Metalworking

Making Toolpaths Terrific with Digital Twins

Kip Hanson | Aug 16, 2022

Many variations, use cases and even definitions for the digital twin exist. Some view it as little more than a highly detailed 3D model of a component or piece of machinery; others will tell you it's a comprehensive digital representation of a physical object and all of the information accrued during its lifecycle. Each position has its merits.

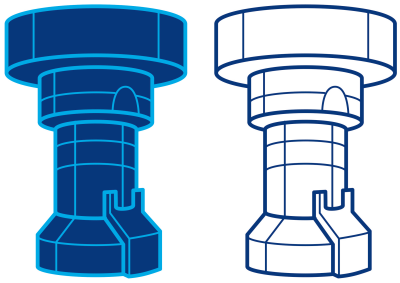
What's not in dispute is that machine shops can use digital twins to make CNC-programmed toolpaths more efficient, thus improving tool life, productivity, and part quality while eliminating surprises during the setup and machining process. The only question is how big the benefits are, and that depends on the quality of the twin.

Here are some suggestions for how to maximize that quality from four of the leading providers of digital twin technology

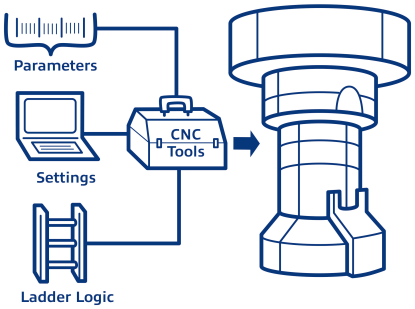
More Than Pretty Pictures

A digital twin must be dimensionally accurate, but its real value often comes from the ***additional data it contains***. That's according to Gene Granata, CGTech's director of product management, who notes that while digital twins are commonly related to CNC machines, many cutting tool manufacturers and third-party, cloud-based providers of tooling data also offer much more than "pretty pictures" of cutting tools and toolholders.

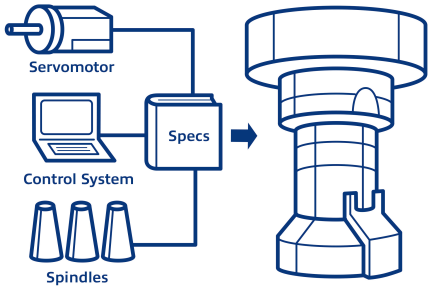
Refining Toolpath with Digital Twins



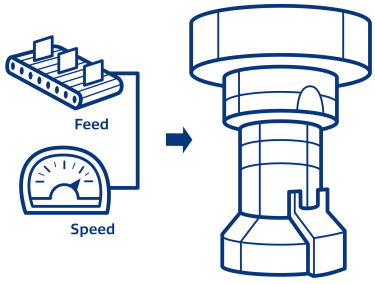
Process works best with an “intelligent twin” rather than a simple 3D model. The most effective have:



Parameters, settings and ladder logic that control CNC tools



Specs for servomotors, control systems, spindles



Feed/speed data for workpiece material

“We recently programmed a stainless steel job in a well-known CAM system using one of the best cutting techniques offered and pulled it into our Vericut software with force optimization. Then we downloaded cutting tool models for five different solid round tools from Sandvik Coromant’s CoroPlus Tool Library and clicked optimize,” Granata says. “With no additional effort, I was able to cut 38 percent off the cycle time. Optimization was simple and highly effective because those cutting tools came into Vericut with ‘cutting intelligence’ (feed and speed information) specific to the stock material we chose to cut.”

Granata isn’t bragging: He’s pointing out that, regardless of CGTech’s or any other software provider’s technical capabilities, it’s the quality of the digital twin that often makes the difference between good toolpaths and great ones. In this example, the programmer could have been anyone. There was no need for decades of machining experience or knowledge of feeds and speeds. The system accessed the necessary cutting information related to the Coromant cutting tool models—sometimes referred to as metadata—and used it to produce a significant benefit.

“Let’s say you have a dozen NC programmers in the shop, all working on toolpaths for the same titanium job. In all likelihood, you’ll get 12 completely different approaches and cycle times,” Granata says. “But by leveraging the information from the cutting tool manufacturer’s digital twins, and then simulating the toolpaths on a kinematically and functionally accurate digital twin of the machine tool, you’re going to achieve consistent, productive results in less time, with less effort.”

