



The Role of Grinding in Modern Tool Production



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Machining makes parts. Grinding makes the tools that make machining possible. A solid carbide end mill, for example, starts as a rod of raw material. Several grinding operations later, it becomes a precision cutting tool that can quickly remove large amounts of aluminum, mild steel, and heat-resistant superalloys (HRSA) such as Inconel and titanium, while consistently achieving micron-level tolerances.



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Grinding is responsible for every feature on that tool. The flute geometry, relief angles, gashing, and edge preparation, together with the carbide grade and coating, help determine how well it performs. The same holds for drills, reamers, broaches, gear hobs, and every other cutting tool used in a machine shop; without grinding, no parts get made.

The process is straightforward, though highly technical and precise. Blank preparation brings the carbide rod to a specified diameter before any cutting geometry is applied. This step is typically performed on a centerless grinder or, with the blank held between centers, on a cylindrical grinder.

From there, the completed blank moves to a five-axis CNC tool and cutter grinder. It's here that the geometric features take shape. Reconditioning a tool at its end of life follows much the same path: worn cutters are inspected, stripped of their coating if applicable, reground, and then returned to service.

Why Tool Geometries Are Getting More Complex

Tool and cutter grinding is a mature, well-understood process, and a machine shop or OEM that can perform some or all of these steps in-house enjoys better control of tool quality and lead time throughout the entire lifecycle. What's changed in recent years are the demands of modern metal removal, and how cutting tools have adapted to meet them.

Today's cutting tools are more geometrically complex than those produced even a few years ago. Cutting tool manufacturers have responded to tighter part tolerances, more difficult workpiece materials, and the push for higher productivity by adding features that would have been difficult or impractical to produce on earlier equipment. For instance, tapered cores increase tool rigidity. Variable helix end mills and asymmetric flute geometry reduce chatter. Multi-step drills and combination tools consolidate operations, making machining simpler and more cost effective. And form tools designed to produce an entire profile in a single pass are common in high-volume environments where cycle time is everything.



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These and similar cutting tool developments have increased complexity throughout the grinding process:

- A tool with four or six guiding margins, instead of the standard two, requires additional passes and tighter control of the tool's outside diameter (OD) between them.
- The form tools just mentioned not only demand accurately ground profiles but may also rely on in-cycle probing and cameras to ensure them.
- A differential helix that changes pitch along the entire flute length requires programming software capable of generating the correct path, a control to execute it, and a machine with the stiffness and thermal stability needed to maintain accuracy throughout the entire grind, from one tool to another.

None of these is impossible, but they do require machinery, software, and technical knowledge that were beyond the reach of most shops just a decade ago.

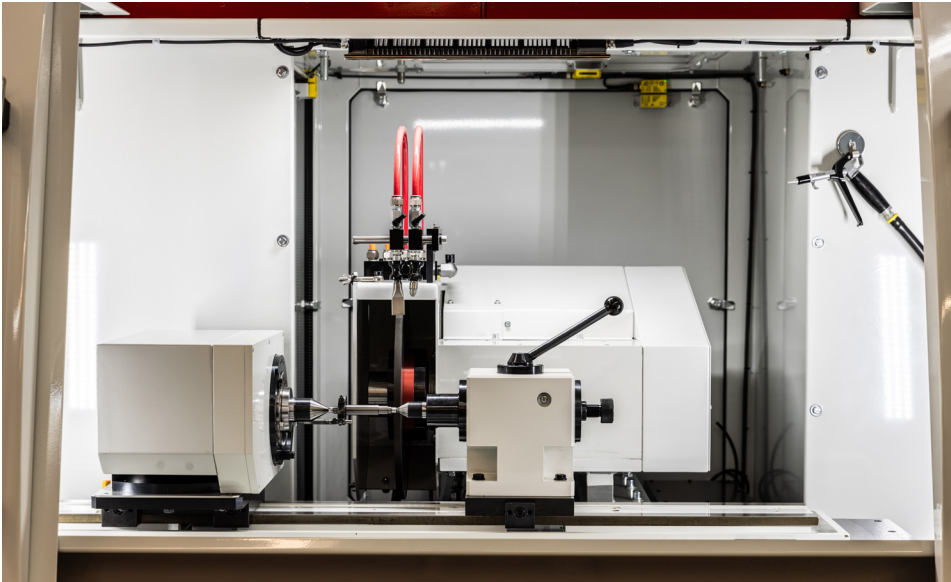
The same trend also affects reconditioning, which has come to account for a significant share of the work in many grinding shops. When worn tools have a proprietary or non-standard geometry, characterizing it through incoming inspection before regrinding becomes a critical first step. In certain cases, the grinder itself acts as a measuring instrument—probing the worn tool to establish what needs restoration. Done correctly, it produces a program suitable for regrinding on future jobs. One practical extension of this: a tool worn past its useful cutting life can often be reduced in diameter and resharpener as a roughing tool, recovering value that would otherwise go into the recycling bin.

