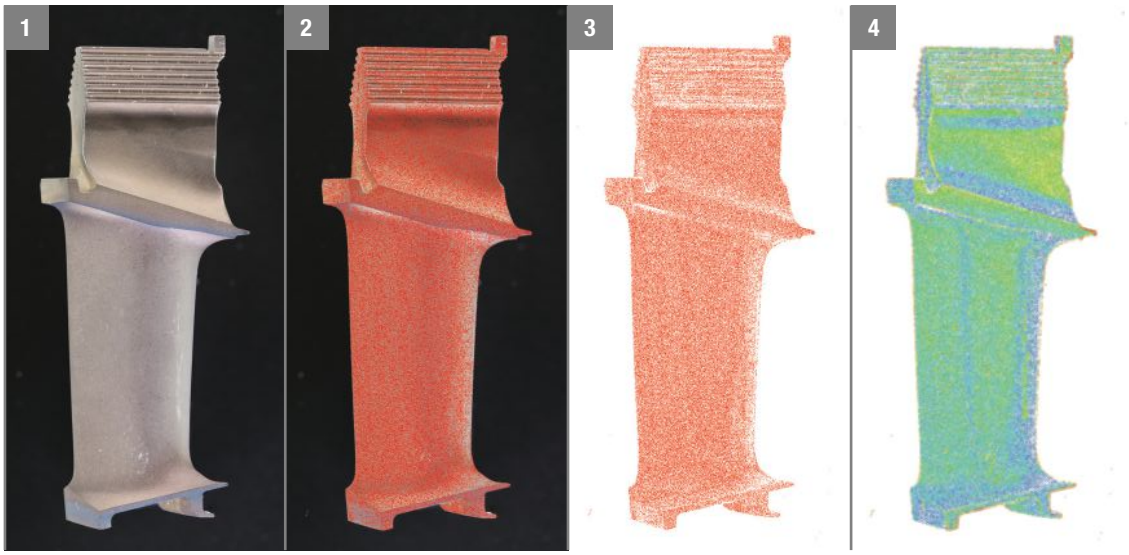
The imaging technology can be selected to fit the job, Mr. Crowley notes. Frequently, a cell phone can be used. For small parts (such as 4-mm gears in a recent test), a camera with a macro lens might be needed. Flat parts can be scanned or imaged in batches. Alitheon is not selling hardware, but instead markets its machine vision software and cloud services.

"We generate a complex equation that can only be solved by one object, even if it is among billions of products indistinguishable to the human eye."

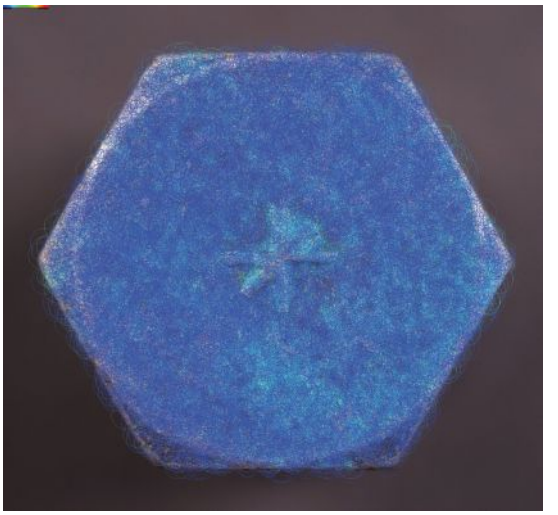
The system works this way: Starting with the image of the part, the software derives something like 100,000 points of interest from that image. The point map is weighted, as the software identifies certain points that are particularly distinctive within the map and therefore particularly useful for identification. These points are then converted to a multidimensional mathematical model, and this model — typically less than 100 kilobytes of data — is all that Alitheon stores. Pixel data itself is not stored, meaning no image can be reverse-generated from the data used. The part is later successfully identified when it is matched to a stored mathematical model. Indeed, this authentication can be performed much later, at a different location, even using different imaging tools.

"We generate a complex equation that can only be solved by one object, even if it is among billions of products indistinguishable to the human eye," Mr. Crowley says.

The technology comes from outside of manufacturing, based on the company founders'



This sequence of images shows how the software creates an identifying mathematical model unique to an individual component. From left to right: (1) A base image is taken using over-the-counter optics. (2) The software identifies about 100,000 unique points of interest. (3) Image data is discarded to leave only these points. (4) The points are weighted to identify stronger points, and this weighted map is ultimately transformed into the multidimensional mathematical model that can later identify this precise component.



Seemingly plain and indistinguishable parts can be traced using the software. Here is the point map of a bolt head, allowing it to be identified out of a large quantity of bolts just like it.

experience in vision-based systems for uses including bomb detection and rapid object identification in the post office. Its applications go beyond manufacturing as well. An airline is testing it for high-speed, tagless luggage tracking. But part production is perhaps the most promising application, particularly in cases where there is a risk of part counterfeiting. In manufacturing, one of the investors in the technology is car maker BMW.

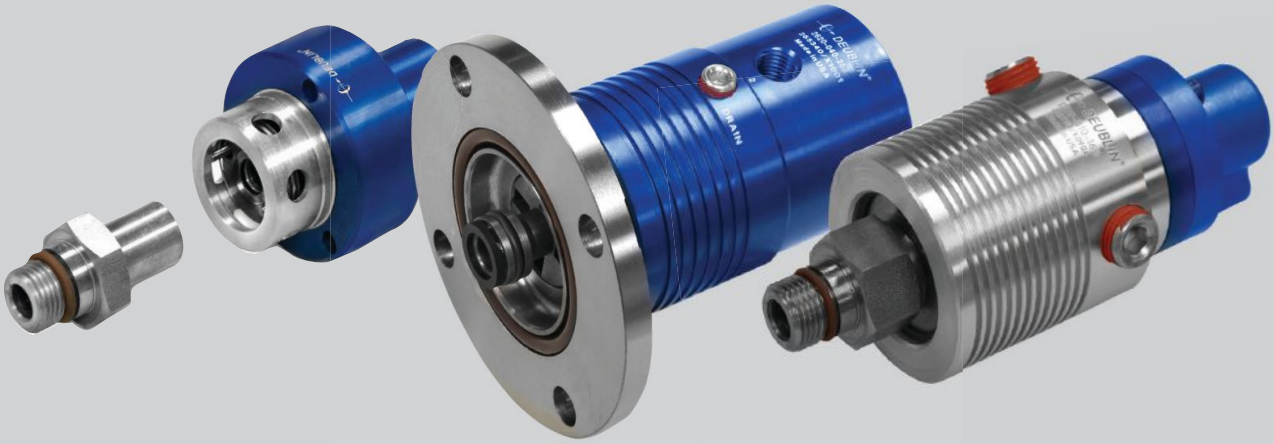
Practically any part can provide enough distinctive detail for ID, Mr. Crowley says. The exception: "Certain amorphous materials lack stable surface features for a positive ID." Beyond that, whether a part has been cast, milled, ground, anodized, or even painted or plated is of no consequence. Even changes to the surface after the modeling might not matter.

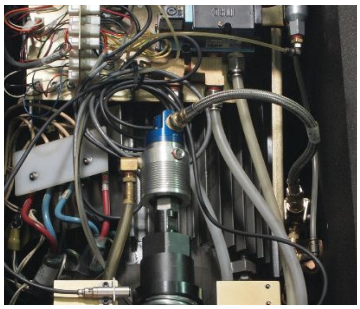
Aircraft component supplier Moog discovered this in a test of the technology. Twenty titanium parts made through additive manufacturing were identical on the outside, but contained secret identifying features on an inner feature a camera could not see. The parts were all registered with FeaturePrint, after which Moog set about damaging nine of them. Parts from this set were subject to wear including (from Moog's report) "dropping the part onto a concrete floor 10 times, attacking the part with a handheld motorized grinder, harperizing the part (a form of vibratory deburring) and grit blasting." None of this abuse foiled the identification. The grit blasting was particularly severe; a part whose image offered 54,000 FeaturePrint points of interest had less than 3,700 points left after this operation. However, even that was still enough to match the model — enough, that is, to still solve the equation associated with that part.

All of this suggests the possibility of parts providing for their own traceability and history even long after manufacturing. If imaging and modeling a part is a routine step in the production process when the part is made, then everything about that part's origin and manufacturing can be discovered in the future, including well into the future, by anyone able to again simply capture that part's image.

Moog purposely damaged some of the test parts like this in its evaluation of the FeaturePrint system. The parts were still identified accurately even after more than 90% of the original points of interest had been removed.

Alitheon | **alitheon.com**





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The Labor of Lean Is Data-Driven

Approximating single-piece flow in a job shop environment requires an ongoing commitment to analyzing and acting on evidence.

MATT DANFORD | SENIOR EDITOR

Fresh from learning to use machine monitoring data in a new way, Todd Chretien is eager to add materials requirements planning and enterprise resource planning to his software toolbox.

At least, this was the case when his employer, Superior Completion Services (SCS), opened the machining area of its sprawling Houston campus to *Modern Machine Shop* earlier this year. At that time, the director of manufacturing and his team were implementing software that encompasses both functionalities (Microsoft's Dynamic suite). As for machine monitoring, this system had only recently become a tool not just for tracking equipment performance but also for scheduling work. Both of these efforts have a common goal: "We want to make all our decisions based on data," Mr. Chretien says.

However, the real story of data-driven transformation in this 95,000-square-foot captive machine shop is not about software. It is about people and the extent of their commitment to reforming the fundamentals of how jobs flow through the shop. At SCS, lean manufacturing is driven by data, and data-driven manufacturing requires ongoing time and effort.

At the time of this writing, their time and effort were devoted largely to ensuring the new management software would accurately model the new approach. Thousands of made-to-order parts, most produced in lot sizes of less than 10, have been organized into loose families. Part families have enabled abandoning batch processing in favor of a cellular machine layout designed to reduce work-in-process (WIP) and maximize throughput. In fact, all but four of the shop's 27 machine tools — two massive lathes and a couple of older manual mills — are in new positions.

Thanks to these changes, jobs that used to remain in the shop for two to three weeks on average now move through in three to five days, Mr. Chretien says. The average number of parts produced per month climbed from 1,100 to more than 1,700 in one year, and that figure continues to increase. The work is more complex, too,

Todd Chretien (right), director of manufacturing at Superior Completion Services, consults with Hal Phillips, manufacturing manager.

