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A few of my favorite things

Man looks for mirror finish and sees a Studer

A long way to grind

Huge hit for little inserts

UNITED GRINDING publication

Spring 2008

Man looks for mirror finish and sees a Studer

-Grinding perfect punches

Discussing the "black art" of precision grinding, Tim Middlehurst, President of Hi-Quality Carbide Tooling Inc., said, "I guess you're just born with it." He truly was; he began working in his father's grinding shop at age 16 with his father and grandfather. "It was all three of us in the shop for a while," he said, "I was fortunate enough that I had a couple of years of working with my grandfather and 15 years with my father, before they retired." Tim and his wife, Wendy, bought the shop in 1997, then Hi-Quality Carbide moved to its present location in Orangeville, Ontario, two years ago. Tim and his tool makers Derrick Armstrong and Riguel Boodram work in the clean, 3,600 sq ft shop that houses 23 pieces of equipment, including some dating from the shop's early days. The shop performs OD and ID cylindrical grinding, surface grinding, CNC turning, wire EDM and polishing.

Over the years, Hi-Quality Carbide built a solid reputation for grinding carbide dies used to cold-head bolts and other products in the fastener and near-net forming industries, as well as carbide tooling for spring making. Then, in 2007, an opportunity – and a challenge – arose. A large, longtime customer, for whom the shop had machined carbide dies, urged the shop to begin grinding carbide extrusion punches. "We decided we would take them up on it," Tim said, adding, "the punches were a whole new product line for us."

And a whole new manufacturing challenge. The punches generally feature high length-to-diameter ratios and range in size from 0.300"-dia. by 4"- long to 1.25"-dia. by 13"-long. They require a significant amount of precision contour grinding. "There are a lot of steps and contours along those shafts," Tim said, "they are not just nice, straight pins." Production

volumes are small, ranging from low single-digits to a maximum of a dozen. "The carbide alloys used for the punches is both hard and tough," Tim said, and "grinding it requires the use of vitrified diamond wheels."

Surface finish is critical

Size tolerances for the punches are 0.000,3" – 0.000,5", "but that's not the problem," Tim said, "It's the surface finish that is the critical part." To minimize galling in operation as well as maximize tool life, the punches require a polished mirror finish. In preparation for polishing, which Hi-Quality Carbide does in house, chatter-free finishes in the range of 2-3 µin. R_a are necessary.

Hi-Quality Carbide grinds precision carbide punches that feature high length-to-diameter ratios. Punches range in size from 0.300"-dia. by 4" - long to 1.25"-dia. by 13"-long. They require a significant amount of precision contour grinding, must meet size tolerances of 0.000,3" – 0.000,5", and surface finish requirements of 2 -3 µin. R_a prior to hand polishing.

Tim realized the shop would need a CNC OD grinder to produce the complex-contoured, low-volume parts efficiently and to consistently generate the required surface finishes. After much research and comparison shopping, he purchased a Studer S33 CNC grinder from United Grinding (represented locally by Machine Tool Systems Inc.).

The machine fit his needs. It features a center distance of 25.6", center height of 6.9" and maximum workpiece weight capacity of 176 lbs. Drive capacity of its external wheelhead is 7.5 kW (10 HP). The robust ISO50 universal workhead with Studer's unique infeed ring sensing is capable of both live spindle grinding and grinding between centers, and has a maximum speed of 1,500 RPM. The workhead spindle is mounted on roller bearings and possesses roundness accuracy of below 0.000,4 mm (0.000,016"). Fine adjustment allows for cylindricity corrections in the 1 µm range during live spindle operations. Rotary disk dressing with Studer's touch dressing technology enables the use of cost-effective vitrified abrasives. To maximize precision, Tim specified glass scales on both the infeed and longitudinal axes.

"One thing that drew us to the Studer was the software…"

Because the shop had no experience in CNC or G-code, "one thing that drew us to the Studer was the software," Tim said. That included intuitive on-machine Pictogramming that leads an operator through steps in grinding a part then generates G-code. StuderGRIND software also permits programs for special applications, such as profiling, to be created on a PC then transferred to the machine control.

