CREEP FEED GRINDING APPLICABILITY CONTINUES TO EXPAND

INTRODUTICON

Many manufacturers view grinding as a somewhat mysterious process requiring years of experience to master. However, a variation on the process – creep feed grinding – provides both high metal removal rates and excellent surface quality in a much wider range of applications than most manufacturers would consider.

When implemented with the right equipment and knowledge, creep feed grinding can often replace operations such as milling and broaching, streamline processes, and produce higher quality parts. Instead of hard milling a part, deburring it, then finishing with surface grinding, creep feed grinding can accomplish the same results in one operation. In some cases, creep feed grinding is as much as 40 percent faster than alternative processes while generating minimal burrs.

Even when cycle times are similar, the savings in secondary operations and re-fixturing times are significant. For example, in situations where a shop mills an unhardened workpiece, sends it to heat treatment, then brings it back for finish grinding, creep feed grinding can eliminate two steps in the sequence.

While traditional reciprocating grinding processes remove small amounts of material in repetitive passes at feed rates in the neighborhood of 200 ipm, the single pass in creep feed grinding are in the range of 2-20 ipm at depths of cut of 0.100" to 1.5" or deeper. Shops typically employ the process on hardened or hard-to-machine materials.

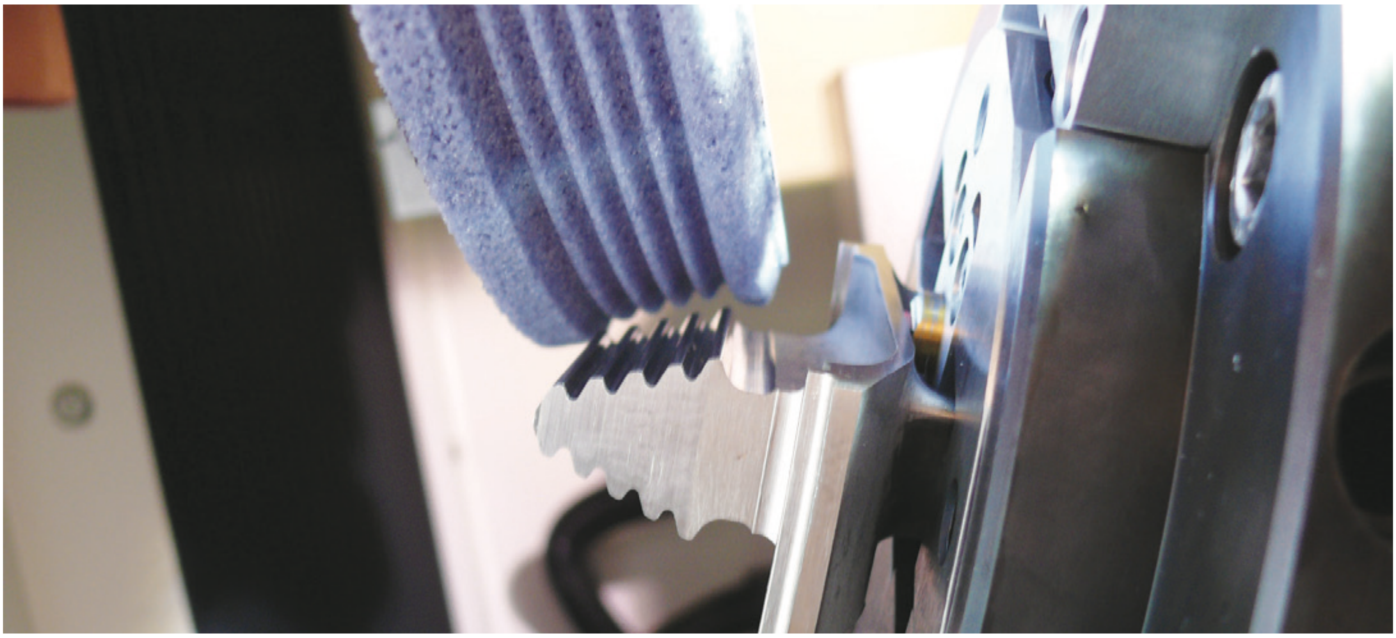
The aggressive parameters of creep feed grinding require exceptional equipment and tools. Special considerations influence the choice of grinding machine, abrasive wheels, wheel dressing methods and coolant. There are also initial challenges to overcome when applying creep feed grinding.

