Creep-Feed Grinding Cuts Costs

By producing groove-type shapes and contours to 1/2 in. deep or more in a single pass, machine cycle time is cut and manufacturing costs are reduced

Creep-feed grinding, a process of grinding finish shapes in solid soft or hard workpieces in one pass, is commonly used in Europe but relatively new to the U.S. industry. Benefits from the process include up to 50 percent reduction of cycle times, excellent repeatability, up to 300 percent more wheel life and improved surface finish compared to conventional reciprocating grinding operations. Additionally, the process does not induce subsurface stresses in workpieces.

The major benefits from creep-feed grinding are gained when shapes or contours a minimum of .015 in. deep are required; the deeper and more sophisticated the shape, the larger the benefits.

The Process. In principle, creep-feed grinding is similar to climb milling. The machine table feeds in the direction of the grinding wheel rotation; this motion tends to exert downward pressure on the workpiece. The grinding wheel is set to full depth and the table feeds at a precisely controlled rate ranging from 2 to 60 ipm. A particular operation's feed rate is dependent on a part's material, hardness, corner radius required, type of grinding wheel and depth of cut; tougher materials require a slower feed rate.

The Machine. A heavy-duty, rugged machine is necessary for production creep-feed grinding operations. The table feed must be variable, precisely controlled and without backlash. The machine should feature a crush or diamond-roll dresser and provide a minimum of 50 gpm of coolant at 30 psi to the grinding wheel-part contact area. The machine should provide full hp without vibration and a dc spindle drive is essential to provide constant peripheral surface speed.

Typically, creep-feed grinding made its U.S. debut in contract shops. Abrasive-Form Inc., Roselle, IL, pioneered the process in the U.S. in 1970. In addition to several other machines, the shop operates 11 large creep-feed grinding machines on a two-shift basis and produces millions of parts annually for the automotive, business machine, aircraft, electronic and medical industries.

John Stevenson, Abrasive-Form's vice president, reports: "Eleven years of production experience has revealed that the process offers substantial manufacturing benefits for roughing or finishing an unlimited variety of simple or sophisticated contours. Presently, the process is an efficient method that competes favorably with milling and broaching operations without some of their inherent drawbacks.

"Creep-feed grinding can produce almost any shape from the solid, in hardened or soft workpieces, in a single pass, in minutes. In comparison, conventional milling or broaching is used to rough-machine a shape in a part, which then is deburred as required, heat treated and finish ground on a reciprocating machine. Therefore creep-feed grinding not only eliminates rough machining operations, but also contributes to minimal material

handling and in-process inventory. It also avoids the manufacturing problems associated with warpage from heat treating operations.

"For example, creep-feed grinding can produce a .300 in. deep form in a 6-in. long part within a three-minute maximum cycle. In comparison, a reciprocating grinder, using a .002-in. downfeed per pass in each direction, would require an about 20-minute cycle.

"Innovative tooling and machine setups further contribute to maximum productivity from creep-feed grinding operations. For instance, dual shuttle fixtures or multiple part holding fixtures are used to achieve maximum machine utilization. Wide grinding wheels, capable of grinding parts in a side-by-side arrangement, also are utilized to provide maximum machine uptime.

"However, the Swiss-made Magerle grinding machines are the real key to our successful creep-feed grinding operations. The extremely rugged machines, specifically built for creep-feed grinding, feature automatic sequencing of crush dressing cycles and size control which ensures consistent production of parts within a.0002-in. depth. The dc spindle drive also provides constant surface speed which contributes to long wheel life and high quality surface finishes.

"Usually, open structure aluminum oxide grinding wheels are used for creep-feed grinding operations. These porous grinding wheels allow room for metal chips and carry coolant to the wheel/ work contact area, and the wheel life ranges up to 300 percent longer than comparative conventional grinding operations. The climb grinding process tends to tear out dull, used abrasive grains and expose new sharp grains which contributes to a free-cutting action and improved surface finishes. The combination of high volume coolant and constant contact pressure with the part also contributes to extended wheel life," Stevenson adds.

Production Operations. The majority of production parts creep-feed ground at Abrasive-Form are about 3 in. long; however, parts up to 47 in. long have been produced. Generally, production parts are ground in batch lots and most of the business is repeat orders.

Actual examples of the benefits provided by creep-feed grinding include productivity improvements, reduced manufacturing costs and many more. In one particular case, overall productivity increased 40 percent when creep-feed grinding replaced milling a slot in a steel investment casting. The process change also contributed to a substantial quality improvement and eliminated a burr problem which had plagued the milling operation.

The operation involves creep-feed grinding an about 5/32-in. deep x 1/2-in. wide form with two vertical ribs in the 4-in. long cast parts. The fixture holds two pairs of parts in a side-by-side arrangement which produces four finished parts per machining cycle. Last year, 40,000 of these parts were produced for the customer.

Another example of creep-feed grinding reveals the economic advantage of the process in combination with a special 2-in. wide crush-dressable diamond grinding wheel. The

German-made grinding wheel has .400-in. depth of crush-dressable diamond abrasive material and has been in use for several months.

The operation involves creep-feed grinding 50 V-grooves per inch, in two directions, to provide sharp pointed teeth similar to a double-cut file, in 1/2-in. wide x 4-in. long carbide strips. The grinding setup utilizes two vacuum chucks which each locate six carbide strips at opposing 45-degree angles from the table travel.

Creep-feed Grinding Benefits

- Fast cycle time
- Excellent repeatability
- Maximum wheel life
- Precision depth control
- No rough machining
- Burr-free surfaces
- No warpage problems
- Minimal part handling
- Low piece cost

For a tooth creep-feed operation, six carbide strips are loaded on each vacuum chuck and the operator pushbutton-actuates the grinding cycle. The machine automatically completes one grinding pass, the table returns to its start location and indexes Outward to position the grinding wheel for cutting another group of V-grooves. The cycle then repeats until the teeth have been ground for the entire length of the carbide strips. The operator then changes the strips between chucks and repeats the cycle.

Another example of production creep-feed grinding involves the familiar "Christmas tree" or root section, holding a .0005-in. tolerance on turbine engine blades. Although productivity comparisons are considered classified the customer reports a significant improvement in quality and repeatability.

The creep-feed grinding operation produces two finish ground turbine blades per cycle. A pair of inconel blades loaded horizontally into a hydraulic chuck is located and clamped on gage points. Pushbutton-actuated, the creep-feed grinding cycle finishes one side of the blades' root section and the table returns to its start position. The operator manually indexes the chuck 180 degrees and repeats the machine cycle.

Regarding the future for creep-feed grinding, Stevenson says: "Because of the benefits it provides, creep-feed grinding will soon make significant inroads into the domestic manufacturing industry. In our experience, it is almost always the most efficient and economical process to produce grinding contours deeper than .015-in. on a production basis.

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