Grinding or hard turning

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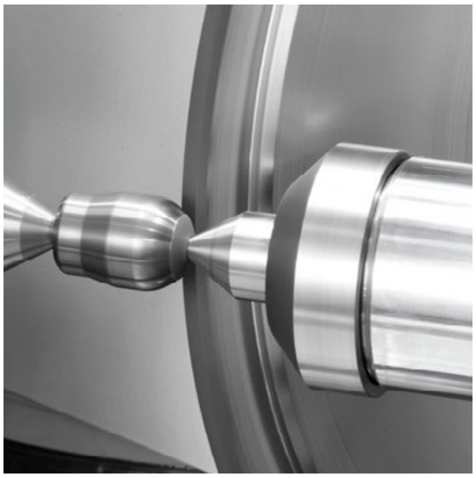
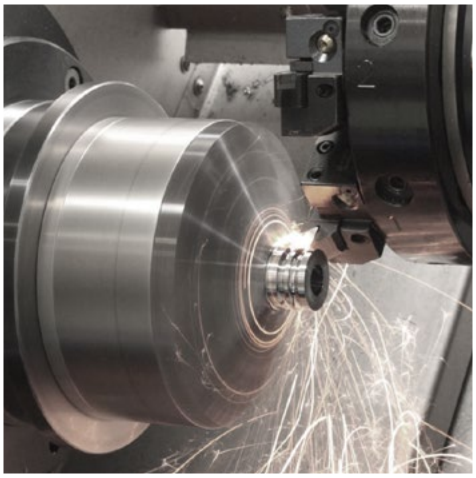
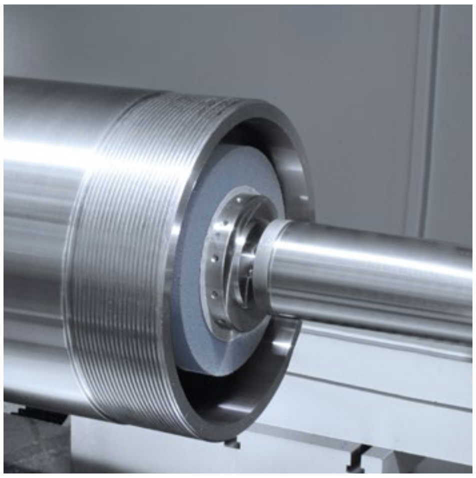
Grinding or Hard Turning?
The Choice is Not as Simple as You May Think

Deciding whether to finish a part with grinding or hard turning can be difficult and is often counterintuitive. Both processes can achieve extremely high tolerances and surface finishes. The most efficient choice will depend on part features, material, lot sizes, the production capabilities of your equipment, and several other factors.







When deciding whether to turn or grind to finish a part, the old calculus was that hard turning is more cost-effective, but if the dimensional tolerance and surface finish requirements are high, you have no choice but to grind.

With today's turning and grinding technology those assumptions are both wrong. With the right machine, hard turning can deliver extremely high tolerances and surface finishes in materials up to 70HRC, including carbide. But grinding may still be the more cost-effective option in many cases. It really all depends on the part configuration, material, the production capabilities of your equipment, the lot sizes, and several other factors.

With its Danobat, Overbeck, and Hembrug companies, Danobat has over 70 years of experience in building precision grinding and finish hard-turning machines. With its unbiased view of both technologies, the builder says that there are no hard and fast rules to determine which process will be most reliable and cost-effective in any given application. But there are some general points that will help get applications engineers started thinking in the right direction. Here's an overview of both processes.

The basics

First, we should make a distinction between hard-turning machines. Hard turning can be accomplished on a variety of standard lathes, but they typically will only deliver roughing quality levels compared to grinding. However, Danobat's Hembrug company produces finish hard turning machines capable of much higher precision with an accuracy spread at the submicron level and surface finishes between 0.1-0.4 microns Ra. And that's with a single point turning process in materials between 55-70 HRC. It is a simple and reliable process that offers many advantages, especially for multi-surface workpieces with complex shapes and a combination of OD and ID machining.

Yet there is still a prominent place for ID and OD grinding, centerless grinding, and some hybrid models have both turning and grinding capabilities on a single machine. Danobat makes all of these machines which is why they are in such a good position to judge which process will offer the most productive option for any given application.

In very general terms:

Hard turning is most advantageous when:

- Round workpieces are geometrically complex and/or require a combination of ID/OD machining.
- High mix/low volume environments require frequent machine setups.
- Dry machining is possible.

Grinding is still the best choice for parts with:

- Thin walls and/or high length-to-diameter ratios.
- Strongly interrupted surfaces.
- Long run parts requiring high process consistency.
- Workpiece forms that cannot be turned.

The inherent advantage of hard turning is that it is a simpler and more flexible process. From a setup and process management perspective, it's little different from working with a conventional lathe – easy to program and easy to change single-point tools. It can be considerably less costly, particularly for parts that previously required both turning and finish grinding operations.

