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The Router Way

Router tools designed for machining mechanical plastics provide an opportunity to maximize productivity.

All images: Onsrud Cutter

Many wear parts are made from mechanical plastics. Common ones include bearings, gears, material-handling parts and machine components such as spacers and positioning mounts where the reduction of vibration is essential.

Traditionally, these types of parts have been fabricated from metal. But mechanical plastics are beginning to replace metal because of their increased durability, excellent machinability, and exceptional mechanical and electrical properties. Common mechanical plastics include acrylonitrile butadiene styrene (ABS), Acetal, Delrin, Hydex, nylon, polycarbonate, polyurethane and polyethylene terephtalate (PET).

Cutting Tool Geometry

Router bits for cutting mechanical plastics have traditionally been run on CNC routers at high spindle speeds and feed rates. Extensive testing and years of field experience have shown that a tool with a high rake and low clearance performs exceptionally well. It machines mechanical plastics more productively than tools with other geometries and imparts a finer surface finish (Figure 1).

This kind of free-cutting geometry is rarely used by shops to machine mechanical plastics. Most use endmills running on CNC milling machines.

Endmills are robust cutting tools specifically designed for heavy loads, slower spindle speeds and lower feed rates. These tools, with their minimal flute area, interfere with the ability to clear the stringy chips generated when machining mechanical plastics. Endmills are designed with minimal rake and low clearance, which can aggravate the melting and rewelding problems common when cutting mechanical plastics. Multiple-flute endmills tend to push the chips, rather than carve or shear the chips like router tools. Clearly, endmills were designed for metalworking applications, but have been applied to mechanical plastics because machinists are comfortable using them.

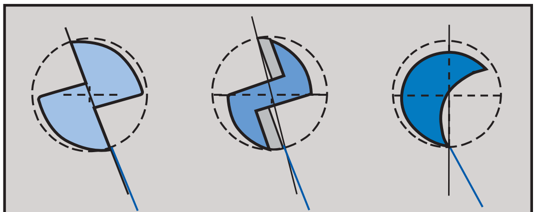


Figure 1: Tool geometries for metal, wood and plastic.

Tool Selection

Mechanical plastics are characterized as either soft or hard. By looking at the chip produced, a machinist can easily determine the flexibility or rigidity of the material being cut. Soft plastic produces a curled chip, while hard plastic produces a splintered wedge. Generally, O-flute tools are applied to soft plastic, while V-flute tools are used with hard plastic (Figure 2).

Figure 2: O-flute tools (left) vs. V-flute tools.

Most wear plastics are made from soft plastic. Consequently, O-flute tools are recommended for machining most mechanical plastics.

O-flute tools are manufactured in straight- or spiral-flute configurations. The choice depends on which direction the user wants the chips to flow. Straight tools have a neutral effect, while spiral tools can influence the chips either upward or downward. (For purposes of clarification, a downcut spiral is a left-hand spiral, while an upcut spiral is a right-hand spiral.)

For the most part, routers with upcut, or right-hand, spirals are applied because they effectively evacuate chips. Downcut, or left-hand, spirals tend to recut chips, which is not advantageous when cutting mechanical plastics where chip welding may be a problem. However, for part hold-down considerations and through-cuts, left-hand spirals are a standard item.

The O-flute spirals are available as single- and double-edge tools in diameters ranging from 1/16" to 3/4". When machining mechanical plastics, the single-edge O-flute spirals impart a finer finish than multiple-flute endmills. When small tool diameters are necessary, the single-edge design, with its more open flute, accentuates chip evacuation. In terms of balance, a maximum cutting-edge diameter of 3/8" is recommended for single-edge tools.

If cutting tool balance is an issue or a deeper cut is required, double-edge O-flute spirals and 3-flute finishing tools are logical selections. Both of these types of tools can machine materials up to 3 1/8" thick. Excellent finishes can be achieved when deep cuts of two to four times the cutting-edge diameter are made at aggressive feed rates. The double-edge O-flutes are available with a low- or high-helix angle to accommodate a range of horsepower requirements. Also, high-helix cutting tools are advantageous in materials over 1" thick.

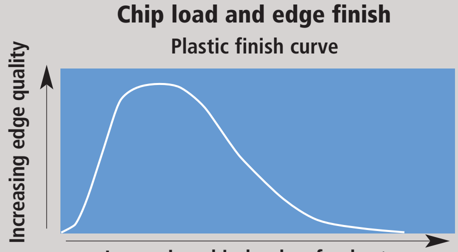


Figure 3: Only a narrow range of chip loads, or feed rates, can achieve fine surface finish. Typical range is from 0.004 to 0.012 ipt.

