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Thinning Out

All images: Stellram

High-feed milling cutters can reduce machining time in roughing applications.

Over the years, machinists have embraced improvements in milling cutters that allowed them to dramatically reduce machining time and part cost. Today, further improvements in tool designs and machining techniques are again offering opportunities to dramatically reduce costs. One of the least-publicized and underappreciated improvements is the potential to reduce machining time by roughing with high-feed milling cutters.

The economics of high-feed milling can be compelling. It is not uncommon to obtain 50 percent or greater improvement, often reducing machining time by hours, days—even weeks.

Several manufacturers currently provide cutting tools for high-feed milling, which are targeted at replacing round button cutters. Designs vary greatly, with differences being the number of cutting edges, trigon or square insert shape, insert size and cutting capability.

Some designs are only for facemilling, but others can also be applied when

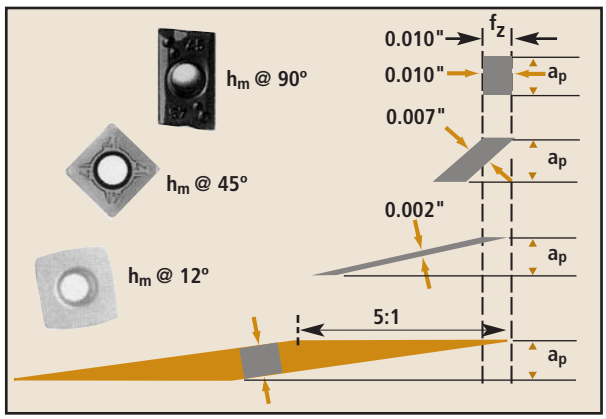


Figure 1: Chip thickness for 90°-, 45°- and 12°-approach angles. One would have to program a feed of 0.050 ipt for the tool with the 12° approach to obtain a true 0.010" chip thickness. a_p = axial DOC; h_m = average chip thickness; f_z = feed per tooth.

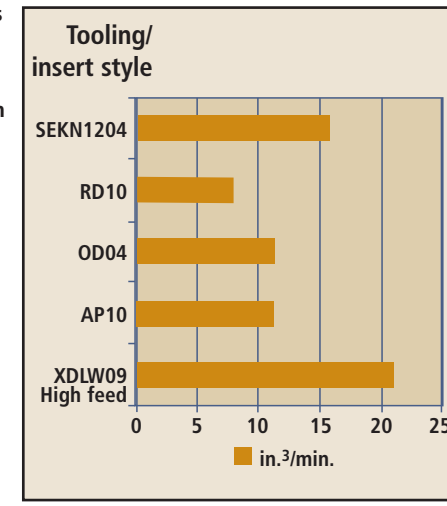


Figure 2: Material removal comparisons for five 1.25"-dia., 3-pocket cutters run at 1,200 rpm at the maximum DOC and feed rate suggested for the insert. A SEK-style insert is able to remove 16 in.³/min. The RD10 10mm round button insert can remove 7 in.³/min. The OD04 4mm octagon insert can remove 11 in.³/min. The AP10 10mm A-style insert can do 11 in.³/min. The XDLW09 high-feed insert is able to remove 21 in.³/min.

ramping and plunging. Yet they all share one common characteristic: The capability to facemill at elevated feed rates, typically 0.080 to 0.120 ipt.

These high feed rates are achieved by thinning the chip with the use of a low-approach-angle cutter—any angle below 45°. With a 90°-approach-angle cutter, at full radial engagement, a feed of 0.010 ipt would equal a true 0.010" chip thickness. With a 45°-approach-angle cutter, at full radial engagement, a feed of 0.010 ipt would equal a true 0.007" chip thickness. One would have to program a feed of 0.014 ipt to obtain a true 0.010" chip thickness. With high-feed cutters that employ even flatter approach angles, such as 12°, typically one would have to increase the programmed feed per tooth roughly 5:1 to maintain a true 0.010" chip thickness (Figure 1).

High-feed cutters work by making repeated passes at DOCs between 1mm (0.039") and 2.5mm (0.098"). Although the DOC is shallow, the volume of material removed per unit of time is far greater with these tools than with industry-standard square- and round-insert cutters because of the high feed rate (Figure 2).

High-Feed Applications

High-feed cutters first appeared in the die and mold industry about 2 years ago, where intense competition created

Down to 30

Arkansas Tool and Die, a manufacturer of precision stamping dies and special machines located in North Little Rock, Ark., was looking for an effective solution to machine 17 holes in an 18"×54"×3.5" die-pressure pad made from 4140 steel using a Matsuura vertical machining center with a BT-50 spindle.

The flat-bottom, blind holes are 2.031" in diameter and 2.667" deep. Due to the part configuration and fixturing, a 4.5" tool projection is required to produce the holes. Cycle time was 15 minutes per hole, or 4½ hours total.

Stellram distributor Doug Glenn, owner of Searcy (Ark.) Industrial Products Inc., worked with Arkansas Tool and Die engineers to prove the feasibility of helically interpolating these holes with Stellram's modular-head A7792VXD09S1.00Z2R1.4 high-feed milling cutter and M-21-M12-C1-5.157 antivibration, heavy-alloy modular shank on the 30-hp VMC.

Starting from the solid, a 2.031"-dia., 2.667"-deep, blind, flat-bottom hole was helically interpolated in the 28-to 32-HRC 4140 steel in just 1 minute, 45 seconds with the high-feed concept. At 1,500 rpm, surface speed was 400 sfm with a feed of 0.045 ipt (135 ipm).

The time required for the job dropped from 4½ hours to 30 minutes.

—T. Hofmann

Arkansas Tool and Die uses helical interpolation to produce holes with Stellram's high-feed milling cutter.

a need for a roughing tool that could rapidly remove large quantities of material from mold cavities. Today, their use is spreading to other industries. New market segments include aerospace, heavy equipment and general manufacturing.

