➤ BY ALAN RICHTER, EDITOR

The Beales in front of one of Current River Die Sinking's Okuma high-speed machining centers. From left to right: Allen, LaVerne and Donald.

All images: Alan Richter

'Tribute' to the Past

A die shop that couldn't find cutting tools 'good enough' for its high-speed machining applications perfected its own design.

When I heard about a forging-die shop in Missouri that claimed to have developed solid-carbide cutters that outperform any commercially available tool when profiling hardened steel, I said "show me."

So off I went to Doniphan, Mo., home of Current River Die Sinking Inc., a manufacturer of hammer dies, press dies, drop-through and compound trim tooling, coin dies, bending dies and a host of other dies. "We've even done cross-wedge dies, which is something almost unheard of in the United States," said Donald Beale, technical director of CRDS, noting that top and bottom rolls of a cross-wedge die roll in opposing directions to stretch a billet, or blank, of steel and reduce its diameter in concentric shafts.

Besides Donald, I met his brother, Allen, who is vice president, and their father, LaVerne, who incorporated the company in 1983. The brothers are working out an agreement to purchase the company from their father.

Pitting Hard Against Hardened

CRDS primarily makes dies out of FX-XTRA Temper 2 steel, from Chicago-based A. Finkl & Sons Co., which is prehardened to 38 to 42 HRC.

The die steel contains 0.80 percent nickel, 1.15 percent chromium and 0.5 percent molybdenum, and, according to Donald, is comparable to H-13 steel in terms of machinability. Compared to H-13, "the Finkl material is a little more resistant to cracking but not quite as resistant to wear," he noted.

The shop also produces press dies out of H-13 hardened to 45 to 50 HRC. The machining is usually done dry with cold air directed at the tool/workpiece interface. However, an oil mist is sometimes used when machining Stellite, Inconel and other high-temperature alloys. Compared to dry machining, the oil mist enables CRDS to impart a finer surface finish at a higher feed rate.

Adding to the difficulty of machining hardened steel is the possible presence of welding material in the workpiece when dies are repaired or reworked. Depending on who performs the welding, the welding material may be of equal or greater hardness than the workpiece. On top of that, the welding material is often a difficult-to-machine cobalt or nickel-base alloy and, when it's a surface weld, the cutting tool experiences interrupted cutting because the weld is uneven.

"We were getting the tool life, but our feed rates when cutting cobalt alloys were abysmal," Donald said.

Moving to High Speed

A dilemma arose a couple years ago when CRDS purchased two Okuma high-speed machining centers, an MA-650V and an MD-550V. The machining centers enabled the shop to perform less sinker EDMing while cutting overall production time by 30 percent, but cutting tools proved to be a consistent weakness in the HSM process.

"When we started out, a tool manufacturer would show us the speeds, feeds and DOC we should be running, and we'd run their tools for less than 30 days before we were looking for a better alternative," Donald said. "I turned the world upside down looking for the best cutter. We went through quite a bit of money researching different tools to find what works best and what doesn't work at all. We had cutters that were working, but 'working' isn't good enough for us."

One example of a cutting tool that worked was a ½"-dia., high-helix, corner-radius endmill, which was run at 125 ipm with a 0.025" DOC at 2,600 rpm for 3 hours before experiencing too much wear. Although that's "moving stock pretty good," it still wasn't utilizing the high-speed machining centers' full capability.

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Tool Evolution

Since the founding of the company, CRDS has been manually grinding its own 2- and 4-flute ball and flat-bottom carbide cutters, down to ⅛" in diameter. The almost-straight flutes are shallow, with as much material as possible behind the flutes for strength, and the tools have a positive rake for ease of cutting. Because the tools are for profiling rather than side cutting, the flute length is only about ½". "Why would I want 3" of flute when I'm not going to use it?" Donald asked rhetorically.

However, the design of the 2- and 4-flute ball and flat-bottom tools dates back further than the inception of CRDS. During his apprenticeship in the 1960s, LaVerne learned to manually grind the tools from someone who learned from someone else.

"Who developed the way to grind these tools? Someone who's probably long since gone," Donald noted.