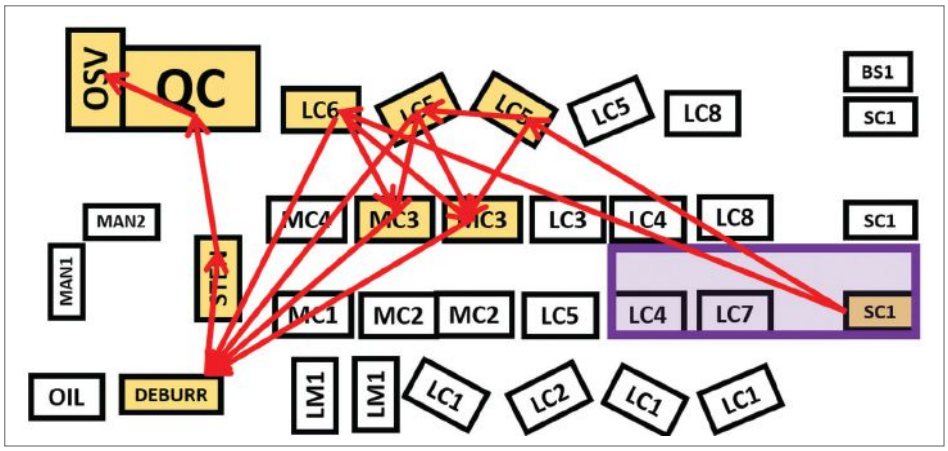
because planners can be more selective in deciding which orders to process in house. For SCS parent company Superior Energy Services, the result is reduced costs and faster assembly of end-use equipment installed hundreds or even thousands of miles away designed to operate in wells thousands of feet beneath the ocean floor.

Lessons in Lean Flow

SCS owes its transformation to not only its employees but also teams of industrial engineering students from the University of Houston's Cullen College of Engineering. Sponsoring this class was a recommendation from Dr. Shahrukh Irani, a lean manufacturing consultant contacted by Mr. Chretien shortly after he was hired to manage the shop. For two years, teams of students visited the shop regularly to identify and present potential means of eliminating waste and improving efficiency.

Mr. Chretien has participated in other lean initiatives, but he says this time was different. "5S programs, setup efficiency and all the lean practices that everybody thinks about are really secondary to getting the work out here," he explains. "The big, sweeping changes come when you change the way you manage your work."

Ideally, workpieces flow one by one from workstation to workstation and leave the floor at the same rate that more raw material arrives. However,

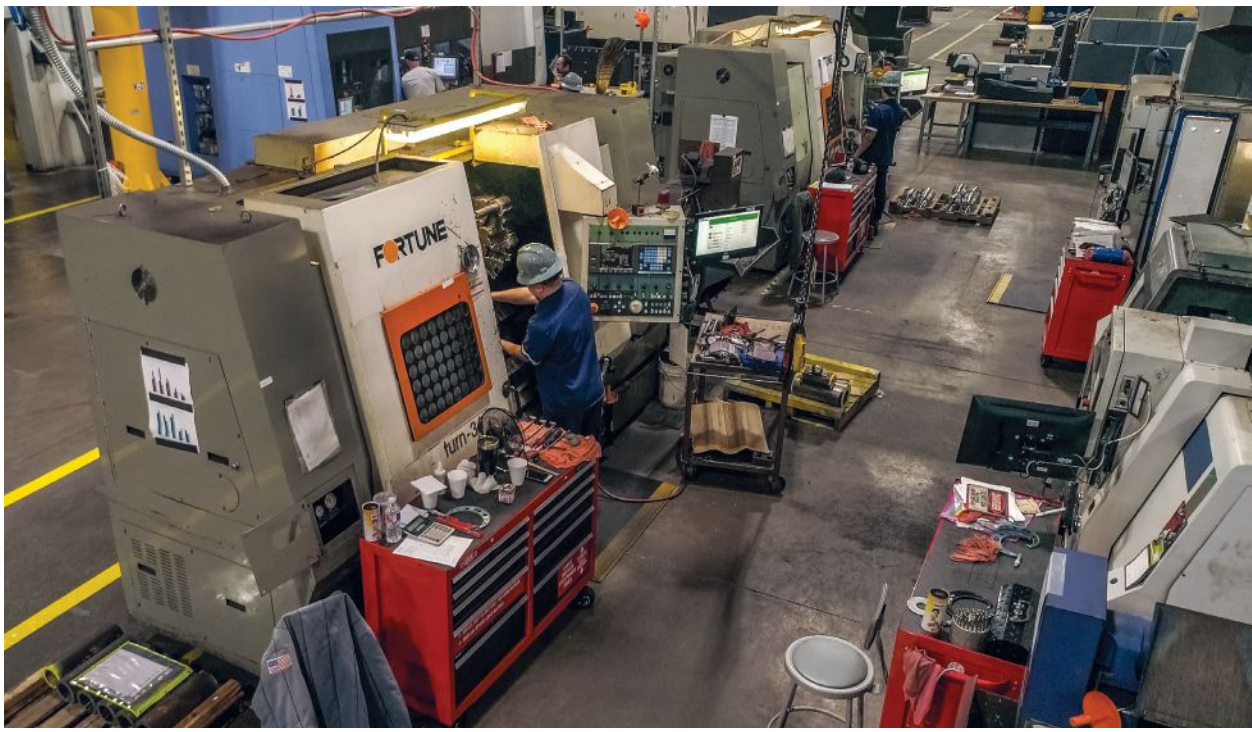


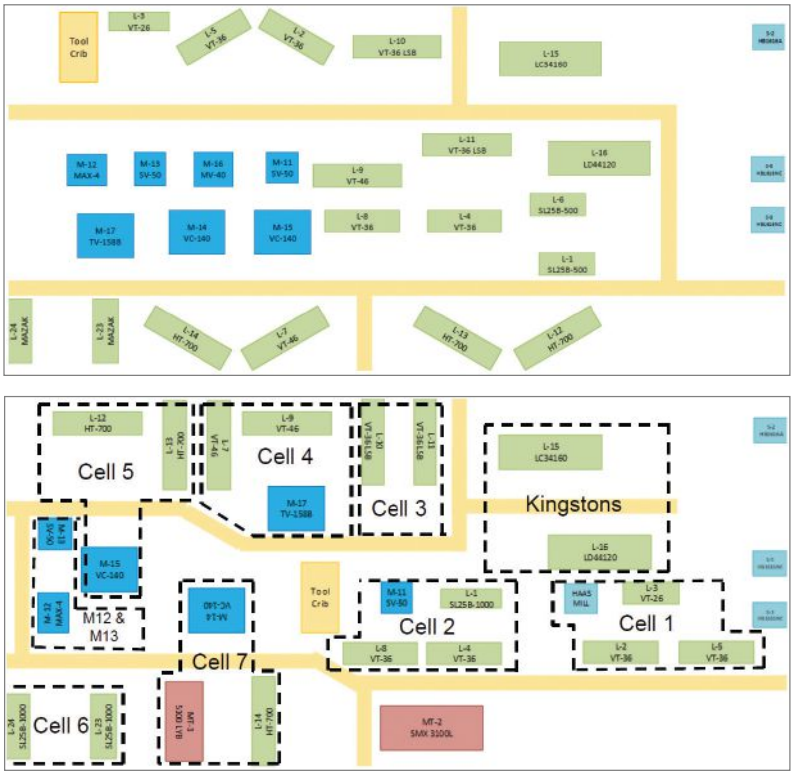
These previously chaotic material flows have been restricted to a single cell. Image: SCS.

a demand-determinant mix of hundreds of unique orders every month, many in lot sizes of only one or two, makes this ideal impossible for SCS to achieve in the traditional way, that is, dedicating machining cells to specific part numbers. Instead, Dr. Irani's approach approximates single-piece flow as closely as possible with "hybrid cells": looser arrangements of machines with multiple entry and exit points to accommodate groups of similar parts.

When the students arrived, machines were arranged into a functional or "process village" layout, with some areas dedicated to turning and some to milling. Made-to-order parts moved in seemingly random fashion about the facility

An example of a "hybrid cell." The new approach has helped SCS move away from batch processing to approximate single-piece flow. Image: SCS.





A flexible cellular configuration has replaced SCS's previous "process village" layout. Image: SCS.

according to which machines were occupied and other variables of the day. Pallets of mostly tubular WIP complicated working in a space already crowded with people, forklifts, tool cabinets and more, particularly with parts that can protrude 50 feet or more from the tailstocks of the larger lathes.

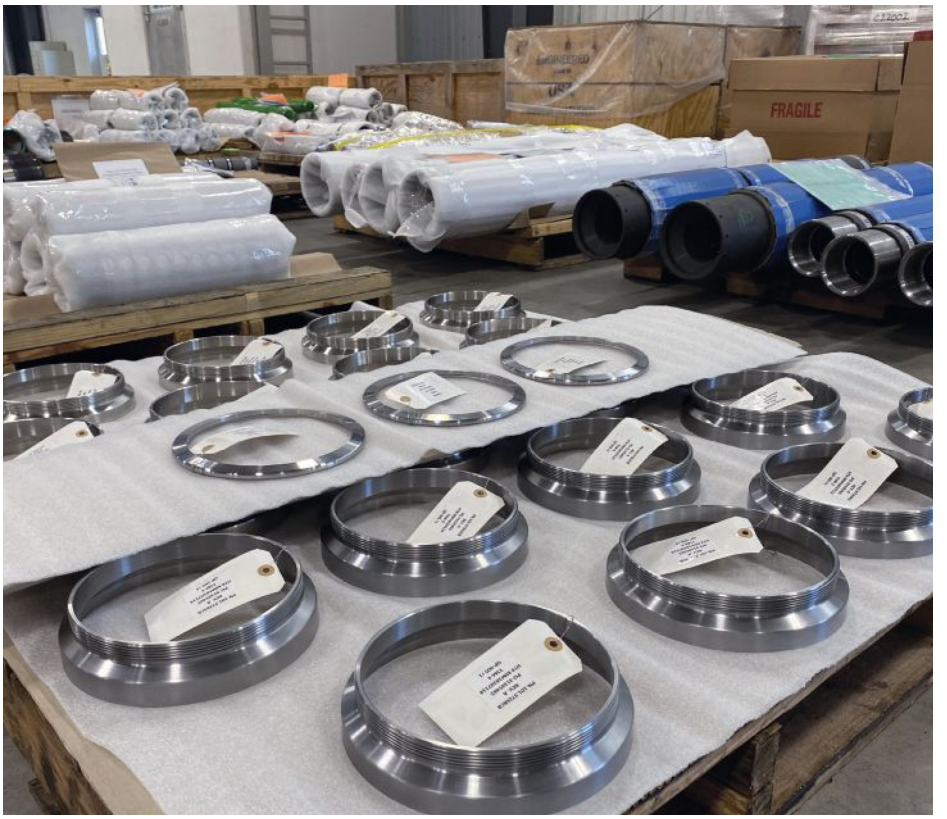
Layout was not the only thing that had to change. Rather than an indicator of activity and therefore success, WIP had to be recognized for the shop-clogger that it is. Rather than focusing on utilization numbers for all machines, the focus needed to be directed toward the bottlenecks. On the shop floor, people had to stop letting pride and ownership in their work, however admirable, stand in the way of sending parts downstream rather than batching them for complete production at each workstation. Proving the worth of these and other lean lessons would require the students to apply their own lessons in data analysis.