Blank Preparation: The Foundation of Tool Quality

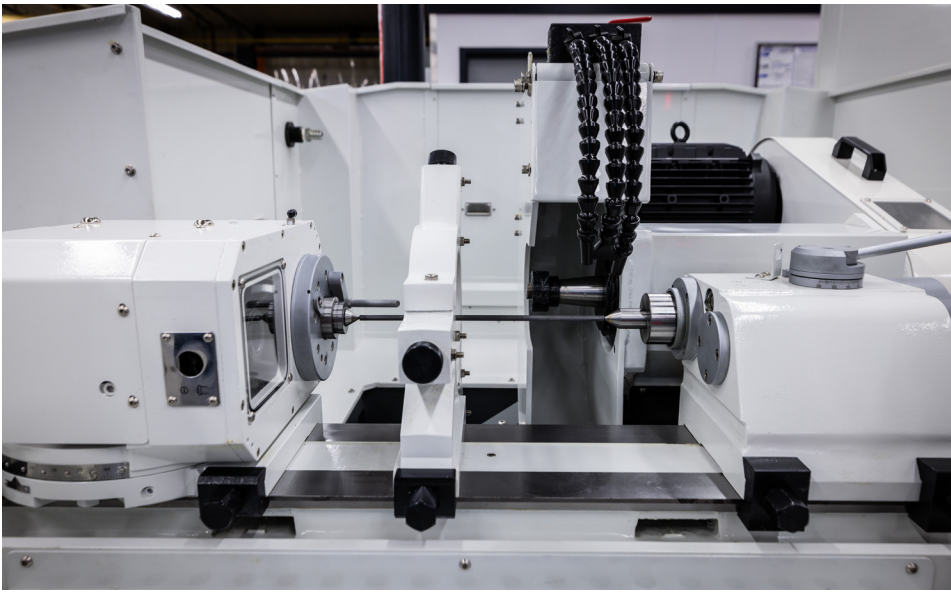
Blank preparation is the least visible step in tool production, but done improperly, it can be the most consequential. That's because a blank not ground to the correct diameter and surface finish, or one with excessive runout between stepped features, can lead to geometry errors in the finished tool. Fixing them at the five-axis grinding stage—though possible—costs significantly more than preventing them earlier.



The centerless grinding unit used in blank preparation differs from the through-feed centerless grinder most machinists are familiar with, even though the principles are the same. Here, the centerless grinder operates in plunge mode: the tool blank rests on a blade between a regulating roller and a spring-loaded tension roller, with the grinding wheel plunging from above. This arrangement handles interrupted surfaces—the OD of a partially fluted drill, for instance—without losing positional accuracy, and holds tolerances in the two-micron range under controlled conditions.



