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PACON is a Top Shop recognized by Modern Machine Shop magazine for its Precision Machining 4.0® shop floor practices.

Precision Machining 4.0 achieves Digital-to-Physical manufacturing through our operationally comprehensive implementation of lean manufacturing principles with Industry 4.0 technologies to produce lower cost, quality precision machined components for both prototype and production.

Precision Machining 4.0 seeks a seamless interconnection of Digital-to-Physical manufacturing: physical components produced and verified from a customer's digital files with PACON's Computer Aided Manufacturing (CAM), Numerically Controlled (NC) toolpath simulation, agile production automation, autonomous inspection, and value chain integration for the highest total value delivered to our customer.

For more information on PACON and Precision Machining 4.0 visit www.paconquality.com.

PACON MFG, INC

SHOP SOLUTIONS

Getting Precise With Precision Machining 4.0®

The Internet of Things is a concept the folks at PACON Mfg Inc., Livermore, Calif., takes seriously. Serving mostly OEM customers and Defense Primes in the development of electronic and motion control components, the company has spent several years optimizing its digital-to-physical manufacturing of high-complexity, precision components.

PACON was started in 1977 by veterans of the microwave electronics industry. It produces a broad range of precision motion components for semiconductor equipment, microwave and structural components for space and defense, and electro-optical system components for life science equipment. According to CEO Steve McClure, "Our DNA is in precision components for mission-critical applications."

McClure said PACON works under an overarching approach referred to as "Precision Machining 4.0," which he defines as "digital-to-physical manufacturing through our operationally comprehensive implementation of lean manufacturing principles with Industry 4.0 technologies." The approach spans the selection of machine tools, how we use them to change the manufacturing process, and our selection of software on the digital-physical side of that, particularly digital.

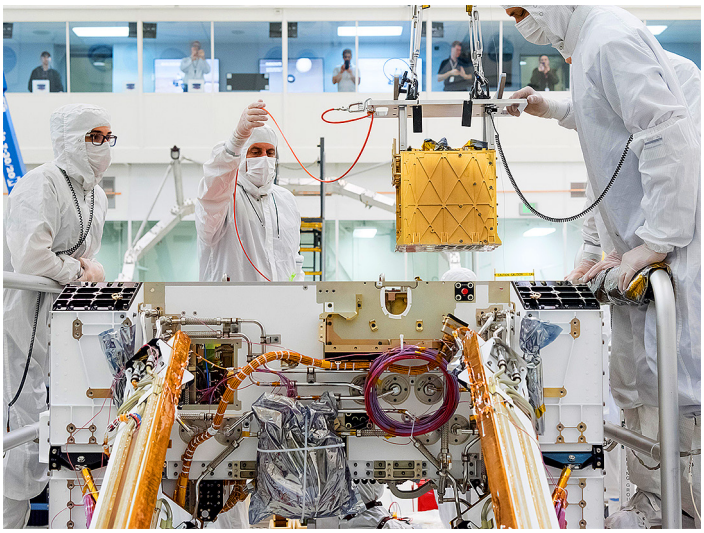
"Precision Machining 4.0 isn't just how we operate," McClure asserted, "it's what has made us the company we are today."

Focused on Digital

PACON specializes in manufacturing close-tolerance components and parts from most materials, mainly aluminum. McClure said that the part complexity for most customers is typically on the higher side. Its customers are usually pushing the envelope in innovation. For them, quality is beyond essential. It's critical. Think of parts for the 2020 Mars Rover, COVID-19 diagnosis automation and vaccine research, missile guidance, and target acquisition electronics.

"Keeping our focus on digital-physical has been key in meeting our customers' expectation of quality, especially as we went from three-axis machines to five-axis," McClure noted. (PACON switched to five-axis in 2015, aiming to decrease scheduling complexity and simplify set-ups while minimizing yield loss).

Making high-quality, complex components required the company to carefully orchestrate changes to its machine tools and software. Since 2000, PACON had been using Mastercam CAD/CAM software from CNC Software LLC in Tolland, Conn., for milling. When PACON moved to five-axis, the company considered alternatives but chose to stay with Mastercam, partly because it didn't want multiple platforms and because PACON thought that new software features would provide a competitive advantage.



PACON delivered more than 50 components for the Mars 2020 Rover Perseverance including those used in the Mars Xoygen In-Sitsu Resource Utilization Experiment (Provided by MOXIE).

Conditions brought on by the pandemic caused many shops to revisit their practices, evaluate internal and external digital processes, and make changes out of necessity, noted Ben Mund, senior market analyst for CNC Software. "PACON has been embracing that process for years, strengthening interoperability between systems and increasing output. They're a great shop to look to as an example," Mund said.