Monster Highway and Minion Lane

One former intern, Danielle DeWitt, continues her work as a full-time data analyst. As a student, her work began with analyzing how previous parts flowed through the shop. Similarities in routings — the specific sequence of operations and workstations involved in a part's production — revealed which parts would be best to group into families, and, from there, which machine tools would be best to group into cells.

However, past work orders specified only which operations to perform (say, "milling op. 10"). More specific information was unnecessary, because which lathes or mill would do the work was solely the determination of Hal Phillips, manufacturing manager, and Tam Ngo, lead machinist. These veterans literally divided prints into piles, relying solely on their expansive manufacturing knowledge and intimate familiarity with the shop and its equipment to schedule work on the fly.

The knowledge and experience of shop veterans were essential to the students' work, but they needed raw data first, Ms. DeWitt says. They found what they needed in output from SCS's machine monitoring system, MDC-Max software from CIMCO. This system's output



With small lots and varied part sizes, work-in-process can create significant challenges for a shop like SCS.

links individual operations with the machines that performed them as well as the work order number, part number, and cycle start and stop times. Matching part number and work orders and comparing start and stop times across different machines provided a means of mapping the route taken by any given part through the facility.

From there, the students massaged the data into the right format for the Production Flow Analysis Software Toolkit, or PFAST (pronounced "fast"). Developed by Dr. Irani and Dr. Smart Khaewsukkho in the early 2000s at the Ohio State University, PFAST automates the task of grouping together clusters of parts based on similarities in their routings. This, in turn, helps identify which particular groups of machine tools might make good hybrid cells.

This is when the veterans' input became critical, Ms. DeWitt says. For example, Mr. Phillips pointed out the need for an additional machine when presented with a potential design for cell 1 that included only two lathes and a mill. A third lathe would be required to achieve flow, he had explained, because cycle times for many parts are offset. That is, operations on one machine might take twice as long as operations on the next, leading to the pileups of WIP that the team had set out to avoid. As he suggested, adding another lathe dedicated to the first, lengthiest operation for any given part in a family processed on the cell, and putting that operation first in line — that is, scheduling the bottleneck — has so far prevented WIP from ever becoming a significant problem.

Other cells are organized and scheduled similarly. Implementation of these cells began quickly once the first began running, effectively silencing anyone still unconvinced by the merits of the new approach. As the layout continued to change, everyone from management to machine operators offered suggestions for how best to lay out any given cell, as well as the positions of shared resources. "We talked about it a lot, and it took a long time to decide exactly how to move everything," Ms. DeWitt says. "There were so many different and valid angles to consider."

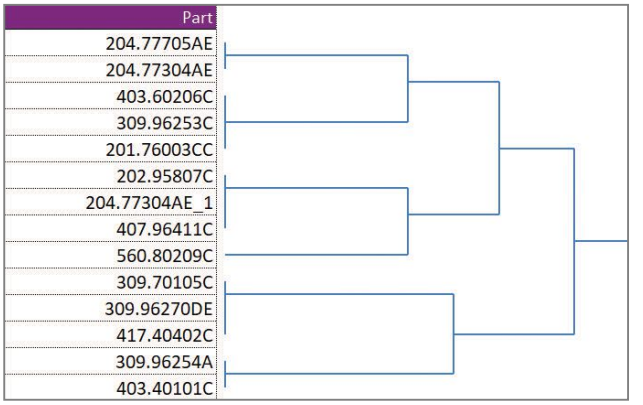
The results of their work is depicted along

LEFT: This area along "Monster Highway" serves a dual purpose: leaving ample space for the rare instances when parts protrude through the tailstocks of these lathes, and serving as an out-of-the-way staging area for small batches of WIP when they do not.

BELOW: Without the right layout, the largest tubular parts can pose a problem in aisles crowded by forklift traffic.

PFAST's PR (part-routing) analysis charts help people to spot commonalities in routings and, from there, group part families and organize machining cells. Here, "1s" denote which workstations are required to process a particular part. Workstations are defined by machine type, not machine. For example, workstation LM1 could denote that the part could go to either machine L23 or machine L24, both of which are Mazak lathes with live tooling. With conversational programming, these machines are dedicated largely to new parts, which is one reason why there are no "1s" in that column. Image: SCS.

Part	LC4	CELL1L	MC2	QC	SC1	LM1	MC3	LC6	LC5	LC1	MC1	LC8	LC3	LC2
204.77705AE				1	1				1	1	1			
204.77304AE				1	1				1	1	1			
403.60206C				1	1					1	1			
309.96253C				1	1					1	1			
201.76003CC				1	1					1	1			
202.95807C				1	1					1	1	1		
204.77304AE_1				1	1					1	1	1		
407.96411C				1	1					1	1	1		
560.80209C				1	1						1	1		
309.70105C				1	1						1			
309.96270DE				1	1						1			
417.40402C				1	1						1			
309.96254A				1	1						1		1	
403.40101C				1	1						1		1	
403.40104C_1			1	1	1			1			1		1	
104.96965AA_1				1	1				1		1			
402.60011FM				1	1				1					
309.70137DE				1	1			1	1					



In this format, PR analysis provides a tiered view of increasingly broader groupings of workstations. The top level encompasses the entire shop. Where to "cut off" and form cells is up to planners. Image: SCS.

with samples of PFAST output shown above. Workflows are more or less linear. All parts move along one of two paths: "Monster Highway" contains the large machines, cranes and wide aisles for the forklift traffic required for larger parts, while "Minion Lane" is dedicated to smaller work. Operators remain in their stations because Mr. Ngo now plays the role of "water spider," dedicating himself entirely to transporting parts as well as needed materials from the centrally located tool crib.

Understanding Capacity

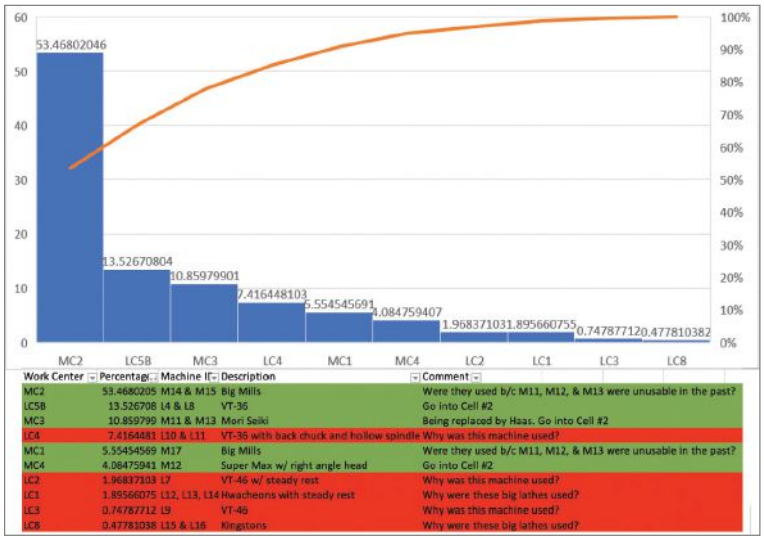
As SCS's practices and philosophies changed, it became increasingly apparent to Ms. DeWitt that the company was not taking full advantage of the skillsets on the shop floor. The result was not just lost opportunity, but also underutilized capacity.

Mr. Phillips and Mr. Ngo can recognize when two jobs share similar setups (a simple example is barstock that requires soft jaws of the same diameter). That is, they know when setting up one job will make setting up another easier and faster, thereby churning out more work overall. The problem was that these shortened setup times were never taken into account during the planning and quoting process, she says. In some cases, jobs quoted based on an expected setup time of more than an hour required less than 10 minutes.

The solution to the problem was driven by the same data that revealed it in the first place: overall equipment effectiveness (OEE) metrics from the machine monitoring system. Although wild discrepancies in cycle time projections

FROM \ TO	SAW	LC6	LC5A	QC	LC5B	LC4	LC3	LC2	LC1	LM1	MC1	MC2	MC3	MC4	LC8
SAW		3529	21751		5519	2546	900	1732	1062	2264	1277	7144	494	475	21
LC6			217	3872	246	1197	25	228	303	58	517	1713	175		
LC5A		2348		16854	1356	349	164	31	93	6	959	10837	2453	768	86
QC															
LC5B		748	2859	6669		34		21	190		521	2022	144	439	
LC4		202	1108	2103	92		146	42	158		368	526			34
LC3		33	66	1096		6			28		402	202			
LC2		284	215	2491	2	38	2				725	98	405		11
LC1		258	76	1012	438	28		1471			230	369			
LM1			1	2459							522	28			
MC1		151	512	2303	387	321	453	653	160	3		919		304	1
MC2		681	7359	7770	5101	256	143	93	1888	641	275		410	69	94
MC3		313	1241	1206	284					38	295	704			
MC4			805	868	206						42	134			
LC8		4	94	11	16	4					34	84			

From-To charts help validate choices about cell organization (numbers indicate how many part numbers move from one particular workstation to another). In this early example, created for the first cell shortly after its installation, all workflows handled entirely within that cell are grouped into the green area. The yellow area contains workflows only partially contained within the cell, and the red area contains those entirely outside it. As data accumulates, refining part families and stricter scheduling of specific part families for specific cells helps push more workflows into the "green" areas of these charts. Image: SCS.