Although the design is effective because of the shallow, almost straight flutes for strength and positive rake for ease of cutting, continuing to grind the tools by hand just wasn't going to "cut it" when HSM. Hand-ground tools are unbalanced and unbalanced tools run aggressively in a high-speed machining center will damage the spindle bearings.

The Okuma machines have a top spindle speed of 12,000 rpm, and, because the chip loads are quite low, CRDS is looking to add a spindle speeder to achieve speeds up to 30,000 rpm and increase productivity further. "With the speeder head, we're going to

A selection of 4-flute ball and flat-bottom solid-carbide cutting tools from Current River Die Sinking's Tribute series.

have to balance every tool and every holder every time, because 0.0005" runout at 30,000 rpm becomes staggering in terms of force," Donald said.

In addition to not being balanced, the hand-ground tools aren't coated, further limiting their effectiveness at high speeds. To remedy the situation, CRDS turned to Shane Hammond at J+S Tool Inc., St. Peters, Mo., to perform the grinding on its CNC tool grinders and coat them. The tools are TiAlN-coated and have a submicron-grain, high-cobalt-content carbide substrate.

The resulting tools have performed impressively. CRDS reports that it's able to run its ½"-dia., 4-flute flat-bottom cutter at 250 ipm—twice the table feed of the previously mentioned corner-radius endmills—at 0.030" DOC and a 2,500-rpm spindle speed for more than 10 hours without chipping and barely burning the tool. "And 250 ipm is not aggressive enough," Donald said. "We did not push that tool hard enough." Nonetheless, having a tool last that long is helpful because cycle times are often 8 to 10 hours.

Of course, learning the trade from their father taught the younger Beales the value of knowing how hard you could push a tool. "This may sound strange, but when Allen and I were younger and learning machining, our father was adamant about knowing how many tools we burned," Donald said. "If you told him none, he'd get mad at you."

So it's no surprise they wanted to find the flat-bottom cutter's limit. CRDS experimented and ran the flat-bottom tool up to 475 ipm and a DOC of 0.030" at 3,800 rpm, Donald recalled. "I attempted to burn and blow up that tool, but I had to quit because I heard harmonics from the material I was cutting. I could hear the material whining—not the cutter."

From Shop to Market

Encouraged by the results, CRDS decided to market the cutting tools, calling them the Tribute series. "We perfected them, we didn't invent them," Donald noted.

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J+S will continue to grind them and CRDS will do the marketing and handle customer relations. In addition to TiAlN, Donald noted that the tools can be coated with any tool coating, including diamond for machining graphite. Although the tools are optimized for the die steels CRDS machines, he added that specials can be engineered based on a customer's workpiece sample at little or no extra cost.

Currently, the tool designs are patent-pending, but protecting a patented design isn't CRDS' main concern. "I've talked to some patent attorneys and they pretty much told me that with a cutter like this, the cost of going with a full patent is prohibitive." Donald explained. "The trick is to be the first to market."

He's also not concerned about other die shops becoming more productive and competitive by applying the cutters. "We're going to help people we know. We can help ourselves and them by reducing costs."

For the foreseeable future, CRDS marketing efforts will focus on the designs it already has rather than compete against existing product lines produced by established toolmakers, which Donald feels have overlooked the mold and die sector because it's such a niche industry. He said: "The bottom line is they're trying to do 30 years-plus of catching up. We've done it for that long. If you want to know what cutter works best in the mold and die industry, don't go to the student, go to the master."

But what if the tools flop in the marketplace? "If we don't sell any at all," Donald said, "we will still have these tools made because they are the best and they will increase our productivity."

And, as I noted at the beginning of this article, when it comes to verifying that the tools can run at productivity-enhancing machining parameters, I didn't want to take the Beales' word for it—as good as it may be—I wanted them to show me. So CRDS ran a test profiling a die made of FX-XTRA Temper 2 steel and was able to achieve a feed of 375 ipm at a DOC of 0.030" and a spindle speed of 3,000 rpm using the ½"-dia. flat-bottom cutter. The tool was run dry and cold air was directed at the tool/workpiece interface, which didn't prevent the tool from glowing occasionally while machining a corner. Nonetheless, the tool passed the test with flying colors.

"A commercial corner-radius endmill would be through if it started to glow," Donald said. △

For more information, contact Current River Die Sinking Inc. by calling (573) 996-7181 or visit www.crdie.com.

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