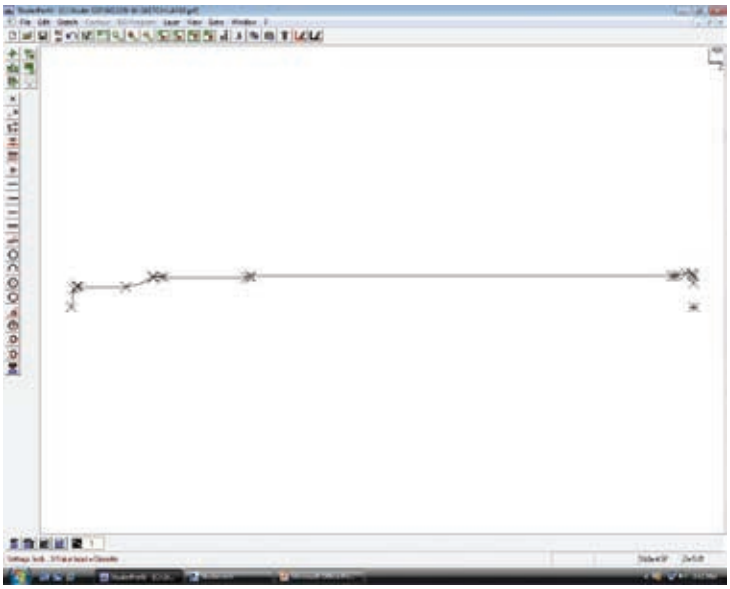
Ease of programming is important, because even though all the punches feature multiple diameters, complex profiles, and critically-dimensioned nose points, every punch profile is unique.

Although the Studer software calculates productive cutting parameters, Tim sets grinding feed rates and speeds based on experience. He said diamond wheel tool representatives say the shop's speeds and feeds "are way off" but "they work just fantastic for us. We've found that we still have a bit of the black art in our grinding."

Hi-Quality Carbide does make full use of the StuderPROFILE feature of the StuderGRIND package. "It enables us to draw the part, select the areas of contour, and then put those into the machine as subroutines that are input into the Pictogramming software," he said.

"We use the StuderPROFILE software to redraw the part offline," he continued, "We have a PC out on the shop floor, hooked to the machine with an Ethernet cable, and that's where we make our drawings. While the machine is running the operator can be doing a drawing and setting up all the contours for the next job."

Hi-Quality Carbide currently works with prints or faxed drawings from customers. The software provides the ability to download a DXF file directly



An operator uses StuderGRIND software running on a PC to define the many dimensions of a profile to be ground. The PC is linked to the S33 grinder with an Ethernet cable, enabling easy program transfer. The operator can even make a drawing and set up contours for the next job while the machine is running.

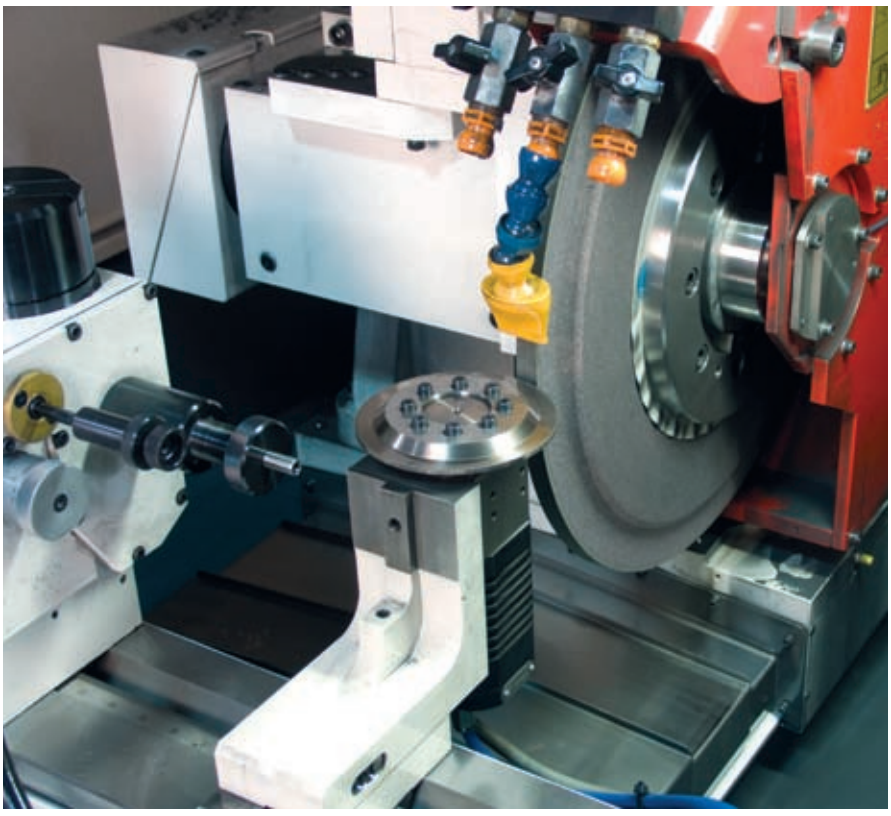
into the machine control, but Tim said his customers do not presently supply files of sufficient accuracy to make use of the feature. "It's nice that the possibility is there," he said, and feels it will be useful in the future.