"As we took on five-axis machining, we found new sets of features in Mastercam to help us do those new things," McClure explained. "Keeping in mind that ours is a digital-physical process, on the front end, we want to do as much as possible in the software. Given that our customers usually give us a STEP file, with Mastercam's integrated SOLIDWORKS reader we can program right off the solid file in the software, which really streamlines the time. So, already in the digital phase we're improving productivity."

The Right Stuff

No machining process can start without the right tooling and fixturing. When PACON first implemented five-axis machining, that unit could hold 30 tools, which, McClure pointed out, were enough for one part. Today, a larger cell holds 313 tools per machine, with roughly a third allocated to standard tools. As programmers add tools for new applications, they eventually become standard and are uploaded into the software's tool library for future parts.

The high-mix shop sees lot sizes ranging from one part to hundreds of parts per week and sought to find a way to standardize and build a library for its fixturing pieces. "We wanted to figure out how to handle a high number of different parts that we could make in a particular week, and standardizing our fixturing was a key piece of that," McClure recalled. "It made simulation a lot easier because we could build the library and weren't building a new fixture for each part anymore."

On the manufacturing side, at least two of the software's major features have become PACON's go-to solutions: Mastercam's Dynamic Motion technology and OptiRough toolpaths. "Dynamic Motion is something we use very, very frequently both for its benefits in cutting super-hard materials and because it helps us reduce cycle times. Essentially, we can cut more parts in less time," McClure said, noting that the company makes structural parts that hold parts of a satellite together. "These things have complex angles because whatever it is holding up must have this weird twist to it. And they have multiple angles, so a bracket, for example, may be holding multiple entities together."

Added Mund, "It's exciting to see a shop use Dynamic Motion as aggressively as PACON does. It's one of our core toolpath engines, and we're constantly moving it into new areas of machining and pushing hard to increase the time savings it delivers. When a shop really commits to using new technology like that, the results are impressive."

"Industry 4.0 has many components," he continued. "For example, with a shop like PACON, simulating the machine environment for safe, fast experimentation is critical, particularly with five-axis machining. From there, it's about how many other connections Mastercam can facilitate to ensure that information can be exchanged and used."

Lighten Up

PACON's parts need to be as light as possible. Their geometries feature a lot of wavy pockets and complex angles that can be machined in one set-up on a five-axis machine. PACON's team found that Mastercam's OptiRough toolpaths—which use the entire flute length of the tool but only a small percentage of the tool's diameter on the initial roughing passes—followed by several successive shorter cuts that bring the part into the desired shape, work well, allowing large amounts of material to be roughed out, yielding a near-net-shaped part.

These toolpaths are also used on electronic enclosures, usually with different levels and features within. While the enclosures don't have complex angles, they do have a lot of features with precision tolerances that need to be machined in between these features.

"Rather than machining some of these parts on a three-axis machine with a number of different operations as is typical for these types of jobs, our five-axis approach greatly simplifies the process and makes us more cost effective as well," McClure asserted.

PACON is certified by one customer for digital product development (DPD), which qualifies the company to use the solid or step file from the customer to make a part according to the "rules" put in place by the latter.

"When we get the drawings of the brackets, many times there are radius intersections that are not friendly," McClure explained. "You have weird cutting corners for the 3D surfaces, and we end up having to do contouring toolpaths to blend them.

"Traditionally, people will pick a tool and say 'this is the radius it's going to be,' but then you end up with something that is non-conforming to the STEP or solid file, and it wouldn't be precise," he elaborated. "That's a problem for our customers because model strength and weight are on all of their drawings, and any deviation of that model means there's a deviation with the simulation."

PACON manufactured more than 50 parts for the Mars Rover that went through the shop's Precision Machining 4.0 process. When issues that limited manufacturability were found, the team was unable to make changes to the model without permission from the customer.

"When we find drawing or model issues, we let our customers know, provide our manufacturability suggestions, and let them determine the path forward," McClure said. "Often the issues we find affect other parts of the assembly, and we collectively avoid costly rework and schedule delays."

However, using its own manufacturing processes, PACON was able to use a ball end mill to contour the surface in such a way that the part could be manufactured.

Resetting Past Practices

For other customers, PACON can modify the solid using the software's Model Prep feature, which allows programmers to push and pull solid models on the fly.

"When customers give us a part that appears too challenging to make," McClure said, "we will always give it a hard look, strategizing how we can tackle it in hopes of not only delivering that component but using that experience gained to open up other families of complex parts."

One of the remarkable things about PACON's success is how the company, intent on simplifying operations, orchestrated so many process and equipment changes to work together harmoniously. "To run a lean manufacturing operation, PACON has had to reset a lot of its past practices," McClure said. "Knowing the end goal is enormously valuable, and ranking the order of your issues and solving one at a time is fundamental."