Chip Load

Once the correct tool geometry is chosen, the proper chip load is the next consideration. In mechanical-plastics machining, the recommended chip load range is 0.004 to 0.012 ipt, which results in an excellent finish and acceptable productivity rates (Figure 3). This narrow range imparts the finest finish through the continuous generation of properly sized or curled chips. Inadequate chip load can lead to knife marks, which adversely affect the finish. O-flute tools with a high rake and low clearance help eliminate knife marks by slightly rubbing the part during machining.

Machining Ways

Today's CNC milling machines are more than adequate to achieve the proper feeds and speeds for router tools. Spindle speeds of 10,000 rpm and higher, with feed rates in excess of 600 ipm, are not uncommon. However, when these kinds of capabilities are not available or feasible, router tools toleranced for machining mechanical plastics can perform

Drills for mechanical plastics

Those machining mechanical plastics have been at the mercy of inappropriately designed drills for years. Jobber drills and similar tools are inadequate in terms of producing clean holes.

As with router tools designed for machining mechanical plastics, drills are available for soft plastics that allow fast plunge speeds and reduce chip wrap. A 60° point and flat-face rake provide an ideal plunging point. The point reduces the stresses introduced into the hole walls and imparts a fine finish without clouding or crazing (lines or tears in the wall of the hole).

—V. Niser

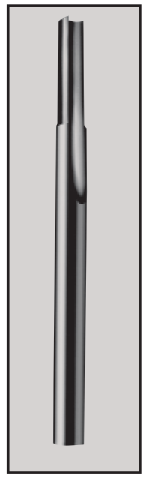
Drill with special point for mechanical plastics.

at spindle speeds of 6,000 rpm and proportionately higher feed rates. The key is maintaining proper chip load to enhance productivity and part finish.

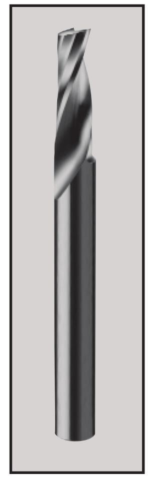
As previously mentioned, endmills are prevalent in machine shops mostly because of availability, cost and, of course, tradition. The downside of endmill geometry for mechanical plastics has been addressed, but application of this type of tool is also a major problem.

Endmills are being used to machine mechanical plastics in the same manner as they have been applied to machine metal for years. Multiple-flute endmills climb-mill when taking a roughing pass and a finishing pass. Many times, taking multiple passes necessitates a tool change between roughing and finishing. Also, coolant is applied to alleviate problems associated with heat generation. All these factors are time-consuming and expensive, and they adversely affect the cycle time and the cost per part.

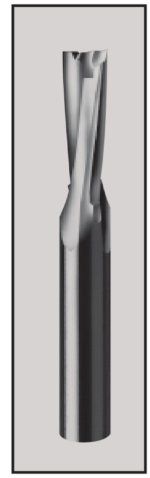
With the use of router tools toleranced for mechanical plastics, the parts can be machined in a conventional-milling method without multiple passes and the aid of coolant. Once again, this is achieved by maintaining a chip load of 0.004 to 0.012 ipt. The increased feed rates associated with heavier chip loads increase productivity and dissipate heat, thus eliminating the need for coolant.



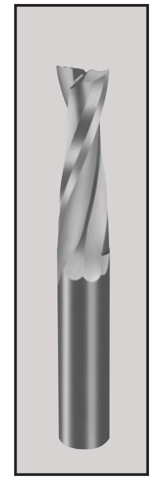
Single-edge, straight O-flute tool.



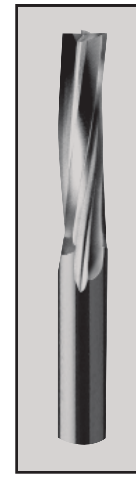
Single-edge, upcut, spiral O-flute tool.



Double-edge, spiral O-flute tool.



High-helix, spiral O-flute tool.



3-flute finishing tool.

The accuracy of CNC milling machines and hard fixturing with mechanical or pneumatic clamping devices enhance the effectiveness of a router tool's geometry, producing higher-quality parts in less time. Machine shops that have adopted this type of tool report increased output of 40 to 50 percent and a reduction in secondary operations, such as deburring.

Use of mechanical plastics by shops will continue to grow. Because shortening cycle times and improving part quality are integral facets of being successful, it behooves the user to look at ways to improve the machining process. Router tools designed for machining mechanical plastics provide such an opportunity. △

About the Author

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