The main advantage of grinding is that it is a more stable process. Grinding wheel behavior remains constant during its entire life and in-process gauging can assure the ability to achieve very high Cpk values in production machining. While single-point turning tools may be easy to change, they wear much faster on hard materials and overall tooling costs in production work are typically lower with grinding. Cylindrical grinding is also likely the only choice for imbalanced or non-round workpieces.

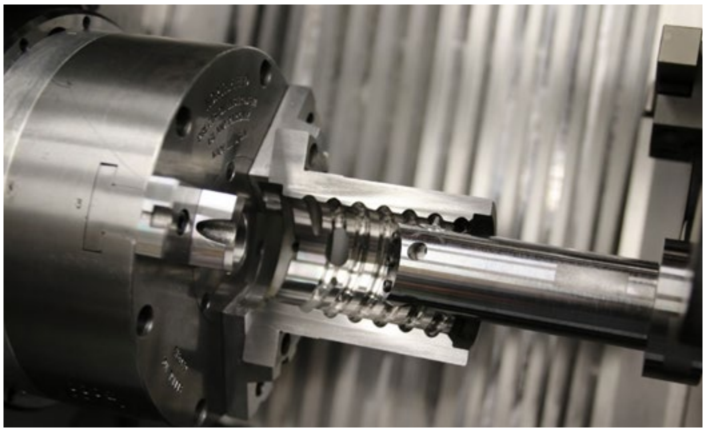
That's the 20,000-foot view. Here's more on the capabilities of each process:

Hard Turning

Why can't you do finish hard turning on almost any machine? The harder the material, the higher the force required to cut the workpiece. This higher cutting force results in much greater pushback pressure on the guideways.

Conventional CNC turning machines simply aren't equipped to handle these higher forces, which then leads to form inaccuracies, poor surface finish, and increased tool wear. A true finish hard-turning machine will deliver constantly high (sub-micron) workpiece accuracy combined with much longer tool life.

Hembrug addresses these demands with several key machine components. The base of its hard turning machines is made of natural granite which offers superior performance over cast iron in stiffness, thermal stability, and vibration-damping capability. The machines also have hydrostatic guideways where the axes float on a pressurized oil film. Without surface-to-surface contact, the slides can operate virtually frictionless and without wear, but also extremely important to hard turning, they further contribute to the machine's vibration-damping capabilities. This is what enables Hembrug machines to achieve form accuracies from 0.5-1 micron, surface finish as smooth as 0.15 micron Ra, and size accuracy ≤ 1 micron.



These capabilities enable hard finishing of precision components such as:

- Ball screw nuts
- Bearings rings and roller bearings
- Hydraulic components
- Drive shafts and gears
- Various mold & die components

Parts are routinely finished with hard turning in materials such as hardened bearing steels, high-speed steels, mold and die steels, case hardened steels, carbide, and exotic aerospace materials as Inconel.

Grinding

An obvious argument for the various forms of cylindrical grinding is with super precision parts. Extremely accurate grinding processes can achieve form accuracy of 0.5-1 micron, size accuracy of ≤ 1 micron, and surface finish of 0.1 micron Ra. But the notion that grinding is just appropriate for high-end parts is dead wrong, and grinding may well be the low-cost option for a wide variety of applications.

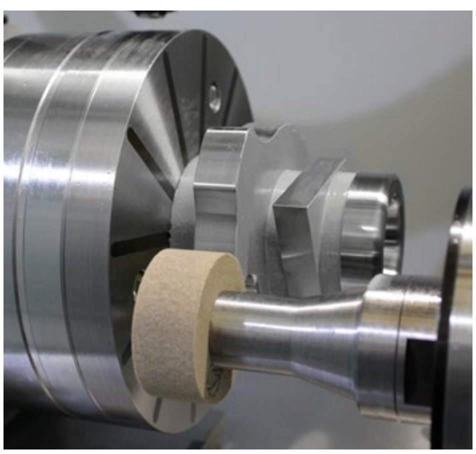
Part of the reason for this is that grinding machines can be configured to generate almost any workpiece feature, some of which cannot be produced on a turning machine. Grinding machine configurations for round parts include:

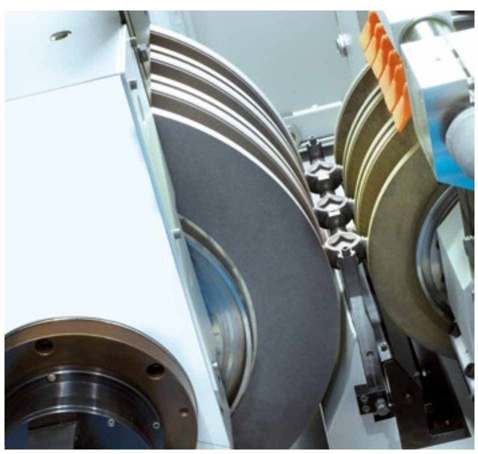
- Universal grinders (ID/OD)

