Creep Feed Grinding Challenges Traditional Surface Machining Methods

Its speed over conventional reciprocating grinding increases directly with the depth of the form. More importantly, the process runs rings around such conventional straight-line machining operations as milling and broaching.

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If your production involves milling, broaching and similar "linear" machining operations and/or grinding to demanding dimensional tolerances or finish requirements, odds are you can produce many of those parts faster, better and for less cost using a process called creep feed grinding (CFG). The process involves slowly feeding---Creep feeding---the workpiece past a form grinding wheel set to the full depth of cut. The desired detail (slot, shoulder, form, etc.) is produced in the workpiece in a single pass under the wheel.

The advantages of CFG are best understood by comparing it to conventional reciprocating grinding. In conventional grinding, the table reciprocates back and forth beneath a grinding wheel that infeeds at a rate of two or three "tenths" per pass. To grind a 0.100-inch-deep slot in mild steel at an in-feed of, say, 0.0002 inch would take 500 passes. A typical reciprocating grinder with a 12-inch stroke operating at 50 spm would require 10 minutes for the job, not counting interruptions for wheel dressing that might be necessary during the operation.

By contrast, with CFG the same 0.100-inch-deep slot can be accomplished in a single pass in a few seconds to a few minutes depending on the length of the cut. Machining speed is probably the greatest advantage of CFG. Additionally, parts are produced to very high accuracy, without burrs or distortion. And complex profiles can be ground into the workpiece as easily as simple ones. The advantages of CFG add up to a cost saving opportunity for most parts which require profiling operations.

As a rule of thumb, CFG can readily remove about 1 cc of metal (mild steel using an aluminum oxide wheel) per kilowatt per minute. One horsepower is roughly equivalent to 0.7 kilowatt, which means that a 10-horsepower CFG machine can remove about 7 cc of stock per minute.

Those of you who are accustomed to working in metrics have already figured out that 7 cc translates to a metal removal rate of about 1/2 cubic inch per minute for a 10-horsepower machine. How, then, can CFG compete favorably against conventional machining methods with their higher metal removal rates?

The answer is found in the sequence of operations typically required to machine a part from the solid. Consider the steps involved in machining a part on a horizontal milling machine. The operation begins with a "soft" (unheat treated) blank. Appropriate cutting tools must be assembled for the job; where an unusual profile is to be milled, custom cutters may be needed. The tools must be sharpened as they become worn, adding further to the cost of the operation.

Milling by its nature leaves burrs which must be removed in a secondary operation. Depending on the part and the nature of the cut, the deburring operation may be simple-or so difficult that its cost exceeds that of the initial machining. Either way, deburring involves another step and another handling.

After the "soft" workpiece has been machined and deburred, it must then be heat treated to the required strength and hardness. Frequently, the parts must be sent to a commercial heat-treater for processing, which not only adds to the cost of the part, but creates a built-in interruption of the production cycle.

The heat-treating process frequently creates distortions in the workpiece which must be corrected. Finally, while milled surfaces are acceptable for commercial tolerances, the workpiece may require a finish grind if close tolerances or fine finishes are specified. Profile surfaces may dictate the use of a form wheel, further increasing the cost of the part. The grinding operation will also give rise to alignment and holding problems.

Now, let's look at production of the same part by CFG. The process starts with a through-hardened blank. The grinding operation is typically performed in one setup on one machine. The part is free of burrs and distortion as it comes off the CF grinder and is ready for downstream operations or for use as is. The direct processing by CFG eliminates the costs of the secondary operations associated with milling, precludes the possibility of rejects due to errors in secondary operations, reduces in-process and handling costs, reduces labor and cutting toot costs, and makes possible faster delivery times on jobs.

There are two more very significant advantages of CFG. In the first place, the CFG part is metallurgically superior to its milled counterpart since it's free of machining stresses and heat-treat-related problems such as decarburization. Secondly, while some materials can only be machined with great difficulty if at all by milling, any material can be machined efficiently by CFG given the correct wheel type, coolant, etc.