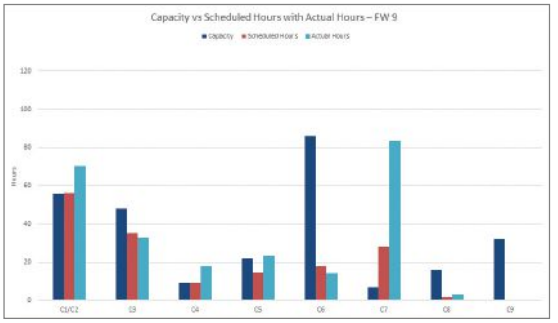
Work Center	Percentag	Machine II	Description	Comment
MC2	53.4680205	M14 & M15	Big Mills	Were they used b/c M11, M12, & M13 were unusable in the past?
LC5B	13.526708	L4 & L8	VT-36	Go into Cell #2
MC3	10.859799	M11 & M13	Mori Seiki	Being replaced by Haas. Go into Cell #2
LC4	7.4164481	L10 & L11	VT-36 with back chuck and hollow spindle	Why was this machine used?
MC1	5.55454569	M17	Big Mills	Were they used b/c M11, M12, & M13 were unusable in the past?
MC4	4.08475941	M12	Super Max w/ right angle head	Go into Cell #2
LC2	1.96837103	L7	VT-46 w/ steady rest	Why was this machine used?
LC1	1.89566075	L12, L13, L14	Hwacheons with steady rest	Why were these big lathes used?
LC3	0.74787712	L9	VT-46	Why was this machine used?
LC8	0.47781038	L15 & L16	Kingstons	Why were these big lathes used?

One insight drawn from this pareto chart was that 53.46% of parts flowing out of the cell were directed to the machines indicated by MC2, both large mills designated M14 and M15. Rather than incorporate either of those workstations, the shop opted to purchase a new mill for Cell 1. Cell 2 duplicates Cell 1 but incorporates mill M14 (which can handle slightly larger parts). As evidenced by the 13.5% of parts flowing out of Cell 1 to workstation LC5B, enough parts require Fortune VT-36 lathes to justify a nearly identical cell (Cell 2). Image: SCS.

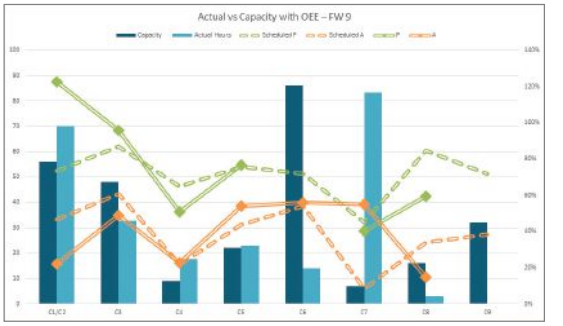
were leading planners to underbid, OEE looked good — utilization was high. However, further examination revealed that this was the case only because availability, a measure of uptime and one of the three components of OEE (the others are performance and quality), included the suspect setup time data. Tweaking the formula so that availability includes only value-added time — that is, actual in-cut cycle time — provides a better metric for determining how many hours were available to fill on a per-cell basis, even if it makes availability and overall OEE look worse.

Better was not perfect. A broken tool, a new hire standing in for a sick shop veteran, or any number of other variables could push actual raw-cut cycle times lower than the estimates used in quoting and scheduling. Alternatively, better-than-expected performance might reveal that the shop has been pricing parts too high. Rather than relying on time to heal the rift between projection and reality as jobs repeat, Ms. Dewitt began tracking each cell's performance (a measure of output over time and another component of OEE). She now creates a rolling, four-week average and multiplies this "performance factor" by the cycle time estimate of every part that crosses a cell.

As demonstrated by the charts on the next page, this process helps ensure that estimates account for the realities of production. By extension, it helps better understand the shop's true capacity and how well it is being utilized. Now, the expertise of Mr. Ngo and Mr. Phillips is backed by data that facilitates a more systematic



Ms. DeWitt created this chart and the one on the right to help understand capacity and schedule more effectively. Step one is gaging how close estimates match reality. The dark blue bars represent per-cell capacity (the total hours available for scheduling the lead-op. lathe). This is calculated by multiplying the combined cell's expected availability (uptime) by the total amount of time the shop is open for business. Here, for example, the team expected Cell 3 to be in cycle for 43% of the 98 hours it was open for business (0.43 × 98 = 48). The red bars are scheduled hours — that is, a total of every scheduled part's lead-lathe, in-the-cut cycle time estimate. The light blue bars represent the same metric, but only for jobs that actually ran. Here, we can see that Cells 1 and 2 (which are virtually identical) both processed more unique part numbers than expected, while Cell 3 processed slightly fewer. With a perfect schedule, all bars match. Image: SCS.



This chart uses overlays of OEE performance and availability metrics to illustrate why the blue bars don't match (the red bar from the first chart, having served its purpose, is removed for simplicity). For example, better-than-expected performance was not enough to make up for lower-than-expected availability on Cell 3, which could have processed more parts. In Cell 7, the more dramatic mismatch in the blue bars was due primarily to two factors: many parts with lengthy cycle times (which translates to fewer interruptions for setup), and moving a particularly skilled employee to that work station. Both boosted availability — and, by extension, the light blue "scheduled hours released" bar — above initial estimates.

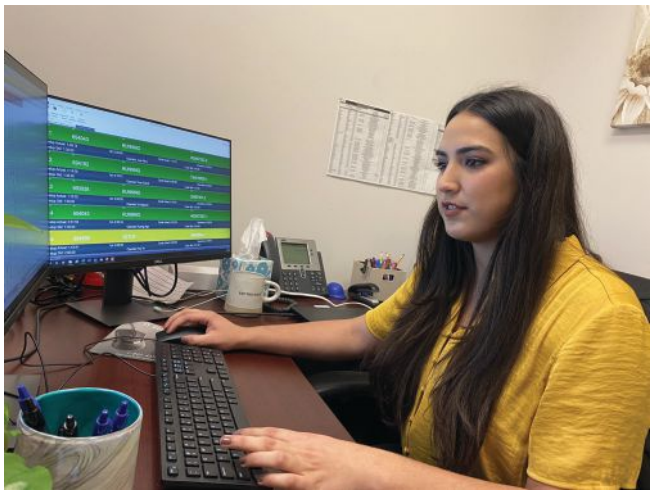
The charts help even when data is incomplete and/or imperfect, she says. For example, Cell 6 consists of two live-tool lathes dedicated to new work and programmed conversationally on the floor. As a result, there is no way to track performance (solid green), and the best the team can do for estimated performance (dashed green) is an average of all cells. In this case, the team had correctly estimated availability, so they determined that performance must have been poor. However, poor performance was not enough by itself to account for the dramatic mismatch between the blue bars. The team also had significantly overestimated capacity (dark blue). Image: SCS.

approach to scheduling that is based on real-world data. They use this capacity information along with due dates and cycle time estimates for the longest operation (almost always conducted on the "lead" machine) to schedule the shop more systematically and effectively.

Putting Data to Work

SCS's scheduling system depends on viewing OEE as more than just a passive gage on performance. Machine monitoring is an active pursuit at this shop, and it is only one of many that justify Ms. DeWitt's hire as a full-time data analyst. "Pretty much anything we can collect data on, I analyze it and figure out where we can improve," she says.

Ms. DeWitt isn't the only new person in a new role at SCS. Mr. Chretien now heads an entire team dedicated to managing work by analyzing and acting on evidence. Nicole Pham, production control supervisor, creates and maintains the schedules; plans and tracks work orders and materials; and estimates lead times, among other duties. Lokesh Ramu, manufacturing engineering manager and Ms. DeWitt's immediate supervisor, analyzes and seeks to improve all of the manufacturing operations on SCS's expansive campus, which include fabrication, assembly and other processes in addition to machining. Vanessa Urango, master planner, develops production schedules for the entire company and works



ABOVE: Setup personnel scan barcodes on every workpiece before work begins. Machine monitoring has been in place for five years, but workstation displays of performance metrics are more recent.

LEFT: Danielle DeWitt was hired full time after working at SCS as an engineering student.

closely with Ms. Pham.

The newness of Ms. Urango's and Mr. Ramu's roles demonstrate that commitment to data-driven transformation extends beyond the machine shop. Like the sponsoring of the UH class, it also demonstrates the company'srecognition that sustaining change requires an ongoing commitment of time and resources, including dedicating employees to the task.

As for the shop, "We had no real manufacturing engineering to speak of — just a few people who did the programming and made the travelers," Mr. Chretien. "Everything grew from the data and our interactions with the students. They showed us what we were missing."

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ERP Makes Documentation Fast, Paperless

EDITED BY **MATT DANFORD** | SENIOR EDITOR

COMPANY
Cox Machine

PROBLEM
Ramp up in work created overwhelming amounts of paper

SOLUTION
Shopfloor, touchscreen interfaces to ERP system data

RESULTS
Improved lead times, fewer errors, easier data tracking, faster report generation

Cox Machine produces aerospace structures in machining cells like this one, each of which is considered a "workstation" in ERP software.

Although Cox Machine had the necessary capabilities and capacity to increase aerospace parts production, something had to give. More parts meant more paper — so much more paper that, in the words of Chief Technical Officer Jason Cox, "It became ridiculous. So, we decided to eliminate all paper."

The means to this end were already in place: Global Shop Solutions' enterprise resource management (ERP) system. Now, all document distribution and control is electronic. Rather than packets of paper, machine operators view and enter data on screens installed at individual workstations. As a result, lead times have increased and labor hours are easier to track. The software also ensures that first-article documentation is ready at the same time as the work.

Customizable Dashboards, Flexible Scheduling

Originally consisting of four machines in a shop built from scrap material by Ernest "Bud" Cox, Cox Machine is now a 160-employee business that supplies aluminum brackets, ribs and other structural components to customers like Spirit Aerosystems, Cessna, Hawker Beechcraft and Gulfstream. ERP software, installed in 1997, provides the operational insight necessary to streamline operations across two separate facilities (an 80,000-square-foot building in Wichita, Kansas, where machining occurs, and a 24,000-square-foot sheet metal fabricating plant nearby).