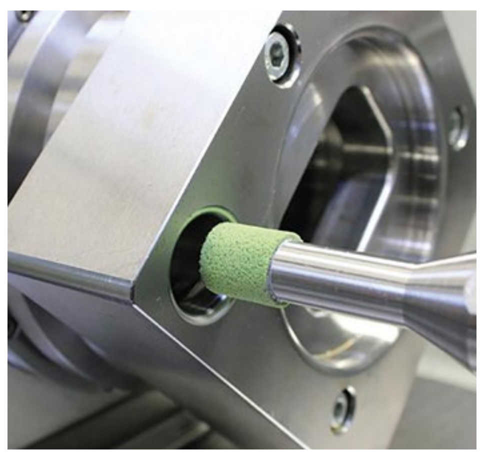
Whether you want a machine just for OD work, ID, or both, there is a wide range of grinders from which to choose. ID/OD grinders provide extreme flexibility to generate a wide range of round or other shaped parts. Peel grinding (workpiece feature grinding with a narrow wheel) can rival the efficiency of single-point hard turning in some applications.

- Centerless grinders

While centerless grinders have been around for a hundred years, they remain the most productive







option for a variety of shaft grinding applications and more. Many people tend to think of centerless grinding primarily in terms of finishing simple cylindrical shapes such as ground bar stock, and it is indeed good at that. But centerless grinders can be customized to finish multi-featured parts as well.

What may come as a surprise is that even though diamond and CBN grinding wheels can be extremely expensive, tooling cost is generally lower with grinding. In some common cases, a grinding wheel can last for as many as 200,000 or even 500,000 parts before it needs to be changed. Even if the wheel cost is important, that's less than a cent per part. And it's not just the cost of the tooling. Longer-wearing grinding wheels reduce process variability and the need for tool changes, increasing machine utilization and throughput.

Which Process for My Part?

It would be nice if there were a clear set of standards to determine whether a part should be finish turned or ground. Unfortunately, it's never that simple and there are many variables to consider before arriving at a final solution. Doing this properly can often lead to counterintuitive conclusions. It helps to work with suppliers with deep experience in both processes to provide unbiased advice. Looking at a few applications illustrates the point.

This tapered bearing inner ring (image 1) is made of 100Cr6 steel hardened to 60 HRC. Previously ground, the manufacturer was looking to reduce process steps, decrease cycle times and improve quality. In the new process, with an OD of 330 mm (approx. 13"), the ring is OD- and ID-turned, and faced. The finish hard turning process is able to hold ID concentricity and taper to < 3 microns, wall thickness to < 3 microns, and angle taper to ± 20 arcsec. The ring is produced complete in 12 minutes.

This tapered bearing inner ring (image 2) is produced on a grinding machine. With similar cost and quality improvement goals, the ring is made of 100Cr6 hardened to 62HRC. The 72.72 mm (2.863") OD and flange are rough and finish ground to a roundness of < 2 microns with an Ra < 0.4 microns. Its cycle time is just 90 seconds.

These are but two examples of well-engineered processes with different conclusions on the best technology for the job. When it comes to making that decision for your parts, it is useful to work with an expert with the knowledge to help show the way. As said at the outset, the decision depends on a variety of factors, and the solution may not at all be obvious, even to experienced manufacturing engineers. Danobat is uniquely positioned to help. Because it manufactures both precision grinding machines, and the world's most accurate finish hard-turning machines, it can address applications without bias toward one or the other.

For more information, please visit **Danobat.com.**

Image 1

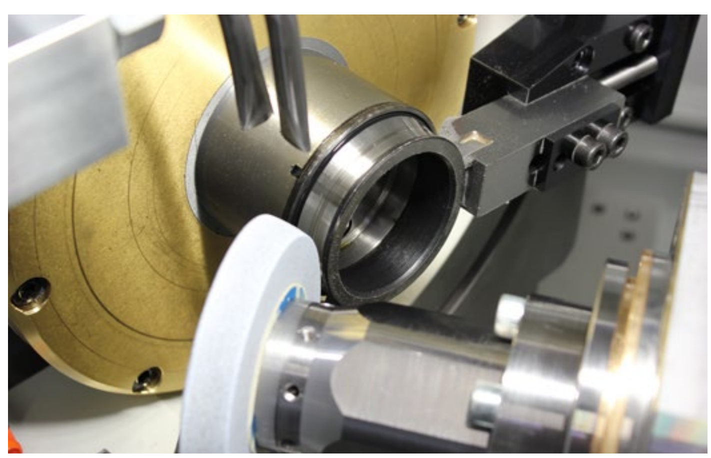


Image 2

About Danobat

Danobat is a world leader in building customized solutions for production grinding and hard turning applications. Based in Elgoibar, Spain, Danobat has over 70 years of experience building turning and grinding systems for customers around the globe. Also included in the Danobat family of companies is Hembrug Machine Tools (The Netherlands) which manufactures high precision hard turning lathes and hybrid machines with hard turning and fine grinding capabilities. And the globally known Overbeck (Germany) specializes in high precision internal, external, face and radius grinding. Combined, the Danobat family of companies manufactures everything from individual machines to fully automated turnkey production systems.

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