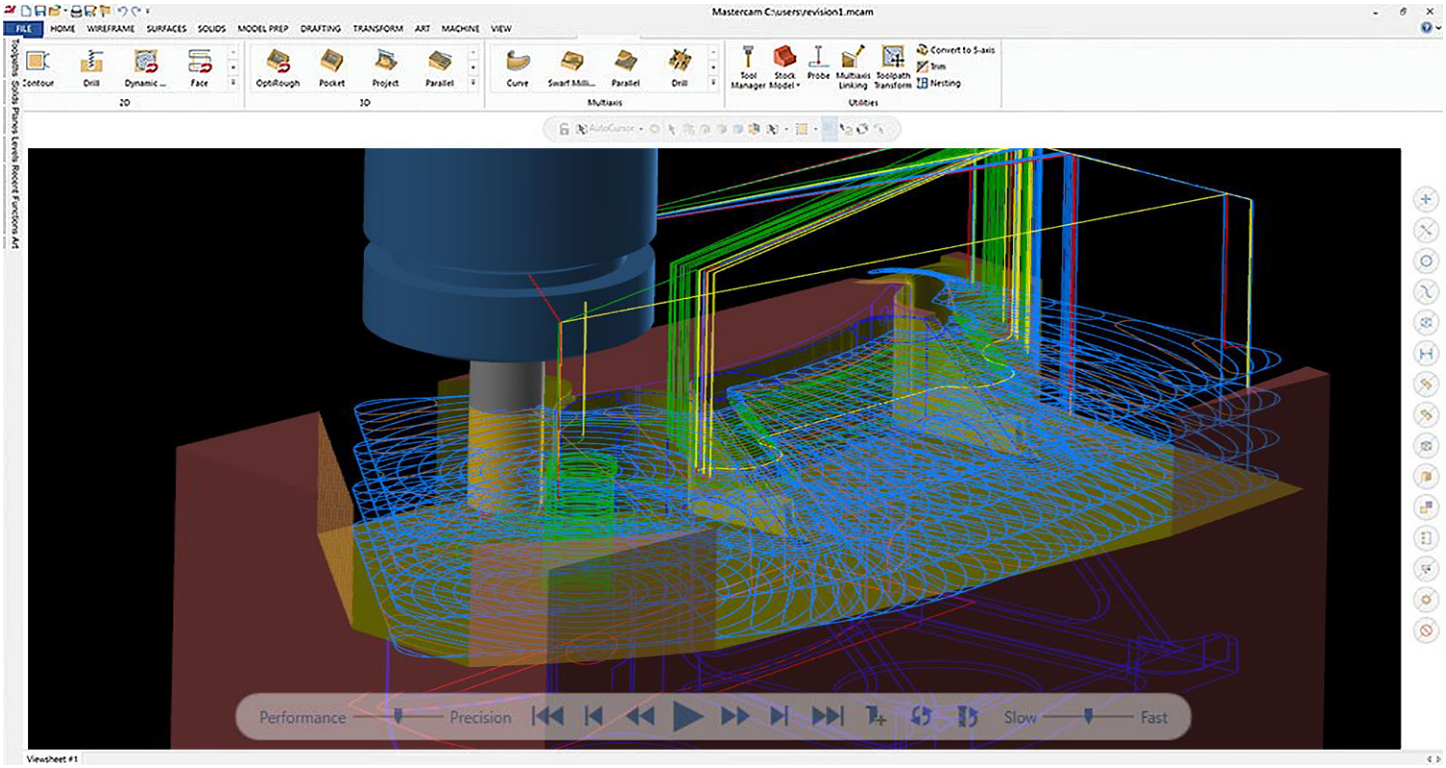
Here is a satellite antenna mast bracket with true position reference planes on bracket fins (Provided by PACON).

In September 2020, PACON acquired a second facility in the San Francisco Bay area. The company has 20 employees, including four full-time programmers, while the rest are machinists and mechanical engineers.

"Our approach has been to hybridize our organization with a combination of journeyman machinists who understand how to machine a part and why it is machined that way," McClure said, "and marry those skills to those coming out of mechanical engineering programs who understand new software capabilities really well."

This combination allows the company to run one shift, seven days a week, while pushing its Precision Manufacturing 4.0 processes as far as possible.

For information on PACON Mfg. Inc., visit https://www.PACONquality.com or call 925-961-0445. For information on CNC Software LLC, visit www.mastercam.com or call 860-875-5006.



Mastercam's OptiRough toolpaths make roughing parts like these a breeze for Pacon, saving them "a ton of time on the programming side." (Provided by CNC Software)

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