High-feed cutters are a good choice for extended-reach applications or when cutting conditions are unstable. By design, these tools direct the cutting forces predominantly in the axial direction (back into the spindle), minimizing vibration and ensuring a stable relationship between the cutting edge and workpiece. Spindle load and deflection are reduced and tool life is increased. Many 15- to 20-hp machines featuring 40-taper spindles can utilize these tools with excellent results because, similar to plunging, the forces are directed axially.

An ideal application for high-feed cutters is helical interpolation. Through helical interpolation, holes can be produced quickly from a solid or by enlarging existing holes.

An ideal application for high-feed cutters is helical interpolation. Through helical interpolation, holes can be produced quickly from a solid or by enlarging existing holes. Holes can be blind with flat bottoms or through-holes. An added benefit is that one cutter can produce a range of different hole diameters. Because the tools direct the cutting forces predominantly in the axial direction, extended-length holes are produced without chatter.

High-Feed Benefits

Although high-feed cutters are roughing tools, when compared with tools with round inserts for pocketing, sidewall surface finishes are often improved. Round inserts contact more of the workpiece surface as they approach a sidewall, increasing chip load and producing vibration. The user must apply a 90° cutter to finish the sidewall. High-feed cutters maintain a constant cutting action irrespective of their position in the pocket. This results in vibration-free cornering.

High-feed cutters can be effective on both older and newer equipment. Older machines, which usually have lower spindle speeds of 6,000 to 8,000 rpm, can increase productivity if they are fitted with high-feed cutters. For example, when machining aluminum with a high-feed cutter and inserts designed for that material, a 6,000-rpm machine can remove the same, or slightly more, material than if the cutter were run at a higher spindle speed. With a high-feed cutter, removal of the material is similar to that of high-speed machining (Table 1).

High-feed cutters are a good choice for extended-reach applications.

An advantage of new machining centers is they are able to achieve higher maximum feed rates (ipm). This allows even more cost savings by taking advantage of the high-feed concept.

High-feed cutters are not for all applications; they are intended for high-

Insert savings

Southern Cast Products in Jonesboro, Ark., a manufacturer of specialty casting components, wanted to improve its machining of flanges and profiling surfaces on a torque converter housing. The material is 80 ductile iron with a hardness of 220 to 250 BHN. The machine used is a Mazak H630 vertical machining center with 30 hp.

The housing is 38"×30"×15" and requires many different surfaces to be milled. The part configuration and fixturing required the milling cutter to be a held on a 9½" shell mill extension to reach all areas of the part.

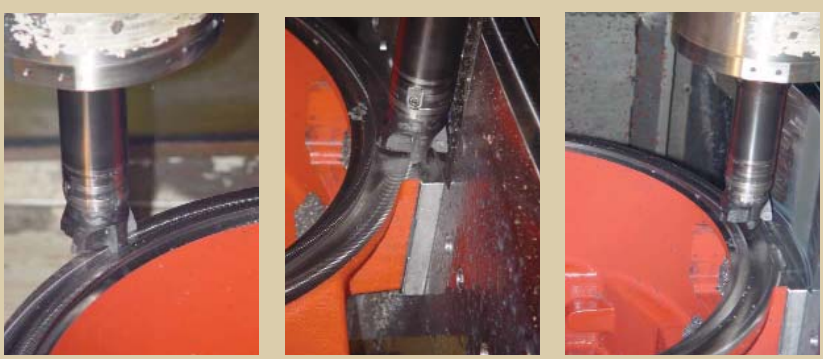
The company was using a 3"-dia. shell mill with 12 inserts; each insert had four cutting edges. One part was completed per set of inserts. Machining time was 1 hour.

Stellram distributor Doug Glenn, owner of Searcy Industrial Products Inc., worked with Southern Cast Products engineers to prove the productivity of Stellram's C7792VXD high-feed milling cutter.

In a test on the torque converter housing, a 3"-dia. high-feed cutter with five inserts, four cutting edges per insert, was run at 985 sfm, 1,250 rpm, 0.050 axial DOC and a feed of 0.027 ipt (170 ipm). Radial DOC varied depending on the area of the part being machined. Two parts were machined per set of inserts.

With the high-feed cutter, cycle time was cut to 30 minutes—a productivity increase of 50 percent. And the tooling cost was reduced because only five inserts were used to machine two parts vs. the 12 inserts neeeded to complete one part with the old procedure.

—T. Hofmann



Southern Cast Products uses a 3"-dia. high-feed milling cutter with five inserts from Stellram to machine a torque converter housing.

Table 1: Comparison of an 8,000-rpm machine removing more cubic inches of material per minute than a 25,000-rpm machine. This example shows a 1.25"-dia., 2-pocket high-speed cutter at 0.006 ipt vs. a 1.25"-dia., 3-pocket high-feed cutter at 0.039 ipt. The high-feed cutter removes 69.32 in.^{3}/min. of material.

diameter	WOC	DOC	rpm	sfm	ipt	pockets	ipm	hp	in.^{3}/min.
1.25"	0.9375"	0.079"	8,000	2,620	0.039	3	936	17.12	69.32
1.25"	0.9375"	0.236"	25,000	8,188	0.006	2	300	16.39	66.38

feed roughing. If a roughing application includes one or more of the following requirements, it may be an opportunity to apply a high-feed cutter:

- DOCs less than 0.100";
- producing mold profiles or pocketing;
- working at extended reaches;
- producing holes or opening up existing holes; and
- high-volume facemilling.

Lastly, the high-feed concept increases a facility's machine capacity. This allows it to enjoy cost-reducing benefits without an outlay for new capital equipment. △

About the Author

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