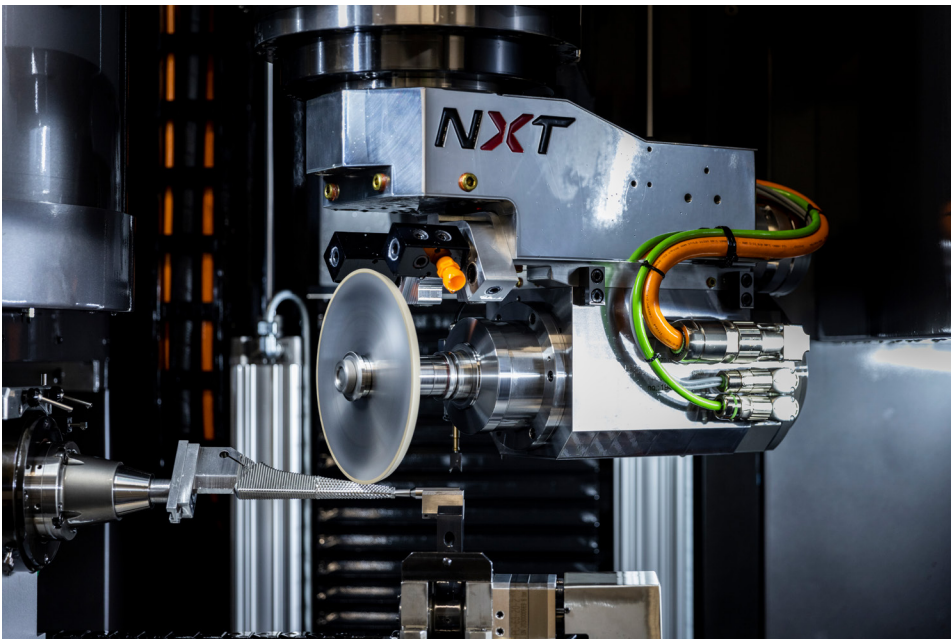
Cylindrical grinding handles what centerless is less suited for: relatively short or larger-diameter tools, and aggressive stock removal. Parts are held in a rotating chuck—with tailstock support on longer workpieces—or between centers using a drive dog for rotation. Regardless of the workholding approach, the two platforms are complementary. Shops running a broad range of tool types generally need both: the centerless handles smaller-diameter and quick-changeover work, while the cylindrical grinder tackles the jobs just described.



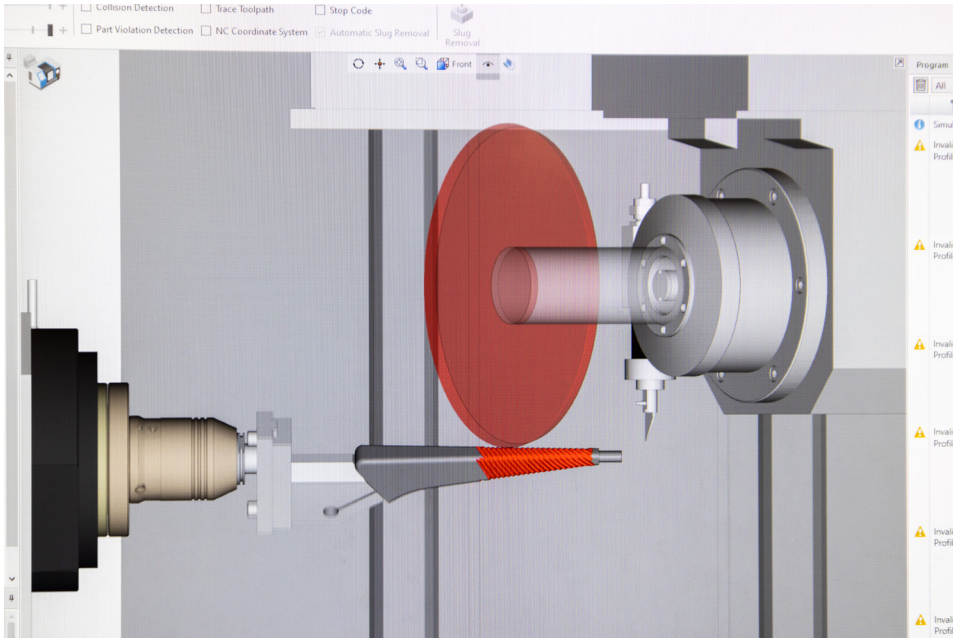
Five-Axis Finishing: Where the Tool Takes Shape

The five-axis CNC tool and cutter grinder is the most capable and complex piece of equipment in the process. It's where the tool's cutting geometry is created, its performance characteristics are determined, and the demands of modern tooling are felt the most. And for these reasons, it's also the platform that has seen the most significant development in recent years, driven by the same complexity that makes tools harder to produce and resharpen.

