TROCHOIDAL TURNING: A STRATEGY FOR EFFICIENCY AND PRODUCTIVITY

The concept of trochoidal turning is based on a machining strategy in which tool paths and the entry and exit movements are optimized to maximize metal removal rates. Thanks to the simultaneous use of different axes in combination with round indexable inserts, this machining strategy is very efficient and offers many advantages in comparison to conventional turning. Innovative trochoidal turning strategies together with advanced CAM software enable shops to significantly increase efficiency and output in a wide range of roughing operations.

Trochoidal turning and milling

Trochoidal turning is essentially separated into two strategies – simple, done on conventional turning machines, and simultaneous, performed on those machines with B-axis movement. These turning strategies echo the concepts of trochoidal milling, a familiar machining method that combines a spiraling cutting path with straight ahead motion.

Trochoidal milling employs light radial depths of cut, large axial depths, and fast feed rates and cutting speeds. It provides high metal removal rates, low radial cutting forces and reduced vibration while maintaining required chip loads on tool cutting edges. The results are increased productivity, shorter cycle times, longer tool life, and reduced wear and tear on the machine tool.

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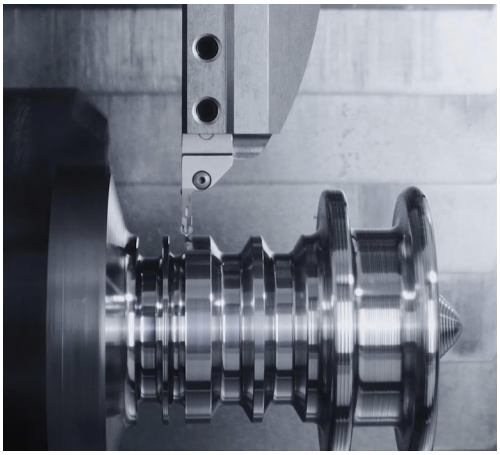
Trochoidal turning, similarly, features lower depths of cut, higher feeds and faster cutting speeds than conventional turning but uses standard round turning inserts that increase toolpath flexibility and permit smooth entry and exit from the workpiece. In trochoidal turning, the insert is always in the cut, eliminating the time lost returning to a set point after every pass. Trochoidal turning performs longitudinal and face turning as well as radial and axial grooving.



The light cuts and reduced cutting forces in trochoidal turning are advantageous when cutting difficult-to-machine materials such as stainless steels and nickel- and titanium-based alloys. Because of the possibility of using high feed rates to get good chip breaking, the approach is also beneficial when turning soft but tough ductile materials that normally produce long chips that endanger operators and wrap around the tool.

The need for application-focused software

Recognizing the productivity advantages of trochoidal turning, CAM software provider OPEN MIND engineered *hyper*MILL® software to expedite trochoidal turning on conventional CNC turning machines. The software enables easy programing of trochoidal turning on standard three-axis turning machines. However, using a multi-tasking machine with B-axis capability enables a shop to take full benefit of trochoidal turning strategies.

Programming the additional axis is somewhat more complex than that for a three-axis machine, but the moving axis provides greater accessibility when turning complex parts and therefore is faster and more efficient. The round inserts combined with light depths of cut and the ability to rotate/swivel the cutting tool relative to the workpiece axis effectively creates more cutting edges and boosts tool life. The software optimizes toolpaths to prevent sudden loads on the inserts. Using the B-axis to freely move the insert in space also promotes uniform movement of machine tool components that reduces stress on the machine and prevents collisions.

Process details

The trochoidal approach essentially consists of reducing depth of cut while increasing feed rate and cutting speed, producing a much higher metal removal rate. Feed rates relative to conventional turning are three to five times faster, and depths of cut are 20 to 30 percent less than typically used. Doubling the metal removal rate potentially reduces cycle time by 50 percent; in grooving applications, cycle time savings can be as much as 70 percent.

The programming algorithms of *hyper*MILL® software are key to successful trochoidal turning. Reducing the depth of cut results in a shallower insert approach angle, making it necessary to increase feed rates to maintain the chip thickness appropriate for the insert and workpiece material. Insert edge geometries also require a certain chip load to break chips and maximize efficiency. Round inserts, reduced depths of cut and software strategies that produce soft part entry and exit also improve tool life in difficult to machine, abrasive materials with high yield strengths. The software varies feed rate and depth of cut (DOC) to reduce heat generated in the cutting process.

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Effects on machine tools and inserts

Increased feed rates put greater stress on machine tool components. Feed rate is directly proportional to metal removal rate, and higher metal removal rates place larger demands on the machine tool spindle. However, round positive-style inserts generally are softer cutting, so in most cases trochoidal turning is suitable for lower-power machines. Regarding insert geometry and style, global toolmaker CERATIZIT typically recommends its RCMT and RCGT inserts for trochoidal turning and GX24 inserts for trochoidal grooving, using 4–6 mm nose-radii and M3 chipbreakers.

Quantifiable results

Trochoidal turning is especially beneficial in high volume production operations such as the manufacturing of traditional automotive components including axles and shafts. The productivity benefits are dramatic.

For example, a shop turning D2 equivalent Cr12MoV steel at a 150 mm/min cutting speed, 0.4 mm/rev feed rate and 3.0mm DOC generated a chip thickness of 0.398 mm and chip volume (metal removal rate) of 234 cm^3/min. When the shop implemented trochoidal turning methods, cutting speed was increased to 350 m/min and feed rate raised to 2.2 mm/rev, while DOC decreased to 0.45 mm. Resulting chip thickness was 0.31mm while metal removal rate more than doubled to 592 cm^3/min.

Industry acceptance

Acceptance of trochoidal turning methods is growing as shops realize the strategies provide productivity benefits similar to those resulting from the high feed/low DOC concepts of trochoidal milling. However, resistance to change and habitual inertia traditionally delay metalworking process development.

“We’ve always done it this way,” and “If it’s not broken, don’t fix it,” are common reactions to innovations in manufacturing technology. An example from the not-too-distant past is the slow and grudging application of hard tool coatings, reluctance that faded when the true benefits of the coatings became clear.

This tendency to disregard innovative technology and not “think outside the box” restricts progress in metalworking productivity. An additional impediment has been the separate research and development paths of cutting tools, machine tools and CNC software.

Until recently, technological improvements in each of these industry sectors moved ahead separately and slowly. A new coating might not be used to its greatest advantage because machine tool capabilities had not sufficiently advanced to take advantage of the coating’s capabilities, or, as in the case of software for trochoidal machining, an innovation had not been widely recognized as a significant technological move forward. Presently, growing teamwork among metalworking technology developers like CERATIZIT and OPEN MIND is generating momentum for significant progress in metalworking productivity.

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