▶ BY PAUL E. AUGUSTUS

Turn to the Unusual

By expanding into machining exotic alloys, shops can attract new customers and better serve existing ones.

"Exotic" in shop lingo usually means any somewhat different or difficult-to-machine alloy. One way to increase a company's customer base and bring in new work from existing clients is to machine exotic alloys.

In the past, such a job may not have been quoted because the shop didn't machine exotics. However, to be successful, a shop must be willing to try new things. Being open-minded about machining exotics allows a company to be viewed as progressive and increases its customer base.

From the Source

Barry Wilson, owner of Mid-South Machine & Supply, Cookeville, Tenn., knows about machining exotics. On any given day, Mid-South machines Hastelloy C-276, Monel M-400, Inconel 625, Nitronic 50 and titanium.

All images: P. Augustus

Ed Taylor and Bob Powell of Plymouth Tube Co. were able to cut the cycle time from 1 hour to less than 10 minutes when machining titanium tensile-strength samples (inset).

Profits from jobs involving exotics are usually higher. Wilson said they can generally be quoted 10 to 20 percent higher, but because the speeds and feeds Mid-South uses to machine exotics are similar to other workpiece materials, the machine time is not substantially more.

He credits the people on the shop floor who make it happen. "They are not afraid of trying new things and pushing their knowledge and tooling to the limit," Wilson said. "We can turn Monel M-400 at 650 sfm, a 0.080" DOC and 0.013 ipr, and Inconel 625 at 400 sfm, a 0.030" DOC and 0.006 ipr."

One project for Mid-South is machining 8-1-1 titanium wheels for radio-controlled trucks from A.I. Designz, also of Cookeville. A.I.'s Jason Beaty said the company designed the wheels out of titanium because no one else offers them. Choosing a machine shop that was capable of processing this type of alloy gave A.I. Designz the assurance to begin promoting its product.

Plymouth Tube Co., Hopkinsville, Ky., is another shop that machines titanium. When the company found productivity was too low for its in-house tensile-strength samples, it switched inserts. The company's extruded-shapes

division is now able to machine titanium at 390 sfm, a 0.050" DOC and 12 ipm. “What used to take us 1 hour to machine we can now do in less than 10 minutes,” said Plymouth’s Ed Taylor.

Plymouth’s Gary Parker added that “trying new tooling has given us a cost and cycle-time advantage [that has let us] outbid some of our competition.” In addition, these advantages have allowed the company to bring back some previous customers it lost because it couldn’t compete dollarwise. After its overall tooling cost was reduced, Plymouth was able to bid at a lower rate.

Machining Basics

“Keep it short” is a statement that holds true for every aspect of machining exotics. Extra attention should be paid to ensure every part of the process supports this idea. Forethought about cutting tools, setups and machining parameters will greatly enhance the final part.

Starting with the setup, fixturing must be designed to keep the part from moving during machining. In other words, the part must be held rigidly.

Many people don’t pay close enough attention to this. Small movements in the workpiece while it’s being cut can cause mechanical fracturing of a carbide tool’s substrate, for example. Small cracks can start along the cutting edge and propagate into larger ones.

Keeping it short also applies to a toolholder. It should not extend any farther than necessary, to reduce vibration.

Concentricity is also critical, because it evenly divides the chip load, which extends tool life and enhances finish. When milling, a shrink-fit toolholder greatly improves tool concentricity.

Other machining fundamentals should be followed, such as picking a high-positive, top-geometry insert. This provides a much freer cutting action, which promotes cleanly sheared chips, and prevents excessive heat generation.

When making multiple passes on a lathe, vary the DOC. This will help ensure that all areas of the carbide wear evenly, which leads to longer tool life.

If built-up edge appears on the insert, it is a usually a sign of turning too slowly. Increase the speed 10 to 15 percent each pass until the BUE disappears.

Arsenal Additions

Coated carbide inserts are only one choice when machining exotics. Whisker-reinforced ceramic and polycrystalline cubic boron nitride inserts are also being used to machine these alloys.

Silicon nitride-base ceramics have a big advantage over carbide inserts because cutting speeds can be five times greater, allowing a cutting speed up to 1,000 sfm. In addition, ceramic inserts have a high resistance to heat and mechanical shock, and they reduce insert notching.