Software plays an important supporting role, with the industry's two dominant platforms offering different, though often complementary, solutions. NUMROTO is purpose-built for cutting tool applications—end mills, drills, reamers, gear tools, and inserts—with deep parametric capability for both standard and complex geometries, as well as a FormTool module that allows point-to-point programming of geometries that don't fit standard templates. It handles the vast majority of rotary cutting tool work and has become the standard platform across multiple competing machine builders. Its limitation is that it doesn't extend to non-round precision components such as medical implants, orthopedic rasps, and similar parts that fall outside its intended scope.



For this application group, there's ESPRIT, a CAD/CAM platform developed for five-axis machining that has since been adapted for freeform precision grinding. Rather than parameterized programming like NUMROTO uses, ESPRIT generates machine motion directly from a CAD model. This capability means the machine can grind virtually any shape, provided that A) the workpiece can be securely fixtured and B) it was accurately modeled.



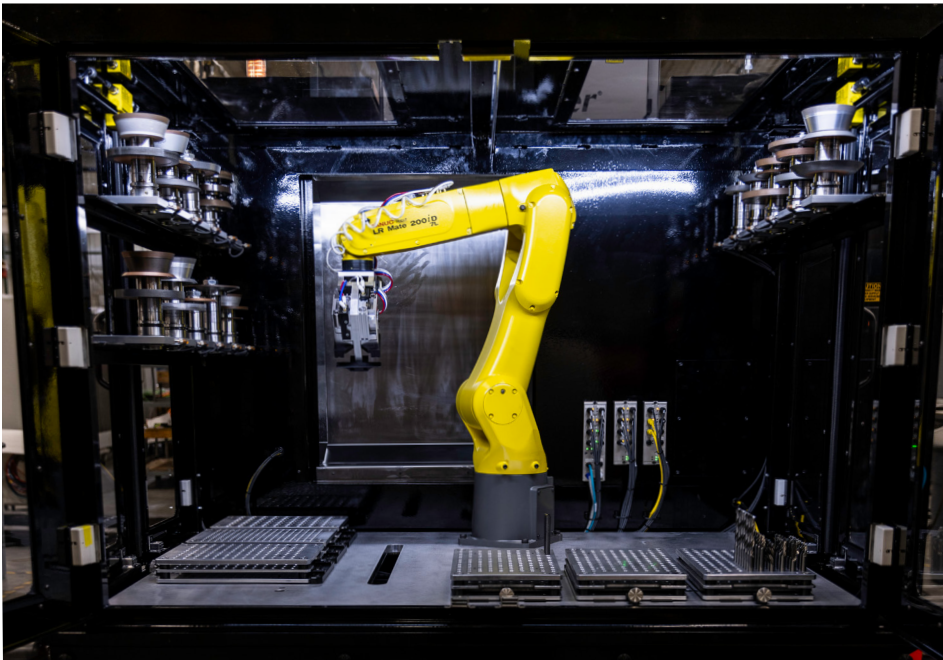
Shops considering five-axis grinding platforms should start by assessing their current and future part mix, identifying the software best suited to it, and then evaluating machine specifications.

The tradeoff seems counterintuitive—given the advanced motion control available in modern grinders and their ability to execute exactly what the toolpath describes, errors in the CAD file reproduce faithfully in the finished part. Getting consistent results, therefore, requires clean models and the means to verify them before production.

Shops considering five-axis grinding platforms should start by assessing their current and future part mix, identifying the software best suited to it, and then evaluating machine specifications. Ultimately, any grinder's capabilities are defined by the software used to program it and the skill of those operating it.

Automation in Tool Grinding

Automated loading and unloading have long been the standard for machine tending in high-volume tool grinding. As technology matured and investment costs fell, the business case has extended to smaller shops, even those engaged in high-mix, low-volume work. Whether CNC lathe, machining center, or five-axis grinder, a robot can keep the machine fed through a second shift or an entire weekend without incurring additional labor costs, recovering production hours the shop would otherwise lose.