For example, the software's flexible scheduling capabilities are particularly important. "We don't choose our delivery dates; our customers choose them for us," Mr. Cox says. "When we »

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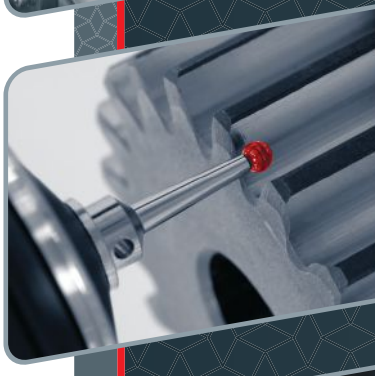

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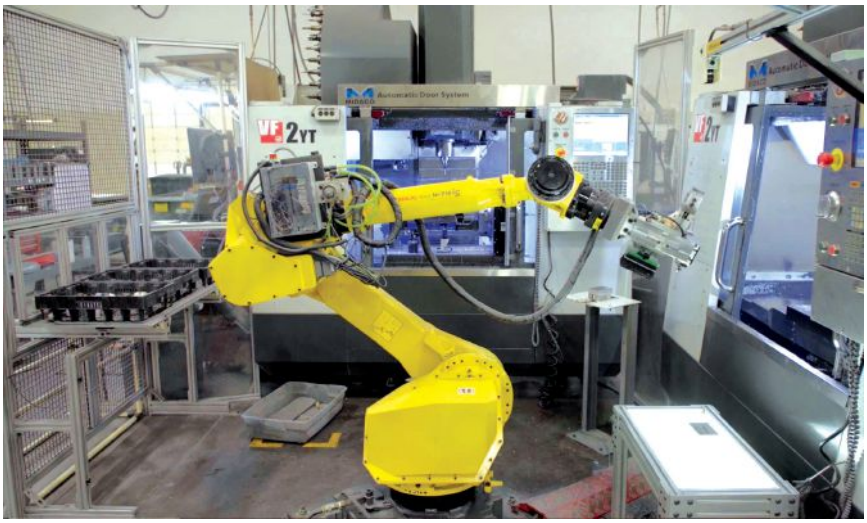

Cox Machine produces aerospace structures in machining cells like this one, each of which is considered a "workstation" in ERP software.

get conflicting delivery dates on large jobs, the system allows us to easily adjust capacity by adding shifts or moving people and workcenters around."

In addition to both quick overviews and detailed, granular data on jobs and parts, the software offers a graphical overview of capacity. This is part of the Advanced Planning & Scheduling (APS) screen, which flexes to allow partially finite and partially infinite scheduling. This helps identify potential problems before they happen. "Looking out at the first two weeks, we load up the system only for what the capacity of a machine will allow so that our dispatch lists are

Thanks to ERP software capabilities, the shop floor at Cox Machine is paperless.

accurate," he says. "But once we get a couple of weeks out, we have the ability to open it up so we can see if we have a capacity issue four, six, or even eight weeks from now."

Meanwhile, customizable ERP dashboards displayed on large screens throughout the plant help keep production on track. For example, the customer service department has a dashboard with a split screen. The left side displays a customer's inventory at its site and shows how many parts it has below its minimum inventory level. The right side lists every job that is either past delivery date or close to being there. "We have a 99+% on-time delivery rate," Mr. Cox says. "This »

dashboard screen shows the 0.5% or so where we're late as a way of helping people focus on what needs to get done."

Paperless Cuts Lead Time

The decision to go paperless was a result of reducing run quantity from six month's worth of inventory to one month's worth. This meant that the company was now creating six times as many jobs, which resulted in six times as much paper.

4 TOOLS FOR PAPERLESS

Strategies to help your shop go paperless: gbm.media/paperless.

To avoid overwhelming the shop floor with plastic packets full of drawings, routers, specifications, part lists and more, the company installed data collection touchscreen stations at every machining cell.

Upon clocking in, operators receive the workcenter's (that is, the cell's) dispatch list, which shows when the previous operation was completed as well as the order of jobs that come next. Employees can access customer and part histories; first-article inspection sheets; setup sheets with workholding and other instructions; and anything else necessary to do the job without leaving their workstations.

All of this is possible thanks to the software's Document Control functionality, which links the ERP system to more than 60 of these touchscreens. "We learned early on that the only way you can truly go paperless is for everyone to have their own station," Mr. Cox says. "Having so many stations also helps us do other things like track direct and indirect labor more accurately. Our operators even do their own inspection at their workstations."

As a result, Cox Machine has reduced its standard lead time for a regular machined part from 16 weeks to an average of four. It can even turn some parts in less than a week when the opportunity arises to set up a work cell with stock material already available in inventory.

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Challenges and Opportunities in Shaft Production

Unique characteristics of shafts create different challenges to that of cubic or flange type parts. EMAG will be taking a look at different technologies required in the manufacturing flow of shafts and also some of the unique solutions that EMAG brings to address some of these opportunities.

PRESENTER: **Kirk Stewart,** Vice President of Sales

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How One Shop Embraced Through-Tool High-Pressure Coolant

EDITED BY **EMILY PROBST** | SENIOR EDITOR

COMPANY:
Burr Oak Tool

PROBLEM:
Only small amounts of fluid made its way into drilled holes using traditional coolant delivery methods

SOLUTION:
LNS Chipblaster

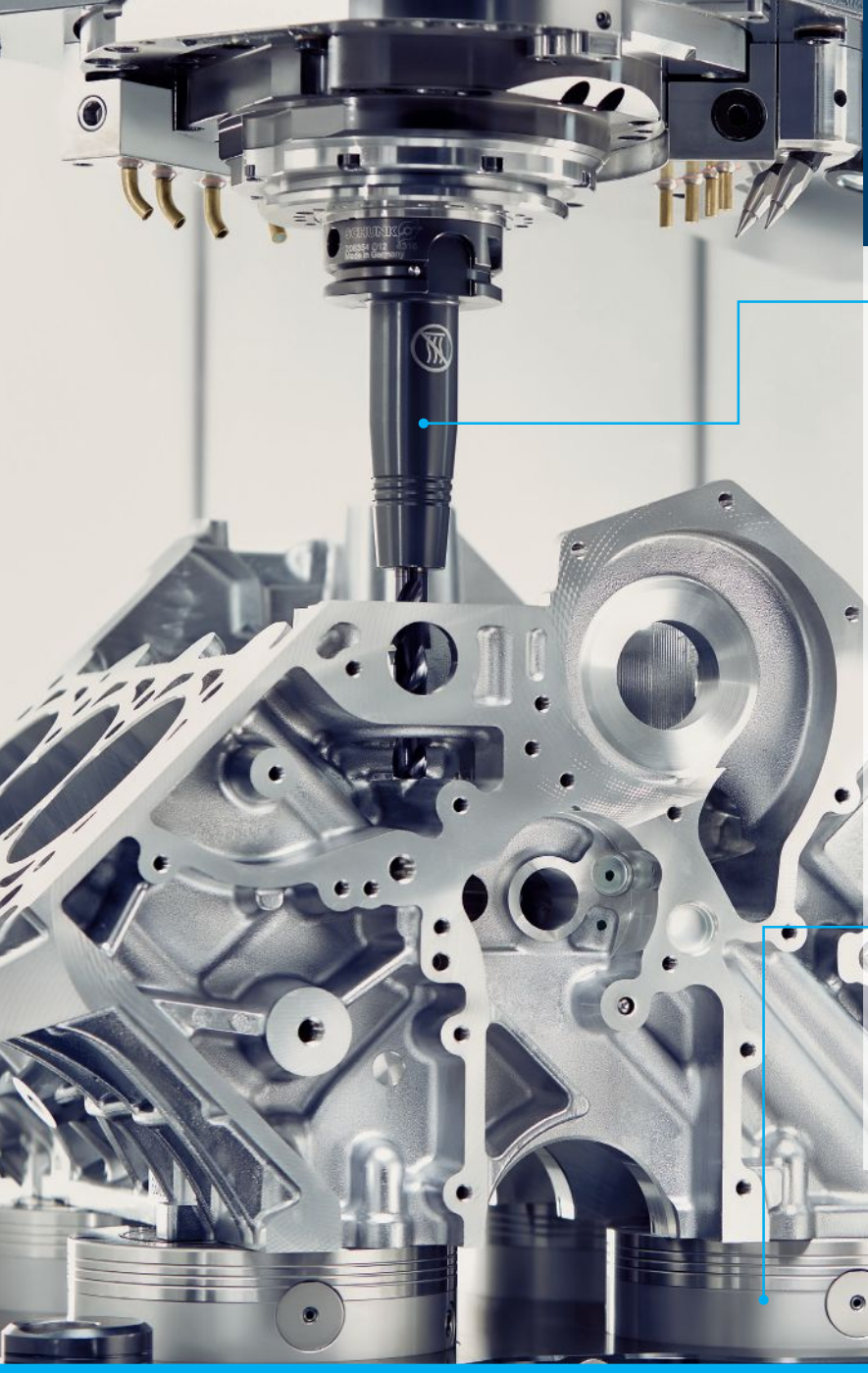
BENEFITS:
Precise coolant flow and pressure reduced cost, increased productivity and improved tool life

In many metalcutting operations, some form of coolant is necessary to reduce cutting temperature and tool wear. This has become especially important as spindle speeds increased through the years. Today, virtually all CNC machines are (or can be) equipped with coolant delivery systems. The conventional approach is to spray the coolant, either at moderate or high pressure, directly onto the workpiece where the cutting takes place. However, this method fell short for Burr Oak Tool in Sturgis, Michigan.

The company was founded as a general machine shop in 1944, but it found a new direction in 1952, when a customer asked it to design and build a special machine to make condenser coils for air conditioning units. Today, with more than 300 employees and 420,000 square feet of floor space across three production facilities, Burr Oak Tool supplies special machines and tooling to users of air conditioner evaporator condenser coils in more than 70 countries.

Over the years, the company sought to continuously refine its processes to reduce cost and increase productivity. In the mid-1980s, it began experimenting with through-tool, high-pressure coolant delivery on its high speed steel drills. »

Pushing coolant through the center of a tool to the cutting area more efficiently cools the workpiece and lubricates the drill.



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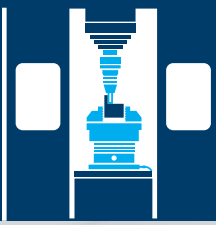

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"We knew that the primary benefits of applying machine coolant were to control the temperature of the workpiece to allow faster speeds and feeds, as well as getting longer life out of the cutting tools," says CEO Newell Franks II. "Using the traditional method of flooding the cutting zone wasn't getting the job done for us. I knew that gundrills used through-hole coolant, so I decided to see what it would take to adapt that method to what we were doing. To get started, I reached out to our hydraulic component supplier and used some of its products to test my theory," Mr. Franks says.

GETTING TO 168

For unattended machining, this shop had to overcome challenges related to chips and coolant: gbm.media/168.

Testing a Theory

His theory centered on the fact that twist drills pull material out of the hole as they work, which means that simply spraying coolant at the work area allows only small amounts of fluid to drizzle into the hole as it works against the pumping action of the drill. Instead, he wanted to try forcing the coolant through the center of the tool to the cutting tool point so it could more efficiently cool the workpiece and lubricate the drill. As a bonus, he would learn that this action also flushes chips out of the hole, thus avoiding re-cutting, which can lead to premature tool wear.