In some cases, creep feed grinding is as much as

40% faster

than alternative processes while generating minimal burrs.

UNITED GRINDING



KEY CHALLENGES

Two key challenges exist for shops considering adding creep feed grinding capability. The first is gaining knowledge and experience needed to successfully implement the process. The second challenge is justifying the cost of creep feed grinding equipment.

For the most part, the average shop has little, if any, in-house knowledge of creep feed grinding, a fact that is true even for some second-tier and OEM operations. To implement the process from scratch, shops must specify and test a large number of variables, including grinding wheels, dressing methods and tools, coolants and depths of cut, speeds and feeds, and more. In these instances, grinding suppliers such as UNITED GRINDING can share their extensive experience in creep feed grinding with their customers, providing ample application support in addition to appropriate equipment.

Many shops are comfortable with milling but less so with grinding. In actuality, creep feed grinding and milling are similar processes – the primary difference is that the tool is a grinding wheel instead of an end mill. Indeed, creep feed grinding can be thought of as milling on steroids, as many of the issues that cause difficulties in milling (e.g., long cycle times, burr generation, tool degradation, etc.) are minimized or eliminated with creep feed grinding. If shop personnel are comfortable with milling, they can learn to be comfortable with grinding in general and with creep feed grinding specifically.

When it comes to cost, a surface grinder may be relatively inexpensive, but the added rigidity, horsepower and other requirements of creep feed grinding add to the cost of the grinding machine. To make the decision to acquire a creep-feed grinding machine, a shop must determine what the overall cost per part will be in terms of tooling, fixturing, grinding wheels and cycle times. Shops rarely purchase creep feed grinders in anticipation of potential work; instead, a production operation generally has to research the benefits of the process relative to the specific parts they make prior to investing in this productivity-boosting technology.

Two key challenges exist for shops considering adding creep feed grinding capability. The first is gaining knowledge and experience needed to successfully implement the process. The second challenge is justifying the cost of creep feed grinding equipment.

THE CREEP FEED GRINDING MACHINE

For creep feed grinding, machine rigidity and horsepower are critical. The creep feed process magnifies cutting forces and makes ball screw drives for the grinding machine a necessity. Rigidity requirements extend to machine structure and fixturing, and as long as the part can be held securely, a wide range of different applications are candidates for creep feed grinding.

When it comes to horsepower, a typical 16" x 32" surface grinder operates in the range of 10 hp. UNITED GRINDING creep feed grinders, on the other hand, start at 23 hp and increase to well over 100 hp. The width of the grinding wheel, depth of cut and wheel geometry generally dictate horsepower requirements, with wider wheels, for instance, more horsepower is required. Surprisingly, while the forces on the machine and the part are high during creep feed grinding operations, the low feed rate and chip load result in relatively low forces on the grit in the abrasive grinding wheel.
Automating a creep feed grinding machine is somewhat challenging because the high metal removal rates generate large amounts of grinding swarf that must be accounted for because excessive amounts of it can cause part misloads. Because there is no operator present to remove swarf in automated operations, creep feed grinding machine engineers design and integrate a comprehensive cleaning system with air knives and other apparatuses to keep the fixture clean and ensure that the swarf is flushed away before it can interfere with the machine's operation. UNITED GRINDING, for example, maintains a specialized automation group that provides input as the equipment and fixturing are designed for its creep feed grinding machines.