The practical challenges in automated tool grinding have always been greater than with general machining, because the tools themselves vary in ways that complicate standard approaches. Case in point: a robot loading identical cylindrical blanks into a collet is a manageable task, whereas one loading tools that have short shanks relative to large bodies, tools that trap grinding oil in internal passages, or tools whose gripping diameter changes during grinding introduce added complexity, requiring the robot to pick and place on different surfaces. Each of these scenarios requires application-specific engineering and machine integration.

The good news? Grinding machine builders like Star Cutter have worked through enough of these non-standard cases to build a meaningful advantage—not just in the equipment they offer, but in the applications knowledge that makes automation work reliably across a broad range of tool types.

The Complete Grinding Portfolio

Whatever the application, there's a strong argument for sourcing grinding equipment from a single supplier that offers a complete portfolio: accountability. That means fewer handoffs, consistent support, and one provider who can speak to the entire process rather than just the one piece their product handles.

Star Cutter's tool grinding lineup spans that process:

- The TRU TECH centerless and cylindrical grinders, acquired in 2023, handle blank preparation with quick changeover and minimal setup complexity—a practical fit for job shops running mixed tool families where long setup times between diameters erode the value of the equipment.



- The NXT five-axis CNC grinder is Star Cutter's flagship platform, with the largest grind zone in its equipment lineup and the flexibility to handle round tools, gear hobs and shaping tools, indexable inserts, and medical cutting tools and orthopedic components in a single machine.



- The FLX is its production-oriented counterpart, designed for extended-length runs on defined tool families, with greater pallet capacity and automated wheel-pack changing for up to 15 positions.



- The UTG Broach Grinder rounds out the lineup as the only broach grinder still manufactured in North America, with an installed base of roughly 140 machines and strong current demand from aviation and power generation markets.



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Long-term supportability runs through the entire Star Cutter offering. For instance, NUMROTO software upgrades are included for the life of the machine—a 20-year-old machine can run today’s current software version with nothing more than a PC upgrade. The UTG recently underwent a full controls redesign to a NUMROTO-based platform, bringing legacy machines, in some cases decades old, fully up to date. And on the NXT platform, remote machine monitoring with AI-assisted diagnostics means Star Cutter’s service team can often identify and resolve issues before they become production problems—a capability that extends to machines well past their initial warranty period.

Application Knowledge as a Differentiator

The machines and software in a grinding operation set the ceiling on what’s possible; whether that ceiling gets reached depends on the application knowledge supporting them. This limitation is particularly true in tool grinding, where the work is varied, the geometries complex, and there’s often a significant gap between operating a machine and knowing how to make a good cutting tool.

In practice, shops new to tool grinding frequently underestimate this gap. Equipment is easily specified and purchased; the knowledge needed to make it productive takes longer to develop. Star Cutter can help. Each member of its application engineering team has extensive production-grinding experience, and can help to significantly compress that development time. The distinction matters most at startup and at the edges of what the equipment can do, which is also where it matters most commercially.

Application support extends to ongoing grinding operations as well: identifying when a regrind is producing inconsistent results and diagnosing why; recognizing when a geometry tweak would improve tool life or reduce cycle time; and knowing when the right answer is an entirely different approach rather than a refinement of the existing one.

These are not machine functions. They are the product of experience, and are worth evaluating as carefully as the equipment specifications.

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Conclusion

As tool geometries have grown more complex and tolerances have tightened, the demands on grinding operations have increased correspondingly—in equipment capability, in software sophistication, and in the depth of knowledge required to run a productive grinding shop. Meeting those demands requires equipment matched to the work, a clear understanding of what each type of grinding contributes to the finished product, and the application knowledge to effectively bridge the two.

Star Cutter offers a complete tool grinding portfolio engineered and manufactured in the U.S.A, including the TRU TECH centerless and cylindrical grinders, NXT and FLX five-axis tool and cutter grinders, and the UTG broach grinder, supported by local applications engineering, ongoing software development, training and service.

Visit starcutter.com to learn more.



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