



Machining

Optimizing Tool Life: The Effect of Lead Angles on Turning Operations

Kip Hanson | Feb 19, 2019

Tired of burning through diamond-shaped cutting tools for lead angle work? We explore the problems created by lead angles—and we talk to cutting-tool manufacturers on the best ways to optimize for your needs.

For general-purpose turning work, CNMG-style, 80-degree diamonds have long been the *insert of choice*. They're widely available, reasonably priced and provide good tool life in a wide variety of materials. They also allow the machinist to face and turn the workpiece with the same tool, simplifying setups and reducing time lost to tool changes. Because of this double duty, 80-degree diamonds free up at least one tool station, an important consideration with crowded lathe turrets.

The Status Quo: Negative Lead Angle Affects Cutting Tool Life

The challenge comes when workpiece materials fall into the “not much fun to cut” category. Nickel or cobalt-based heat-resistant superalloys such as Inconel 718 and cobalt-chromium (CoCr), Ti-6Al-4V titanium, most tool steels, and 300-series or PH stainless steels can create a host of problems for machinists, including built-up edge (BUE), excessive flank wear and especially depth-of-cut notching.

Unfortunately, these problems are somewhat self-inflicted. By using an 80-degree diamond insert, the lathe machinist is cutting with a negative 5-degree lead angle tool, which is bad for tool life—assuming the usual “face and turn” style *tool holder* is used. Whether milling or turning, switching to a positive lead angle not only thins the chip, but also spreads cutting forces across a greater length of carbide, which reduces or, in some cases, eliminates the failure modes.

“Tools with negative lead angles are the most commonly applied of all turning tools,” says Aaron Schade, program manager for the Knowledge Center Americas at *Kennametal*. “That doesn't mean they're the best, only that that's what everybody's using. Because you have clearance in both directions, a negative lead angle makes the tool more versatile—you can face the part and then turn up to a shoulder, whereas a tool with a positive lead angle means you'll need to come back with a second tool for these operations.”



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Changing Directions in Lead Angles

Just as Kennametal, Seco and most other cutting tool manufacturers offer turning tools with an assortment of lead angles and geometries, they also offer tools able to cut in multiple directions. These “groove-turn” inserts have been around for decades and have continued to grow in popularity (and capabilities) as shops everywhere attempt to do more with less.

One cutting-tool manufacturer recently put a new spin on multidirectional turning, however, breaking the rules of conventional machining in the process. “A number of positive-lead turning products exist that are capable of very high feed rates,” says John Winter, product manager at Sandvik Coromant. “The problem is that they cannot cut a shoulder or perform a facing operation. Prime can.”

CoroTurn Prime looks much like any other positive-lead angle turning tool except for one thing: it’s backward. It’s designed to turn in the Z-positive direction, and has the clearance angles and geometry needed to plunge into a workpiece and turn away from the chuck. According to Winter, this gives it significantly higher metal removal capabilities than traditional turning tools, especially in superalloys and other difficult materials.

To a programmer, the downside is immediately clear: adopting the Prime platform means the CNC code must also be backward. Yet Winter dismisses this argument.

“In today’s world, shops need to be as competitive as possible, and you have to be willing to break with convention,” says Winter. “Just as positive lead angle turning tools improve productivity, so too does **PrimeTurning**. It might be a little extra work upfront, but for certain applications, it’s well worth the effort.”

Round and Round: The Value of Round Cutting Tool Inserts

Although the benefits are difficult to quantify, switching to a tool with a positive lead angle can offer significant improvements in tool life. And when tool life is better, productivity goes up, either because there’s less downtime or because feed rates can be significantly increased.

“We recommend round inserts wherever possible, primarily because they’re the most cost-effective solution for customers who want to remove large quantities of material in the shortest time possible or where tool life is problematic,” says Aaron-Michael Eller, product manager for ISO turning and advanced materials at **Seco Tools**. “On a straight turn using a light depth of cut, for example, you can easily get a dozen or more indexes per insert and feed it like crazy.”

This is why Kennametal, Seco Tools, **Sandvik Coromant** and all turning tool manufacturers offer tool

holders that accept round as well as various rhomboid-shaped inserts with 15-degree, 45-degree and 75-degree lead angles. All offer the opportunity to dramatically improve a shop's turning operations.

Not So Fast: Lead Angles Can Cause Chatter and Tool Deflection

Despite the potential benefits, however, there is a downside—as lead angles grow more positive, tool engagement increases, generating higher cutting forces that are now shifted in a radial direction; the machinist may have eliminated depth-of-cut notching, but will possibly be facing chatter and tool deflection instead.

Also, the chip thinning effect means those chips are harder to control, and heavier feed rates will likely be needed to compensate. It's these considerations, plus the fact that a second tool will be required to face the workpiece and clean out the uncut areas adjacent to any shoulders, that explain why most machinists take the 80-degree path of least resistance.

While adopting a positive lead angle turning strategy is admittedly a balancing act and may require a series of time-consuming tests to master, both experts agree that—for the right application—it's well worth the effort.

"Yes, you will need a fairly rigid setup, and yes, you must adjust your processes somewhat, but positive lead angles generally equate to increased metal removal rates, tool life and productivity," says Seco's Eller.

Why are the right tool holders so important? Read "Lessons in High-Performance Machining: Don't Forget the Tool Holders."

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No Magic Formula to Determine the Optimal Cutting Tool

The first process change is determining what lead angle is best. This process is definitely one of those instances where more is not always better. Assuming a constant depth of cut, switching from a negative 5-degree tool to one with a positive 45-degree lead angle increases workpiece engagement by a whopping 40 percent. Again, adjustments to the cutting parameters will almost certainly be needed to achieve the desired results.

Since cutting forces are always perpendicular to the tool's lead angle, going positive means greater radial tool pressure is applied to the workpiece. When turning slender shafts and thin-walled parts in these scenarios and with most boring operations, a neutral lead angle is usually best, since the feed forces are almost entirely in the Z-axis. It's a complex trade-off. Unfortunately, there's no magic formula to determine the optimal cutting tool.

"You need a good understanding of the impact that lead angles have on turning operation, but at the same time recognize that part configuration also plays a critical role in tool selection," says Schade. "If it's a straight Z-axis cut with no shoulders and no facing, there's really an unlimited number of tooling options, whereas undercuts, profiling, shoulders, and other part features tend to limit what can be done with a single tool."

“Everything in machining is application dependent, and what’s most important is to grasp the available options and use them to your best advantage—switching to a positive lead angle is one such option,” says Schade.



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