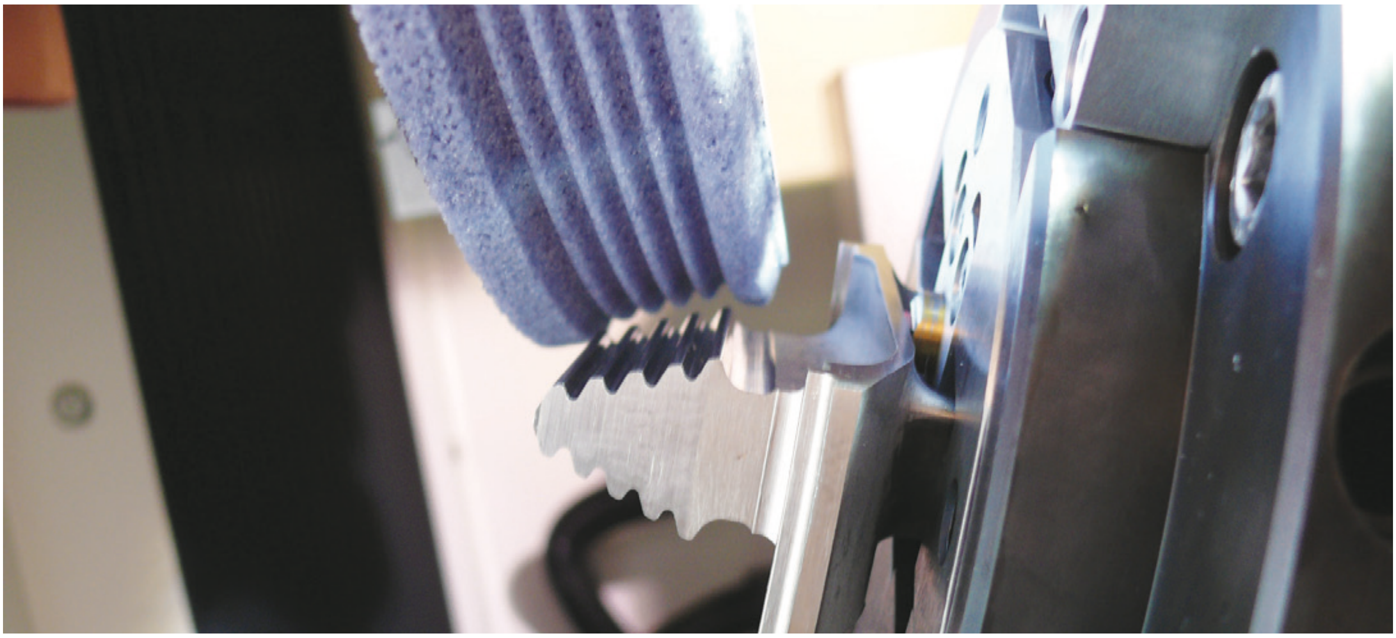
When it comes to horsepower, a typical 16" x 32" surface grinder operates in the range of 10 hp. UNITED GRINDING creep feed grinders, on the other hand, start at 23 hp and increase to well over 100 hp.

WHEEL CHOICE

Wheel choice, as with any tooling decision in metalcutting, depends on the specific application and desired cost per part. Wheel options include conventional abrasives as well vitrified cubic boron nitride (CBN) and CBN-plated materials. However, a resin-bonded CBN grinding wheel may be the best choice for creep feed grinding a slot 0.100" in width. However, the most widely used wheels are conventional glass-bonded abrasives, including aluminum oxides and ceramics, due to their lower cost.

Plated CBN and vitrified CBN wheels are highly productive in some creep feed grinding applications, but may involve investments of $5,000 to $10,000 compared to $450 for a conventional abrasive wheel. Frequently, a shop will begin an application with a conventional wheel and later introduce a CBN wheel to decrease the wear on the more expensive tool.

Most wheels used in creep-feed processes are 12", 16" or 20" in diameter and between 0.500" and 8" in width, but some applications, such as automotive steering racks, require wheel as wide as 10". The majority of wheels intended for creep feed grinding feature a high level of porosity to facilitate coolant flow and swarf removal.



COOLANT DELIVERY

Heat management is another key consideration in creep feed grinding. Thus, coolant flow and delivery to the optimal cut zone are critical concerns for process success.

For effective coolant management, coolant flow rate should match wheel speed, and CNC-guided coolant nozzles compensate for the changes in wheel diameter resulting from dressing. Both water-soluble and oil-based coolants can be effective in creep feed grinding, but plated CBN grinding wheels generally require the use of oil-based coolant and higher rpm and surface speeds. Using water-soluble coolant with plated CBN wheels, however, will reduce wheel life.

Furthermore, while grinding machines may run either kind of coolant, changing in midstream can be complicated. Transitioning from water-soluble to oil-based coolant will require the addition of fire-suppression and other additional accessories that can reduce the risk of flammability inherent with oil-based fluids.