Twinning the Control

Given the increased complexity of today’s machine tools and the shortage of experienced machinists and programmers, Granata says embracing the digital twin and ***toolpath simulation*** will be crucial to success.

That’s undoubtedly true, but keep in mind the “kinematically and functionally accurate” qualifier he used.

Silvère Proisy, digital twin product and market manager for Hexagon’s Manufacturing Intelligence division, suggests it applies not only to the machine tool and all its many mechanical components, but also to the servomotors, control system, spindle and how it all behaves under load.

Says Proisy, “This is why Hexagon has a team of technical people who spend each day designing virtual machines that perform exactly like those on our customers’ factory floors. That’s the only way to achieve a truly accurate toolpath simulation.”

Here again, it comes down to data. Proisy describes a more comprehensive digital twin than those available from most machine manufacturers. It contains all of the parameters, machine settings and ladder logic that determine how CNC machine tools react when given commands from the NC program. It is an intelligent twin, rather than the simpler, purely volumetric 3D models on which much of the industry currently relies.

“Whether you’re using our NCSIMUL product or a competing system like Vericut, you need this level of detail to accurately simulate how the machine will react in real life, when you’re actually removing metal,” Proisy says.

Fusion of Technology

Autodesk product manager George Roberts agrees.

“It’s critical that a manufacturing software system accurately represents everything on the shop floor,

be it in Autodesk Fusion 360, our CAMplete NC verification solutions or another CAM-focused platform," he says. "That can be through the lens of G-code post-processing or simulation and verification, but also through machine monitoring and analysis of the resulting data."

Roberts' last point—***data collection***—touches on an enhancement of the digital twin, although it appears to be in its early stages. There's no shortage of news stories about how equipment-makers have begun to deploy "connected smart products" and gather usage information from the field, analyzing it for predictive maintenance or warranty purposes and using it to improve future product iterations.

The CNC machine tool industry has the same opportunities as other sections of that industry, and the sensor data that fills a shop's MES (manufacturing execution system) dashboards might also find its way into a lathe or machining center's digital twin.

"Autodesk is one of many companies investing heavily into digital twin technology," Roberts says. "Data collection and machine analytics is part of this, which is why we recently acquired technology from CIMCO and Prodsmart for shop floor management and machine monitoring. Machine tools can provide a wealth of data. For example, the operator will want to know whether the machine is running and if there's a problem such as chatter or an overload situation, while the supervisor might be more interested in broader usage statistics and overall machine performance. I can envision that each of these data sources might be incorporated into the digital twin at some point."

Get Started with a 'Small Step'

Rahul Garg, vice president of industrial machinery at Siemens Digital Industries Software agrees with his colleagues about the need for digital twin accuracy and comprehensiveness.

And while he's a firm believer in using simulation to verify toolpaths, optimize machining processes and avoid crashes, he points out another important use.

"Though not yet widespread, CNC machine tool manufacturers are beginning to utilize the digital twin for some of the ***analytical and predictive maintenance*** activities discussed here, but what's probably more common is its role in training," Garg says.

"Here, an operator or maybe a repair technician is presented with a virtual representation of the machine control and allowed to see the impact of changes to the programmable logic controller, for instance, or what happens when they invoke a certain G- or M-code. But they're also using digital twins for job preparation and process planning, all of which serves to increase efficiency in the real world."

You might be thinking this is all cool stuff for shops with newer machine tools, but what about everyone else? Not to worry, says Garg. For starters, anyone using Siemens NX or any other advanced CAM system already has access to tremendous machine and toolpath simulation capabilities.

And anyone wishing to gather information from older CNC machinery can "easily retrofit" Siemens sensors onto legacy equipment, he says, and use the company's Industrial Edge to virtualize the entire production floor and capture its data, regardless of machine brand or vintage.

Think your shop is too small for all this technical wizardry? Think again, says Garg. "I strongly believe that these capabilities—from program preparation and toolpath simulation to operator training and process optimization—are especially relevant to the job shops of the world," he says. "Each is easily leveraged and will improve your overall profitability, reduce defects, and increase throughput. All it takes to get started is a small step in that direction."

