



Machining

## 8 Important Facts About 5-Axis Machining Centers and High-Performance Machining

Kip Hanson | Jun 05, 2018

Are you unsure about the value of 5-axis machining for your machine shop? Look no further than this helpful list of factoids that is sure to help guide you through its benefits.

Perhaps your shop is thinking about acquiring 5-axis CNC machines. Or perhaps your shop already did and you're still figuring out the best way to program the machine and tool it up. Whatever the case, there's a lot to consider if you're going to make the most effective use of these ultra-productive machine tools.

Mastering *5-axis machining* promises greatly improved part quality, reduced work-in-process and lower fixture costs, but it does require some new ways of thinking. Before you travel much further down the 5-axis road, consider the following concepts—some serve to dispel the rumors around this important machining technology, while others are simply designed to get you off to a running start.

### 1. You Don't Need 5-Axis Work to Justify a 5-Axis Machining Center

Do I need a machine? Many shops hesitate to make the considerable investment in a 5-axis machining center because they're not making the turbine blades, blisks, orthopedic implants and similar parts that are plastered over the front of any 5-axis machine brochure. Don't worry about it; you generally don't need simultaneous 5-axis work to justify a 5-axis machining center. Any part that gets machined on more than one side will benefit from the reduced part handling that comes with 3+2 machining, allowing completion of five of the six sides of most any orthogonal workpiece.

### 2. 5-Axis Machining on a Multitasking Lathe Might Be More Effective Than on a 5-Axis Machining Center

Maybe your parts are more round than they are orthogonal but still contain features that lend themselves well to 5-axis machining. It might be time to consider a multitasking lathe or 5-axis mill-turn center. These offer much of the same functionality as 5-axis machining centers and are able to produce complex, multisurface workpieces, but because they often carry a secondary spindle, many parts can often be completed in a single operation.

"I have seen great advantages using mill-turn machines," says Dr. Thomas Kurfess, a professor and the HUSCO/Ramirez Distinguished Chair in Fluid Power and Motion Control at the Georgia Institute of Technology. "However, to really leverage these machine tools, you really have to think outside of the box. Mill-turn machines are much more than a mill and a lathe combined; they offer a compact and much more repeatable 4- or 5-axis machining system that has a very unique and versatile configuration. Plus, they have a relatively small footprint, making them ideal machines for those who know how to leverage their advantages."

### 3. Why You Cannot Use a Trunnion Instead of a 5-Axis Machine

Perhaps you're thinking that you'll slap a tilt-rotary trunnion table on one of your 3-axis vertical machining centers, thereby eliminating the need for a 5-axis mill. There's nothing wrong with this approach and it is a good way to get started with 5-axis machining, but just bear in mind that a dedicated 5-axis machine tool carries control options such as tool center point control (TCPC), 5-axis auto-tuning, dynamic work offsets, and other features designed to make setup fast and easy, never mind a far more rigid, accurate machine construction. Simply put, a trunnion-equipped 3-axis VMC cannot compete with a true 5-axis machining center.

"Adding a tilt rotary trunnion table is a great way to transition to 5-axis machining," explains Kurfess. "However, if you purchase a 5-axis configuration from an OEM, the machine and its supporting systems are fully integrated for 5-axis operations, resulting in smoother programming and workflows."

## 3 Important Things to Understand About High-Performance Machining

Every machinist, shop owner and production supervisor wants the same things: to machine parts faster, extend tool life, decrease machine wear and improve part quality. These are all achievable with a 5-axis machining strategy, but there is another way to accomplish the same objectives without investing in a new machine tool. It's called high-performance machining, or HPM, and if you're not taking advantage of it, you're missing out on some big benefits.

"You will need some good engineering and machining understanding to fully take advantage of HPM, so training and a strong technical base are important to fully utilize HPM," says Dr. Thomas Kurfess, professor of fluid power and motion control at the Georgia Institute of Technology. "The investment in the know-how is not a major one and always generates a significant return on investment."

Here are a few pointers to get you going in the right direction:

### 1. HFM vs HPM vs HSM: What's the Difference?

High-speed machining (HSM), high-feed milling (HFM), trochoidal toolpaths, chip thinning, helical ramping, corner picking—these are just a few of the machining techniques that fall under the umbrella term "high-performance machining," or HPM. The most important thing to know is this: If you're milling parts with the same toolpaths and cutting tools you used 20 years ago, it's time to open a tooling catalog, talk to your CAM provider and wrap your

arms around HPM. No other technology will have a more positive impact on your milling operations.