During initial experimentation, Burr Oak Tool ran pressures ranging from 200 to 700 psi. It also used multi-stage centrifugal pumps to raise pressures to about 250 psi. The initial results were very promising, Mr. Franks says. After seeing positive results on the drilling machines, the company decided to turn its attention to the milling machines. It modified its milling cutters to pump the coolant into the pocket, cooling more uniformly, eliminating thermal shock and more effectively evacuating chips.

From Theory to Reality

"When our experiments proved successful, we began looking for available high-pressure delivery machines," Mr. Franks says. "We tried a few brands that didn't perform to our expectations, »

Burr Oak Tool currently has 30 machine tools equipped with LNS ChipBlaster high pressure systems.

and then we purchased our first ChipBlasters in 1994. We found that these units performed significantly better, lasted longer and required less maintenance. The LNS ChipBlasters allow us to run 1,000-psi coolant on all of our machines with coolant filtration levels of 1 micron. This combination has allowed us to turn hours into minutes and minutes into seconds when machining steel and aluminum parts," he says. Over the years Burr Oak Tool has purchased 60 ChipBlaster high-pressure systems, adding one to each new machine it installs.

When the company first began working with ChipBlaster machines, it experimented with pressure and flow on various applications. By consulting ChipBlaster charts that listed the number of gallons of coolant that flows through various-size orifices at 1,000 psi, Burr Oak Tool realized that some of the larger drills and milling cutters it used would require greater volumes of coolant. The company then built special flow gages that mounted on the spindle or mill toolholder to measure precisely how many gallons per minute they needed to deliver and shared this data with ChipBlaster.

Burr Oak Tool determined that its CAT 40 machines required 13 gpm and the CAT 50 machines needed 21 gpm to achieve more consistent pressure and cooling, so ChipBlaster changed the pumps accordingly. By delivering the precise amount of flow and pressure, Burr Oak Tool saw improved tool life and faster throughput.

One example of the benefits of through-tool high-pressure coolant at Burr Oak Tool is with a stripper plate for a die that requires 3,200 holes drilled into 34-HRC 4140 steel. The holes are 1 mm in diameter and 6 mm deep. These are starter holes through which EDM wire is threaded. Originally, this process involved a solid drill and typically produced a number of broken drills and required a lot of pecking. Using the ChipBlaster to deliver high-pressure coolant through a single drill enables the machine to create all 3,200 holes with no pecking. This method, combined with using a speed head, cuts production time from between six to eight hours down to just 40 minutes.

Because applications like this one require drilling very small holes, the ChipBlaster units are equipped with 1-micron filters that eliminate tiny particles that could clog the small tools.

"When people ask me about how through-tool high-pressure coolant delivery helps our

For one die part, which was run on this Mazak VMC equipped with the ChipBlaster high-pressure system, switching from a solid drill to a through-hole drill reduced production times from between six and eight hours to just 40 minutes.

production, I tell them it's as simple as this: With the right equipment, like the LNS ChipBlaster systems, we can cut steel like it's aluminum and aluminum like it's wood," Mr. Franks says.

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Ease of Use Is Key for Shopfloor CMM Inspection

EDITED BY **EMILY PROBST** | SENIOR EDITOR

COMPANY
Flying J Machine

PROBLEM
CMMs aren't used if only one person knows how to run it

SOLUTION
Keyence's XM series of CMMs

BENEFITS
Simplified inspection, more widely used

Although Flying J Machine has a coordinate measuring machine (CMM), company President Jay Hegemann found himself in a predicament. "With CMMs, there's usually one guy who knows how to run it," he says. "And unless you have a large shop where it's being used all the time, I think most CMMs end up like mine — expensive dust collectors."

Since this was the reality for his shop, Mr. Hegemann paid particular attention when he received an email about Keyence's XM series handheld probe CMMs. After bringing in a specialist for a product demo, Mr. Hegemann ordered an XM and has been reaping the benefits of a simplified inspection process ever since.

A Self-Taught Machinist

Flying J Machine has been in business since 2000. The Escondido, California, company has nine employees, nearly 8,000 square feet of floor space and a variety of modern equipment. This includes several »

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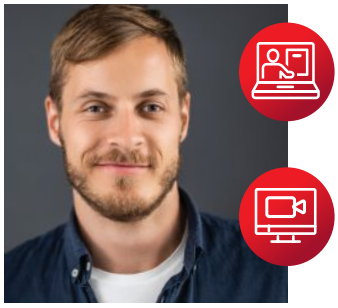

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Haas CNC machining centers and lathes, a Mitsubishi wire EDM, laser cutting equipment and a small-hole EDM. Much of its work serves oceanographers — mostly instruments that measure water properties — but the shop also has customers in the semiconductor, communications and defense industries.

Mr. Hegemann is self-taught. While working in his father's small product development company during his early 20s, Mr. Hegemann convinced his father to buy a CNC knee mill. Over the next six months, he read the manual and began making prototypes for his dad. When a local business asked him to machine some parts, he jumped at the prospect. Since then he's gone off on his own, continuing to add capabilities to his growing company, even though he's often had to stay up all night learning a new skill or mastering a machine tool.

GAGING A NEW CMM PURCHASE

Check out part 1 of a three-part guide to buying a new coordinate measuring machine (CMM): gbm.media/buyacmm1.

No Need for Training

One such capability is the aforementioned CMM. According to Mr. Hegemann, the problem with such equipment is that it uses PC-DMIS, which requires a fair amount of training to learn. "So you send someone out to class thinking they'll train everyone else when they get back, but then that person quits, or if he does train other people, those people use it so seldom that they forget how," he says.

Because of this, it was critical for Mr. Hegemann to find measuring equipment that anyone could use without the need for complicated programming and extensive training. When Keyence's local XM specialist brought the system in for a demonstration, Mr. Hegemann knew a good thing when he saw it. "The writing was on the wall," he says. "The XM is fast, accurate and easy to use. I ordered one that day."

The Keyence XM series CMM is small enough to fit on a bench, but thanks to its movable stage and handheld probe, it can measure large and complex parts. According to the company, it has a simple user interface with an extensive but easy-to-understand list of measurement options. Tools such as lines, points, circles and planes are displayed on the screen, walking the

This is the shop floor of Flying J Machine, where the XM series can be used by machinists right next to mills to quickly spot-check or fully inspect their parts.

user through the measuring process while providing geometric dimensioning and tolerancing (GD&T) functionality, virtual figures, statistics and trend analyses, deviation display, and other advanced features. »

“I can’t really say how much time it saves, because it’s more a case of something that is actually being used compared to something that’s not being used.”

– JAY HEGEMANN, *President, Flying J Machine*

Mastering Measurement

Mr. Hegemann says the XM is simple enough to use that his company skipped the training offer from Keyence and got right to work. Everyone in the shop has since gained the ability to check their own parts with just a few minutes of instruction. “It’s so much better than our old CMM,” he says. “You just walk up, click on the appropriate icon, and you measure a bore, the distance between holes, flatness, whatever. I can’t really say how much time it saves, because it’s more a case of something that is actually being used compared to something that’s not being used.”

To those who may be skeptical of the handheld probe (as Mr. Hegemann was, initially), he says the XM is incredibly accurate. “I wasn’t sure at first, so I grabbed a 1.4375-inch ring gage, which is ground to within 50 millionths (0.000050 inch), and started checking. Every time I measured it, the Keyence XM was within a tenth (0.0001 inch) of what it was supposed to be. You don’t have to be super careful; you just hold the probe to the surface, apply a little pressure, hit the button, and move on to the next point. It’s the real deal.”

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Tooling and Workholding

Corner Radius Increases Edge Stability

Walter USA's MC232 Perform solid carbide milling cutters feature a corner radius and reduced neck to improve performance in difficult-to-access geometries. The corner radius is also said to improve tool life by increasing edge stability, while the reduced neck enables milling at a wider variety of cutting depths.

Available in diameters ranging from $^{1}/_{8}$" to $^{3}/_{4}$" and from 2 to 20 mm, the MC232 can be used for most typical milling applications such as shoulder milling, slotting, pocket milling, helical plunging and ramping in various materials. According to the company, the tool is best suited to small and medium batches of steel, stainless steel and cast iron parts.

Walter USA LLC | 800-945-9554
walter-tools.com/us

Center Jaw Enables Vise To Hold Two Workpieces

Hoffmann Group's Garant Xtric centering vise now includes a center jaw and is available in four new base lengths. Size XS has a base length of 136 mm for processing small components. Sizes XS, S and M are now available with a jaw width of 80 mm. Vises with a jaw width of 125 mm, 32 kN of clamping force and lengths ranging to 270 mm are available for these sizes. All models are alternatively available with pivot jaws.

The Xtric can be converted to a double vise by changing the standard spindle bearing and inserting the center jaw, as seen to the left. The jaws, which can be rotated 180 degrees and interchanged with micron-level precision, are then put back in place. A click mechanism speeds this process, while Garant gripper jaws enable blanks to be clamped without pre-stamping, says the company.

Top jaws suitable for the Lang positioning system are available. All models are equipped with an Endutec automation interface, which can be used as a coolant hole, as well as gripper mounting holes on both sides. The Xtric device can also be equipped with adapter plates for use with zero-point clamping systems.

Hoffmann Group USA | 844-448-7725 | hoffmann-group.com

Miniature Clamp Grips Small Parts Securely

Schunk's Vero-S NSE Mikro 49-13 is a completely sealed miniature clamping module designed for metalcutting, assembly, material handling and measurement applications. The module measures 49 mm in diameter, with a 13-mm height above table.

The clamping module is actuated with an axial piston, which is said to result in high pull-down forces despite the device's compact dimensions. The dual-stroke drive system achieves pull-down forces ranging to 1,500 N by using the integrated standard turbo function. Depending on the thread size of the 10-mm diameter clamping pin, holding forces range from 3,000 N (M3) to 5,000 N (M4). Self-retaining, form-fitting locking is performed mechanically via spring assembly.

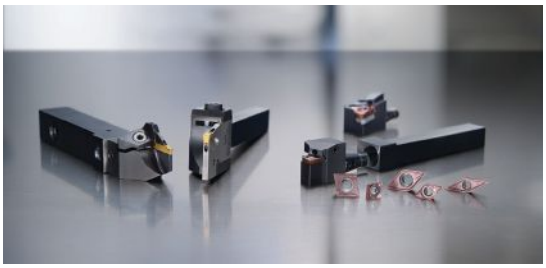
The position of the clamping slide is detected through dynamic pressure monitoring, making the module suitable for metalcutting and automation applications. A 6-bar pressure system is sufficient for the module's pneumatic function. All functional parts are made of stainless steel.