Contouring magic with a single wheel

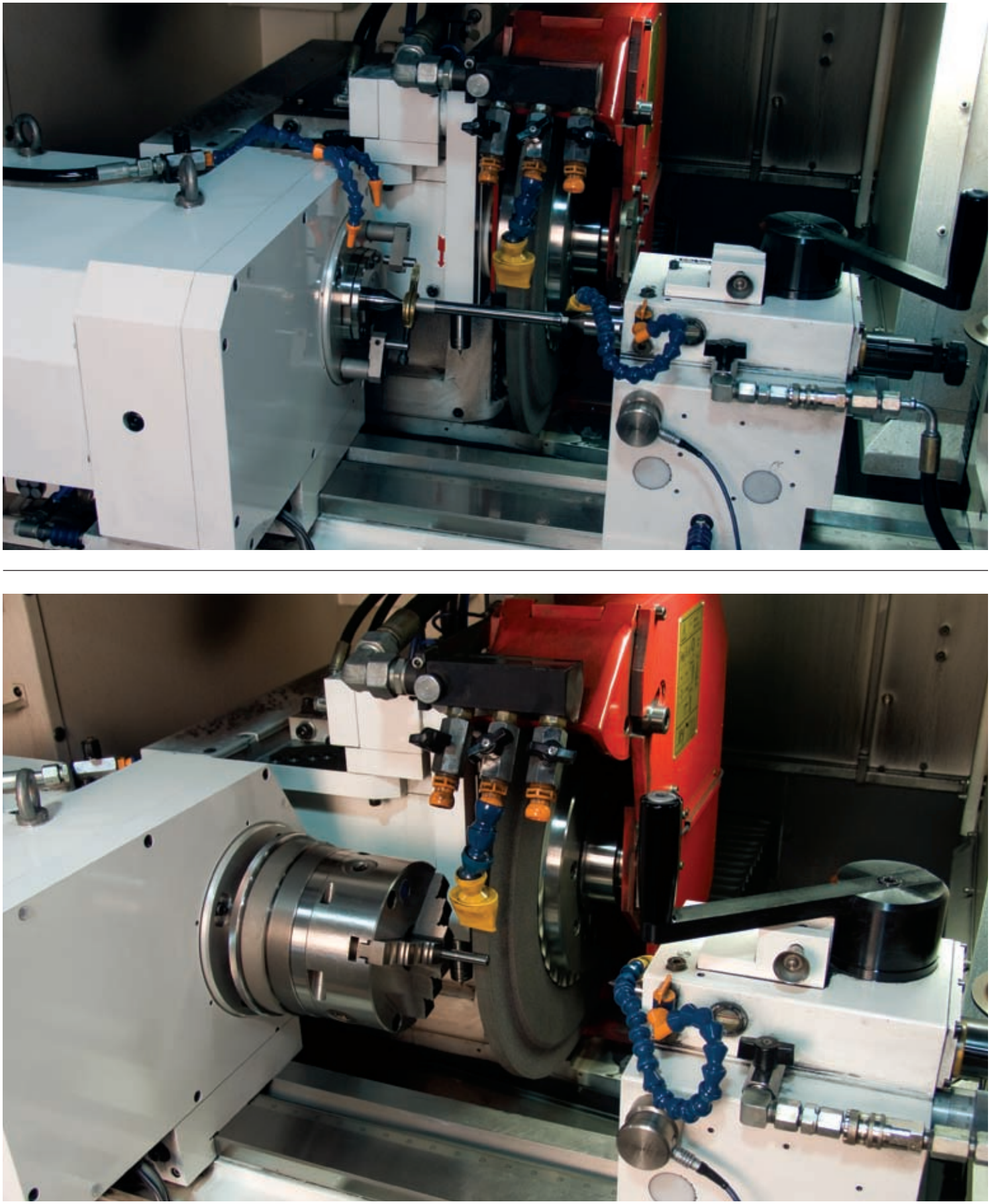
Surprisingly, Hi-Quality Carbide doesn't dress wheels to match the individual punch profiles. The shop uses a straight-front, flat, ½" or 7/8"-wide wheel in plunging and oscillation passes to establish the punch diameters. The same wheels grind the profiles; "The trick is that we have a rotary disk dresser that forms a radius on each wheel corner, and we use that same corner radius to profile all of our contours," Tim said.