## 2. You Don't Need the Latest and Greatest Machine Tool for High-Performance Machining

You might be thinking that implementing HPM requires a new machine tool. Not necessarily. While it's true that HPM works best with a modern CNC that's rigid and able to corner quick—and has a robust spindle interface—there's nothing stopping you from trying HFM, for example, which actually reduces cutting forces and tool deflection, or leveraging chip thinning effect with high axial engagement trochoidal toolpaths. You might need to upgrade your CAM system, but even an old dog of a machining center is capable of learning some surprising new tricks.

## 3. You Do Need the Right Cutters for High-Performance Machining

There's much more to this topic than the toolpaths, however—there's also the cutting tool. Using a general purpose 4-flute end mill or corncob rougher for HPM is like putting retread tires on a sports car. End mills with 5, 7 and 11 flutes allow faster metal removal rates. Variable pitch and variable helix cutters stop chatter in its tracks. Multiphase coatings extend tool life even at elevated feeds and speeds. Cutting tool technology has changed mightily over the past few years, so talk to your tooling representative, and if you don't hear the right answers, find one who's familiar with the latest machining strategies. The bottom line is that you definitely need the right *cutting tools* (and toolpaths) for HPM to be effective.

## 4. All 5-Axis Machining Centers Are Not Alike

Speaking of machine construction, be aware that in 5-axis machining land, not all machine tools are built alike. Three distinct styles of machine are available—those with tilt-rotary tables integrated to what is basically a 3-axis machining center; those machines with an integrated tilt-rotary but are using a traveling X-axis column—and those machines where the milling head swivels left to right above a rotary table-equipped bed. Each has its pros and cons, and buyers must consider things such as tool interference, workpiece size, required part accuracy and machine cost to make the best decision for their particular application.

*Once you've adopted 5-axis, you will want to know how to get the most out of it. Here's some excellent guidance in the article: "Learn How to Push Your 5-Axis Machine's Output."*

## 5. Fixturing Multiple Parts Is Easier Than You Think: You Are Not Limited to Single Parts

You might have heard that 5-axis machining means you can only produce one part per machine cycle. Not true. Granted, the most common method for gripping parts on a 5-axis machining center is a single,

extended height vise that clamps a pre-machined dovetail at the bottom of the workpiece blank. But for those who need to machine 3, 4, 6 or more parts per cycle, there are an increasingly broad array of **workholding options** available. The result is that fixturing multiple parts on a 5-axis machine is easier and more flexible than you might think.

Kurfess puts it this way: "Not only are there a wide variety of excellent fixtures for 5-axis machining, many of them are nicely integrated into the programming capability of the machine, enabling even greater productivity of your fixturing. Once again, this is a significant advantage of purchasing a true 5-axis system."

## 6. You Don't Have to Dovetail Your Own Blanks

Did someone say dovetail? If you're dreading the thought of not only having to saw workpiece blanks but then cut the dovetails on them as well, you might consider focusing on what you're best at and ordering pre-cut, pre-dovetailed material from your steel supplier. You should also take a look at vises that rely on a series of pins, knife edges or even photo-activated glue to securely hold workpieces in place.

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Dr. Thomas Kurfess

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Georgia Institute of Technology

## 7. Improved Accuracy, Less Handling with 5-Axis Machining

Consider the traditional machining methodology whereby a 6-sided part requires six separate handlings and multiple fixtures to complete. As any machinist knows, no matter how well-designed the fixture, some small amount of part accuracy is lost with each operation. Since 5-axis completes all but the bottom of the workpiece without repositioning the part, the only thing preventing perfect accuracy is the machine tool itself.

## 8. 'Done In One' 5-Axis Machining Is Fun

A well-known machine tool builder suggests that adopting a "done in one" machining approach is one of the best things you can do for your shop's bottom line. They're right. With 5-axis, the baskets and bins of partially completed workpieces sitting around the shop are history. Cash flow is improved. Lead times are reduced while flexibility is increased. The burrs created when breaking into an intersecting feature are easier to remove.

"Not only do 5-axis machines help to reduce work-in-process, they also allow companies to better utilize their highly trained workforce and equipment," says Kurfess. "First, a part and machine are not spending idle time in load and unload operations. Second, skilled operators are not performing low value added functions such as load/unload. Rather, they can spend time programming and setting up other machines as necessary."

You might still scrap out a workpiece now and then, but you'll discover it sooner rather than later.

Simply put, 5-axis is the best thing to happen to machining centers since automatic toolchangers.

*Have you only dipped your toes into 5-axis machining? What's holding you back? Share your experience.*

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