Schunk Inc. | 800-772-4865 | us.schunk.com

Toolholder Increases Swiss-Type Insert Indexing Efficiency

Seco's modular QC (Quick-Change) toolholders for Swiss-type machining are designed to enable fast, easy and repeatable insert indexing and tool changes outside of tight machine workspaces. For ease of use, the QC toolholder allows users to remove both cutting heads and inserts as a single assembly, then index and »

reinstall them. Manufacturers may also use this system to exchange cutting heads and inserts with a second set more efficiently. The cutting head also features double carbide pins for accurate, consistent and secure insert mounting and indexing.



The line includes cutting heads for general ISO turning, multi-directional turning (MDT), threading and parting off. Shanks are available in metric sizes of 10, 12 and 16 mm, and inch sizes of 0.375", 0.500" and 0.625".

The toolholders also feature Seco's Jetstream Tooling and Jetstream Tooling Duo technology for chip control, surface finish quality and extended tool life. Jetstream Tooling directs high-pressure coolant through the QC Toolholder to the cutting zone. Jetstream Tooling Duo, available on a selection of cutting heads, adds a second coolant channel to the underside of the holder. The second coolant channel can be switched off if needed.

Seco Tools LLC | 248-528-5200 | secotools.com/us

Extra Teeth Boost Reamer Feeds

Monaghan Tooling Group's Top Speed Ring is a reamer designed to provide higher feed rates than traditional »

cutting rings. The modular tool requires no setting and is ready to use out of the box, the company says. According to Monaghan, the Top Speed Ring is ideal for high-speed reaming applications, long production runs, large-hole reaming and cases in which precise, repeatable reaming is required.

The tool is available in diameters ranging from 50.600 to 225.000 mm (1.9921" to 8.8583"). Four extra teeth compared to expandable rings allow for faster cutting with better surface finishes and roundness, the company claims. The reamer comes in solid, straight or left-hand flute designs in a variety of coatings and geometries, including specials.

Toolholders come with internal coolant channels. The Top Speed Ring holders are made with either cylindrical shanks or module connections for runout compensation. The reamer also can can be repaired or retipped.

Monaghan Tooling Group | 800-732-4565 | monaghantooling.com

Gundrilling Guide Pads Resist Breakage

Tungaloy's DeepTri-Drill line of indexable gundrills now includes FH3135-grade guide pads. These guide pads were developed specifically to enhance thermal crack resistance when machining with water-emulsifiable oils.

DeepTri-Drill is a line of indexable-insert gundrills designed for productivity and application security when drilling deep holes while eliminating the need for regrinding.

The tribological conditions during gundrilling between the guide pad surfaces and the wall of the hole being drilled are far more severe than those during other applications, Tungaloy explains. While straight cutting oils have long been preferred, more manufacturers are using more environmentally conscious water-emulsifiable or soluble oils over petroleum-based coolants. These oils have lower lubricity and can adversely affect the guide pad quality during gundrilling.

The dedicated carbide substrate of the FH3135 guide pad provides enhanced resistance to fracturing and thermal cracking, reducing the risk of guide pad breakage for use with these lower-lubricity oils. In addition, the new guide pad features a double-chamfer geometry on the corners of both ends, smoothing entry into the guide bushing or pilot hole to limit vibration impact and further decrease the risk of rupture.

Tungaloy America Inc. | 888-554-8394
tungaloy.com/us

Drilling Units Cut Various Light Materials

Suhner's EconoMaster drilling units are suitable for multiple materials, including light metal, wood, composite, plastic and foam. The drilling unit features low power and air consumption, an adjustable motor housing, adjustable total stroke ranging to 4", a hydraulic feed control cylinder, a J33 taper spindle end, 0" to $^1/_2$" drill chucks, electric front and rear position limit switches, a belt tensioner, and a chrome-plated quill.

Other features include adjustable feed stroke of $^1/_2$" to 3"; 400-lb thrust at 85 psi; operating pressures ranging to 110 psi; TEFC/IP56 protection; standard 230/460-V power; concentricity of 0.002" total indicator runout; speeds ranging to 9,600 rpm; and an air connection retract/advance of $^1/_4$" to 27 NPT.

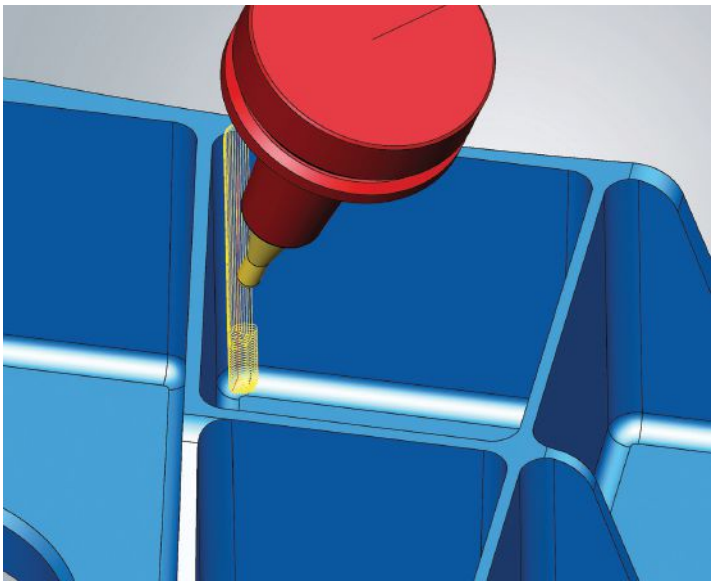
EconoMaster drilling units can be supplied with an adjustable stand, inline vertical configuration and a range of spindle and toolholder options.

Suhner Industrial Products Corp.
706-235-5593 | suhner.com

JEDD COLE | EDITOR | jcole@mmsonline.com

Systems and Software

Five-Axis Strategies Improved



Open Mind Technologies' HyperMill 2020.1 features enhancements to 3D and five-axis machining as well as new automation and additive manufacturing strategies.

Corner Rest Machining strategies for 3D and five-axis techniques provide benefits in complex machining applications, including mold and die. Corners can be machined largely by vertical stroking motions. Afterward, traditional Z-level steps can be used to blend with the vertical section and the lower floor area. The top section has an automatic surface extension to enable the production of sharp edges.

A 5-Axis Blade Tangent Milling strategy is designed to improve surface quality when milling with conical barrel cutters that have a large primary angle.

The Mill-Turn module's Automatic Contour Feature Splitting functionality enables HyperMill to automatically determine the area to be machined based on the turning contour. The grooving job will automatically recognize if a contour is a groove, making it faster and easier to program certain areas.

HyperMill's Automation Center enables users to automate the job list creation processes in hyperCAD-S, serving as both a development and runtime environment. New features also include the ability to select and position the clamping device,as well as to define a uniform process for all programmers.

HyperMill's Additive Manufacturing enables provides efficient hybrid processing with simultaneous additive manufacturing and subtractive machining on one machine tool. The software offers flexible strategies for additive material applications, including filling strategies for both planes and freeform shapes and in 2D and 3D sections. Applications also include hybrid machining to fix damaged parts and additive machining on an existing component.

Open Mind Technologies USA Inc. | 888-516-1232
openmind-tech.com

Vibration Sensors Operate, Channel Data Wirelessly

VocalZoom's autonomous sensors combine contactless, high-resolution vibration sensor technology with built-in data processing and wireless communications for low-cost and fast deployment of monitoring applications in Industrial Internet of Things (IIoT) environments. The laser sensors measure motion and vibrations of a surface to enable industrial manufacturers to monitor the real-time health and performance of engines, turbines, pumps and more. Because of their compact and contactless form, the sensors can function on hot, wet and moving surfaces, and they can continue to analyze mechanical health through glass, according to the company. The autonomous sensors also include built-in real-time data processing and decentralized data logic powered by Ucontrol's uPC platform, offering a standalone solution for edge processing and data »

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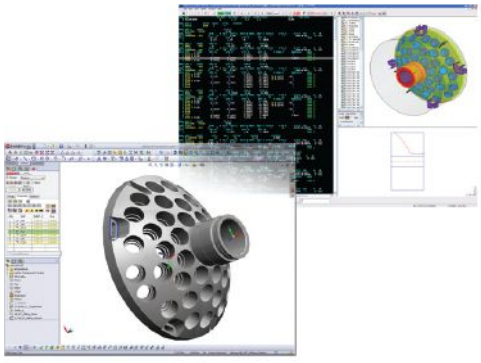

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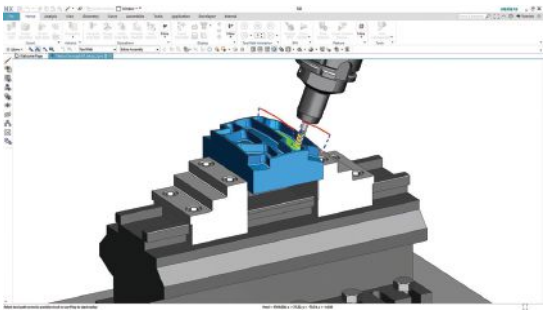
analytics. The system can connect to a computer in the manufacturer's production line or to an internal or external cloud.

Combining VocalZoom's sensor and data processor into one unit allows the autonomous sensor to measure and analyze results without additional products. This makes it a more affordable alternative to many other solutions on the market, the company claims. Even while calculating rpm, thickness, vibration anomalies, height, rotation, homogeneity, weight and flow, the optical sensors don't influence the product itself, resulting in more accurate readings. Unlike traditional monitoring systems, VocalZoom says, the sensors are not susceptible to ambient noise or vibrations.

The autonomous sensor enables automatic wireless LAN setup; provides real-time alerts via text and email; connects directly to on-premise computers or programmable logic controllers; streams raw data to a secured gateway over wireless (optional); provides customizable dashboards for monitoring; and applies power management capability for low battery power consumption.

VocalZoom | vocalzoom.com



Cloud-Based Software Includes CAM, AM and NC Postprocessing

Siemens Digital Industries Software's NX platform uses cloud-based technology to power robot programming, 3D printing, and CNC programming and postprocessing. The platform includes NX CAM, NX Additive Manufacturing and Post Hub.

NX CAM software's 5-Axis Adaptive Milling, an advanced roughing strategy, enables high material removal rates using fewer setups, resulting in shorter machining times, the company says. The 5-Axis Guiding Curves finishing strategy now includes parametric tool axis interpolation for better tool axis control and surface finish.