CFG is not a black art. It is a straightforward, thoroughly predictable machining process. However, successful results cannot be achieved with inadequate or insufficient equipment or a less-than-complete commitment to making the process work. Buying a machine is not enough; CFG must be implemented from a systems standpoint. The plant or shop that tries to acquire CFG capability by upgrading a 10- or 15-year-old machine for the purpose is almost certain to fail. So, too, will the firm which expects simply to buy a machine, stick it in a corner, hook it up and do creep feed grinding.

Proper care must be given to the selection of the machine, type of wheel for the operation, type of coolant, coolant flow and capacity, coolant filtration, wheel dressing, and every other factor which affects the process. Like the proverbial chain, the CFG system will be only as effective as its weakest link.

A machine designed from the ground up for CFG should be specified since high levels of rigidity, accuracy and power are crucial. Unlike reciprocating grinding where stock removal and power consumption per pass are low, CFG cuts to full depth with a high arc of contact. CFG machines routinely utilize 100 percent of available horsepower, and the machine must be rigid enough to handle such loading. Not just the iron, but bearings, spindle, motor, table drive ... everything must be rigid.

Grinding wheel selections --- a study in its own right --- is also critical to success. Improper selection --- for example, using a wheel that is too dense for the work material and type of cut --- can result in burnt and/or out-of-tolerance parts.

Selection of the type of wheel can also make or break the job. Aluminum oxide wheels are suitable for most materials, but CBN wheels are usually more efficient for tool steels and such difficult-to machine metals as Inconel and Rene, and diamond wheels are usually best for carbides and ceramics.

Proper wheel dressing is critical to maintaining the stock removal capabilities of the grinding wheel. Crush roll dressing produces the sharpest, most free-cutting wheel. When brought into contact with the wheel, the crush roll fractures the bond on the face of the wheel, leaving grains that are completely intact, full and sharp.

Proper crush roll dressing requires rigid conditions. The wider or harder the wheel, the greater the rigidity required. Ideally, the crush roll should be mounted on the grinding head above the wheel.

Diamond roll dressing produces a wheel which is almost as sharp as a crush dressed wheel if performed correctly. The diamond roll dresses faster, lasts longer, and can maintain incredibly close tolerances. It is the ultimate production tool where circumstances permit its use.

In diamond roll dressing, the wheel must be rotated at an appropriate speed relative to the roll. Accordingly, the CFG machine must have a variable speed (d-c drive) spindle capable of rotating the wheel at the required speed. This is important, since most grinding machines have a-c (constant speed) spindles and are thus unsuitable for diamond roll dressing.

Coolant is another important consideration. It must be delivered to the grinding zone in sufficient volume and at sufficient pressure to cleanse the grinding wheel and prevent it from becoming loaded, to provide the lubricity needed to promote chip formation, and to keep the wheel and workpiece cool by drawing heat away. Effective coolant filtration is also needed to remove suspended particles. This is particularly important where part finish is critical.

These comments are not intended to discourage potential users of CFG. But the would-be user must be made aware that no component of the system can be ignored if the operation is to succeed. In CFG, as in good pizza making, there's no skimping on the family recipe.

Applications for CFG

In grinding operations involving modest metal removal (to depths of .010 inch), grinding times for creep feed grinding versus reciprocating grinding are roughly equivalent. As the form gets deeper however (0.020 to 0.030 inch), CFG begins to demonstrate a clear advantage over reciprocating grinding in terms of speed. The advantage increases directly with the depth of the form; CFG can be as much as 100 times faster for grinding a 1/4-inch deep slot.

Perhaps the greatest potential for CFG is as an alternative to horizontal milling operations. While the process is "limited" to straight-line machining, the requirements for this type of operation in industry are staggering. Imaginative fixturing and multipart setups further increase the efficiency of the process.