Heat management is another key consideration in creep feed grinding. Thus, coolant flow and delivery to the optimal cut zone are critical concerns for process success.

WHEEL DRESSING

CNC single point, full form diamond roll and crush roll are the three main techniques for creep feed grinding wheel dressing to produce the desired profiles. Production quantity, wheel form and part surface finish quality dictate the proper dressing technique. For example, low production quantity and intricate form applications can use CNC dressing.

While on the other hand, that same form in a high production scenario would use a full-form diamond roll dressing, and in the case of high quantities and tight radius profiles, the application would require a carbide or steel crush roll for dressing.

The high material removal rates of creep feed grinding wear wheels rapidly, which makes determining when to dress the wheel another application-dependent decision. MÄGERLE and BLOHM creep feed grinding machines from UNITED GRINDING come with optional continuous dressing systems to maintain sharpness throughout an entire operation.

Some wheel materials – particularly CBN – and operations permit intermittent dressing, with dressing of the wheel at selected part-completion intervals or even between roughing and finishing passes to maintain desired tolerances. As the grinding wheel is dressed, its diameter shrinks, and it is necessary to increase rpm to maintain a constant cutting speed in terms of surface feet per minute.

Many variables affect the need to dress the wheel, including the materials being ground, grinding wheel type and the speeds and feeds at which the wheel is applied. The only way to fully determine the optimal dressing time is to grind until the wheel no longer produces the desired form.

A wheel will eventually break down, and exactly when that occurs must be determined. UNITED GRINDING has extensive experience in creep feed applications and can provide approximations of dressing intervals when installing a turnkey creep feed grinding setup. However, the only certain way to determine if a grinding wheel is being fully utilized is to push it to failure, then reduce the grinding parameters to establish a safe margin for continuing production.

Ongoing dressing maintains a wheel's sharpness and produces extremely consistent part dimensions as opposed to using a broaching process. When using a broach to cut the teeth of an automotive steering rack, for example, the broach wears each time it completes a pass, slightly degrading accuracy. Later passes progressively move away from the original tolerances until the tool must be changed. In creep feed grinding, however, continuous or repeated dressing operations ensure that any wear that does occur is negligible for results that remain consistent from the first to the thousandth part.

In creep feed grinding, however, continuous or repeated dressing operations ensure that any wear that does occur is negligible for results that remain consistent from the first to the thousandth part.

CNC ADVANTAGES

Advances in the speed and flexibility of machine control technology have contributed significantly to the expanded applicability of creep feed grinding, especially in the case of complex parts with multiple features. For instance, an aerospace turbine blade may require grinding a fir tree-shaped feature, a V-notch and tip. The blade is moved from fixture to fixture in the machine, and each feature becomes a datum for the next grinding operation.

To grind parts with a variety of features, multiple profiles can be dressed into a single wheel or via packs of wheels with differing profiles. A typical wheel pack might have a flat wheel on one end for grinding a turbine blade's flat, a serrated wheel profile in the middle for creating a fir tree feature, and a wheel with a profile for grinding the blade tip. Creep feed grinding machines such as those available from UNITED GRINDING offer 5- and 6-axis capabilities that allow users to fully exploit a machine's CNC functionality and the advantages of the creep feed grinding processes.

CONCLUSION

Initially introduced in the aerospace industry in the 1970s to grind superalloy engine components, creep feed grinding today is recognized for the productivity and part quality it provides. The process's growing range of applications include everything from grinding automotive steering racks, saw blades and hair clipper parts to massive rolls for corrugated cardboard manufacturing, ceramic heart valve components and tiny pins used in engine management mechanisms. Additionally, creep feed grinding can eliminate the need for typical secondary operations that would otherwise increase costs per part and add to production time – particularly when manufacturers choose a manufacturing technology partner like UNITED GRINDING, which has the equipment and expertise shops need to leverage this technology for their part-production operations.

Additionally, creep feed grinding can eliminate the need for typical secondary operations that would otherwise increase costs per part and add to production time – particularly when manufacturers choose a manufacturing technology partner like UNITED GRINDING, which has the equipment and expertise shops need to leverage this technology for their part-production operations.