The Studer S33 provides the ability to dress in process, but Hi-Quality Carbide hasn't used it so far. "We have found that the vitrified diamond wheels hold up really well with the low quantities we are doing. We can do up to six or eight pieces without a dress, then dress at the end of the batch," Tim said.

The machine's 1,500 RPM workhead also provides an advantage when grinding the punches. Although the punch ends appear to be flat, they in fact feature a very slight included angle. "We are grinding down to a point, basically," Tim said, and at the point grinding surface speed approaches zero. Sufficient speed is crucial in maintaining surface finish. As a result, the shop utilizes the workhead's speed capability "Pretty much at its max," he said, "We are running high rpm to keep the sfm up." He said his comparison shopping showed him that competitive machines max out at a much lower RPM.



Hi-Quality Carbide employs the S33 grinder's rotary disk dresser to maintain a radius on the corners of flat grinding wheels, and uses those corners to profile complex contours on carbide punches



The universal workhead of the S33 grinder is capable of both grinding between centers (top) and live spindle grinding (bottom)

From between-centers to chucked in minutes

The workhead's ability to support both live spindle grinding and grinding between centers also is essential. Tim processes the punches in two steps, first grinding the main body between centers, then chucking the back end of the punch and finish grinding the profiled end. Between the dead centers, a brass drive dog holds the end of the shaft and picks up a pin on the workhead to spin the part. "We grind the major diameter, chuck it, indicate off it, and then do our contours on the end," he said.

Tim employs a coarse wheel for the punch major diameters, and a fine wheel for the profiles and the end of the punch, removing 0.040" – 0.050" grind stock in both cases. "When we grind the main body between centers, we use the coarse wheel, and we grind a little bit faster. When we chuck it and do the working end of the punch we are still removing the same amount of grind stock -- mind you over a shorter area -- but we are not slowing down that much," he said.

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Acoustic sensors eliminate scrap

Throughout both grinding and dressing, Tim said, the Studer Sensitron acoustic gap control is "our eyes, and our ears, actually." The S33 has one microphone built into the end the spindle to monitor live spindle grinding and dressing, and another on the tailstock for between-center grinding operations.

The system prevents collisions that would damage the wheel or punch. Tim said the diamond wheels cost about $4,000 each, and the carbide punch blanks are expensive as well, typically $500 – 600 for a large example. Regarding the blanks, he said, "The most critical thing there is you don't have time to have the blanks replaced. It takes two weeks to get them. If you are only doing a lot of three and you scrap one, you just lost a third of your order."

The Sensitron system has helped to keep the shop's scrap rate very low. "I think we might have scrapped two pieces," Tim said, adding that those incidents probably were a result of the shop's learning curve with the new machine.

"When I saw the Studer S33 grind carbide, I said yep, that's exactly what I want."

All of a grinder's sophisticated systems can be neutralized by the generation of a low-tech problem: chatter. Tim said the results are obvious. During his machine shopping, as soon as he saw a carbide part ground on competitive machines, he reported that he said, "No, that's not the finish I want. When I saw the Studer S33 grind carbide, I said yep, that's exactly what I want. Just like that, it was that easy." Tim credits the machine's build quality and the rigidity and vibration-absorbing nature of its Granitan synthetic granite base. Eliminating chatter is "a key to achieving the required surface finish. We grind to finish size, then polish after. As soon as you have chatter, then you are talking about a lot of handwork."

Tim said he bought the Studer S33 solely to gain the capability to OD grind carbide punches, although he has plans to grind carbide feed rolls and roll forming dies on the machine in the future. ■

Owner, Tim Middlehurst, looked at a number of machines in his search for a mirror surface finish. "When I saw the Studer S33 grind carbide, I said yep, that's exactly what I want. Just like that, it was that easy."

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