Robotic programming now enables users to program and simulate multiple robots performing machining tasks such as drilling, deburring and polishing.

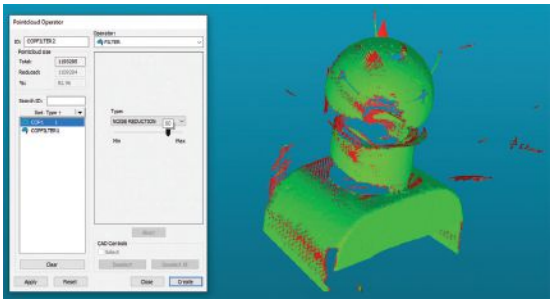
NX Additive Manufacturing facilitates the AM process from design model to printed part, the company says, with integration designed to eliminate the need to convert and remodel parts between applications. The Siemens HP MJF Build Processor enables printing of color parts directly out of NX without the need for third-party build processors. It supports the HP Multi-Jet Fusion (MJF) 5200 and 540 color 3D printers.

Post Hub is a cloud-based postprocessing system designed to streamline the generation of production-ready CNC programs. Fully integrated in NX CAM and with more than 1,000 postprocessors, Post Hub can help manufacturers generate programs for a range of CNC machine and control configurations, the company says.

Siemens Digital Industries Software | 262-312-2720
plm.automation.siemens.com

Software Eases Use of Portable Measuring Arms

PC-DMIS 2020 R1, available from Hexagon's Manufacturing Intelligence division, offers new features and capabilities as well as an enhanced user experience for portable measuring arm operators and those who scan and create point cloud data.



Guided Portable Execution streamlines the creation and execution of contact Auto Features. This is said to take the guesswork out of manual measurement paths by guiding the user through the measurements, showing where measurement points need to be taken in red and points already captured in green, while automatically scaling and rotating to the active Auto Feature. Users of scanning devices can now show the point cloud data as a mesh display, selecting a predefined profile from the portable scanning widget toolbar. The point cloud noise reduction filter automatically removes any points too far away from the global cloud. Filter sensitivity is adjustable.

The Protect feature, introduced in PC-DMIS 2019 R1 to help users version-control their measurement routines and add levels of traceability to their processes, has been enhanced with the addition of a Supervisor role. Ideal for companies that follow a multi-level approval process, this feature enables restrictions on who has the authority to certify or reject measurement routine changes submitted by the programmer.

Home Page was introduced in PC-DMIS 2019 R2, offering a more intuitive way for the user to manage and access their routines with links to resources, information and forums on the PC-DMIS home screen. In 2020 R1, this has been improved with the addition of example measurement routines and preloaded best practice templates, as well as the capability for users to create and share their own templates.

Hexagon Manufacturing Intelligence | 800-283-3600 tesatechnology.com

JEDD COLE | EDITOR | jcole@mmsonline.com

Modern Equipment Review

Multi-Sensor Machine Measures Microscopic Part Features

Mitutoyo America's MiScan, a multi-sensor microscopic form measurement system, combines coordinate measuring machine (CMM) and optical measurement technology. The MPP-Nano probe can use styli with diameters as small as 125 microns to measure details of parts ranging from optical components to precision punches and dies. The observation camera is said to ease measurement setup. The SP25M scanning probe is also supported, enabling measurement of small and large workpieces and features.

The system uses the same image head as Mitutoyo's Quick Vision measuring system. The Quick Vision Apex lighting system is also incorporated, providing multiple lighting functions and evaluation software.

The MiScan enables efficient, high-accuracy measurement of miniature optical tubes for micro camera arrays. The MPP-Nano can also measure the contour of high-degree aspheric lenses used in vehicle-mounted cameras.

Previously, efficient scanning of microscopic gear teeth has been difficult, the company says. The MiScan, together with the MPP-Nano, addresses this application. The user enters each nominal using GearPak, Mitutoyo's gear teeth evaluation software, to evaluate the tooth profile error and tooth trace error.

| Mitutoyo America Corp. | 630-820-9666 mitutoyo.com

Dust Collection Filter Saves Energy

The ProTura SB from Parker Hannifin is a nanopleated dust collection filter designed for a variety of applications. It features a 100% synthetic base media with a nanofiber layer applied to the collection surface. The SB nanocoating is said to increase filter life when compared with filters using spunbond polyester filter media. The Protura SB is also said to enable higher efficiency and greater energy savings with lower average differential pressure over the life of the filter. The nanofiber layer in this pleated filter is durable against abrasive particulates.

| Parker Hannifin | 800-272-7537 | parker.com

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Large-Part Machining Center Features Space-Conscious Design

Mazak's FJV-35/80 double-column VMC is designed to provide high precision over extended periods of operation with intelligent CNC functions and rigid construction. Suitable for industries such as aerospace, construction, die/mold and heavy machinery, the FJV-35/80 accommodates workpieces weighing up to 6,614 lbs on its 88.19" × 29.53" worktable. The machining center's design eliminates the spindle overhang often incorporated in C-frame vertical machining centers and facilitates convenient loading/unloading of large workpieces, the company says.

The FJV-35/80 can be equipped with a 50-taper, 50 hp, 10,000-rpm integrated spindle that generates up to 433 foot-pounds of torque for cutting large cast iron, steel and aluminum workpieces. Other options include a 7,000-rpm high-torque spindle for heavy-duty machining of steel or cast iron as well as an 18,000-rpm CAT 40 spindle for efficient machining of aluminum and other nonferrous materials.

The XYZ machine axis travels measure 78.74", 31.50" and 25.98", respectively. Rapid traverse speeds are 1,574 ipm in the X and Y axes and 1,181 ipm in the Z axis. A 30-tool magazine helps reduce setup time and enables use of redundant tooling for unattended production.

With the machine's Mazatrol SmoothG CNC, users can generate programs for processing complex parts through off-centerline machining as well as angled drilling, milling and tapping. It uses EIA/ISO and Mazatrol conversational languages in addition to advanced programming functions.

Mazak Corp. | 800-231-1456 | mazakusa.com

Compact Laser Marker Meets High Production Demands

Foba Laser's Y.0200-S laser marking device features a compact design for greater versatility. The system is said to be ideal for demanding production schedules, especially in the electronics and automotive supplies or metal and plastics processing industries. The Y.0200-S can keep pace with legal ID specifications and provide a high level of code contrast and durability, even on robust, high-density materials, the company says.

The 20-W fiber laser can be used with a 6-mm marking head for high speed or a 10-mm marking head for fine detail. The system can mark as fast as 1,300 characters per sec. with the 6-mm head or 1,000 characters per sec. with the 10-mm head. The marking head can be oriented between 0 and 90 degrees for reaching tight spaces.

The Y.0200-S is equipped with Foba Go touchscreen control software and an IP65-rated 10.1" color screen. The device can also be used via web browser.

| Foba | fobalaser.com | 630-694-3243

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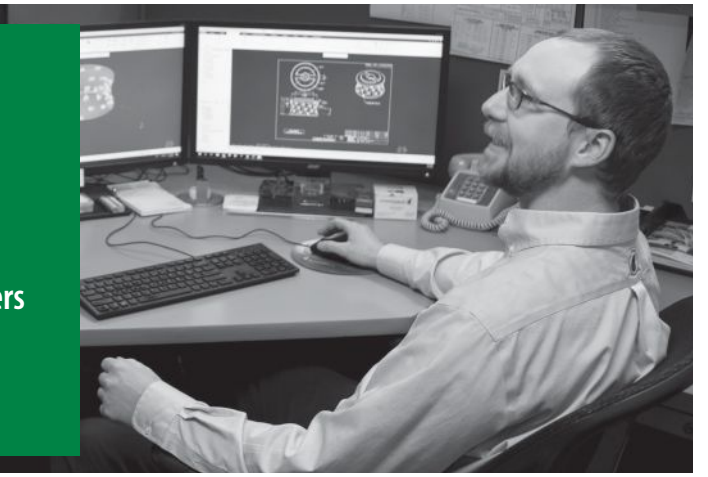

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Metalworking Activity Collapses as Coronavirus Forces Broad Economic Contraction

The reading hits a record low as new orders contract, exports shrink and unemployment soars.

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A.C. Michael Guckes, MBA
CHIEF ECONOMIST/
DIRECTOR OF ANALYTICS—
GARDNER INTELLIGENCE

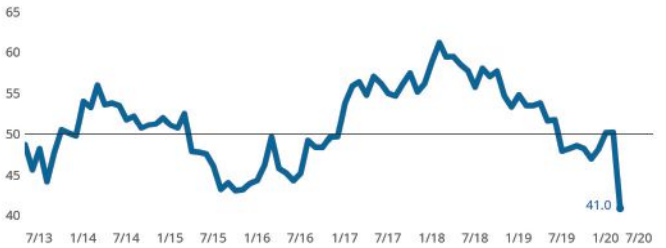
Michael has performed economic analysis, modeling and forecasting work for nearly 20 years. Gardner Intelligence is a division of Gardner Business Media, publisher of this magazine.

With a reading of 41.0, the Gardner Business Index (GBI): Metalworking reported the lowest reading in its more than eight-year history. Gardner Intelligence's review of the six underlying industry components — whose average is calculated for the reading — observed all-time lows for new orders, exports and employment.

It is important to remember that these readings represent the *breadth*, not the *rate*, of change, indicating only that a large proportion of metalworking manufacturers reported some decreased level of business activity. The readings do not show the magnitude of that decrease.

The reason supplier deliveries moved higher has to do with how the supplier delivery question is asked (responses are either "slower," "same" or "faster"). In normal times, when demand for upstream goods is high, supply chains cannot keep pace with these orders. The resulting backlog of supplier orders thus lengthens their delivery times.

METALWORKING BUSINESS INDEX



The metalworking industry has not been spared from the forced closure of much of the world's economy in order to battle the coronavirus. After reporting a nascent rebound in economic conditions earlier in 2020, the Metalworking Index plummeted to an all-time low in March.

MANUFACTURERS REPORT LENGTHENING SUPPLIER DELIVERIES WHILE NEW ORDERS FALL TO ALL-TIME LOW

Survey respondents reported a steep contraction among most elements of business activity. The reading for supplier deliveries moved higher as supplier deliveries slowed due to the massive economic disruption being caused by COVID-19. In normal times, the supplier deliveries reading moves higher when suppliers' backlogs grow, causing longer delivery times.

Index readings above 50 indicate expanding activity while values below 50 indicate contracting activity. The further away a reading is from 50, the greater the magnitude of change in business activity.

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