As when cutting with carbide inserts, ramping into the workpiece and varying the DOC should be practiced when using ceramic inserts, to reduce the risk of catastrophic edge failure. Ceramic inserts are run at high cutting speeds and, therefore, generate an extreme amount of heat. When machining titanium, for example, there is always the risk of workpiece combustion. Therefore, applying coated carbide inserts at

Taking a closer look at alloys

An alloy is simply two or more different metals combined to obtain a desirable property. Exotic alloys are broken down into four types: nickel-base, cobalt-base, iron-base and titanium/titanium alloys.

Nickel-base alloys are available in cast and wrought form, with wrought being more common. They are often recognized by their trade names, such as Monel, Hastelloy and Inconel.

Cobalt-base alloys, or carbide-hardened cobalt-chrome materials, contain 40 to 70 percent cobalt. These alloys are primarily available as castings but can also be forged to produce rod and flat stock.

Iron-base alloys are less expensive than nickel- or cobalt-base alloys. Wear resistance increases along with the carbon content, and chromium provides oxidation resistance. Iron-base alloys are available in a standard mill form, such as billet bar and sheet.

Titanium alloys are generally used in corrosive environments. The metal’s high strength-to-weight ratio and nonmagnetic properties are desirable. Titanium castings, plates and sheets are available.

—P. Augustus

A selection of nickel-base parts machined at Mid-South.

A rigid setup is critical when cutting exotics, such as titanium.

slower cutting speeds may be the safer alternative.

PCBN tools can machine harder nickel- and cobalt-base alloys. At machining temperatures up to 1,000° C, PCBN tools remain stable, even at cutting speeds up to 1,000 sfm.

Edge preparation for these inserts is critical. A 15° to 20° × 0.008" T-land is recommended for roughing and a 0.0005" hone is effective for finishing.

Communicating the specifics of an application to your tooling salesman also is important. Tool grades, coatings and geometries evolve quickly. Evaluating new grades and designs annually allow a company to benefit from the higher speeds and feeds these tools can provide.

In addition, information can be a very big—yet hidden—asset and should be shared among employees. Successful techniques obtained on one machine can then be adapted to other types of machines as well. A small idea can yield large dividends because of the difficulty of machining exotics.

About the Author

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The following companies contributed to this report:

A.I. Designz
(931) 510-3137
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(931) 520-7567
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Plymouth Tube Co.
(800) 718-7590
www.plymouth.com

USING CARBIDE TOOLS

MATERIAL	HARDNESS (BHN)	PROCESS	DOC (IN.)	SPEED (SFM)	FEED (IPR)
Iron-base	135-320	Finishing	0.015-0.040	100-350	0.002-0.006
		Roughing	0.040-0.100	100-300	0.004-0.014
Nickel-base	175-350	Finishing	0.015-0.040	100-350	0.002-0.006
		Roughing	0.040-0.100	100-300	0.004-0.014
Cobalt-base	150-425	Finishing	0.015-0.040	100-350	0.002-0.006
		Roughing	0.040-0.100	100-300	0.004-0.014
Titanium	110-250	Finishing	0.015-0.040	100-400	0.002-0.006
		Roughing	0.040-0.100	100-350	0.004-0.014
Titanium alloys	300-450	Finishing	0.015-0.040	100-350	0.002-0.006
		Roughing	0.040-0.100	100-300	0.004-0.014
USING PCBN		Finishing	0.020	500-1,000	0.001-0.004
USING CERAMICS		Finishing	0.050	500-1,000	0.002-0.008

Table 1: Recommended starting-point cutting conditions for exotic alloys.

MATERIAL	UP TO 0.125" DIA.	0.125"-0.250" DIA.	0.250"-0.500" DIA.	0.5"-1.0" DIA.	1.0"-1.250" DIA.
Iron-base	0.0005"-0.001"	0.0008"-0.002"	0.001"-0.003"	0.002"-0.004"	0.003"-0.005"
Nickel-base	0.0005"-0.001"	0.0008"-0.002"	0.001"-0.003"	0.002"-0.004"	0.003"-0.005"
Cobalt-base	0.0005"-0.001"	0.0008"-0.002"	0.001"-0.003"	0.002"-0.004"	0.003"-0.005"
Titanium alloys	0.0007"-0.0015"	0.001"-0.0025"	0.0015"-0.004"	0.003"-0.005"	0.004"-0.006"

Table 2: Chip load per tooth when milling with solid coated-carbide cutting tools.