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Automated Microdrilling of Abrasive Parts

Hypertherm (Hanover, NH) was founded in 1968 by President Dick Couch and Bob Dean when they discovered an innovative way to increase the speed and accuracy of plasma cutting to levels that had not been achieved before. Radially injecting water into a plasma cutting nozzle created a narrower arc and became the foundation of Hypertherm's advanced plasma-cutting technology. Couch patented the radially injected water technique and unveiled Hypertherm's first plasma cutter, the PAC400.

Today, 40 years and 75 patents later, Hypertherm is an associate-owned company with nine buildings and 1100 employees. The company designs and manufactures advanced plasma-cutting systems for use in a variety of industries including shipbuilding, manufacturing, and automotive repair. Its product lines include handheld and mechanized plasma cutters and consumables, as well as CNC motion and height controls.

The water-injection technique resolved several issues that had plagued plasma-cutting technology from its beginnings 14 years prior to Hypertherm's innovation. One problem, the accumulation of dross, and a second phenomenon called double-arcing were virtually eliminated. The Hypertherm system, which uses only one gas, nitrogen, also eliminated the need to purchase and stock several different types of gas for cutting. End users also saw a marked improvement in nozzle life, because steam from the water helped to cool and protect the nozzle, reducing its wear rate.

Cutter nozzles and swirl rings made of lava are at the heart of Hypertherm's technology. The lava used is an abrasive material mined in South Africa in 13 x 13" (330 x 330-mm) blocks. The material comes to Hypertherm in boxes of 6" (152-mm) rods (or "bars") that are approximately 1" (25.4 mm) in diameter. All of the swirl rings are cut on a lathe, machined and micro-drilled, and then baked in an oven.

In its "green state," the lava can actually be cut with a knife, but even in its green state, lava is abrasive and extremely aggressive toward tooling. baking can be even more so after baking. The density of the material can also change, not only from one blank to the next, but from one end of a 6" (152-mm) bar to the other. Finally, the more the product is handled, the greater the chance of chipping, breaking, and scrapping parts.

Several years ago, Hypertherm visited the EASTEC exposition, specifically looking for a way to automate the drilling process to increase volume, improve accuracy, and minimize attended operation associated with the production of swirl rings. Swirl rings were being produced manually, one part at a time on arbors and bench-top machining centers, by several operators working three shifts per day.

Lava blanks are microdrilled on a high-speed Datron Velociraptor using a fourth and fifth axis at Hypertherm's Hanover, NH, plant. The blanks are machined into plasma-cutter swirl rings.

The fine dust produced in machining is particularly hard on microdrills, quickly filling flutes and snapping the tool. Making the drilling process even more challenging is the fact that the holes are often drilled at an angle, and that lava will grow during baking, changing tolerances. Holes that are slightly out of spec before

Hypertherm selected two Datron Velociraptor M8 high-speed machining centers with pick-and-place automation systems for untended part changes from Datron Dynamics

A finished Hypertherm cutter swirl ring with 0.011" (0.28-mm) holes microdrilled in abrasive lava.

Inc. (Milford, NH). These machines were installed to drill face holes, back holes, and radial holes ranging in diameter from 0.011 to 0.025" (0.28–0.64 mm) on all swirl rings in their product line. With installation of the Datron M8 machines, Hypertherm's process was transformed from manual to highly automated.

"Now, we're able to load 100 pieces into the Datron equipment, and they all come out ready to go into the oven. There's no handling," explains Tim McCarville, manufacturing process technician for Hypertherm's Lava Div. "To do the volume we're doing on the Datron machining centers today, the way we did it before, would take eight people with at least four people drilling all the time, plus two operators running the lathes. Now we have just two operators per shift running two lathes and loading one Datron VMC each.

"It just takes 5 min for the operator to load a Datron with a tray of 100 blanks and inspect the parts coming off. The pick-and-place system picks each blank off the lathe tray for drilling, and puts it on the bake sheet in a pattern that's ideal for controlled baking. After inspection of the first and last piece of a 100-piece run the entire sheet goes right into the oven."

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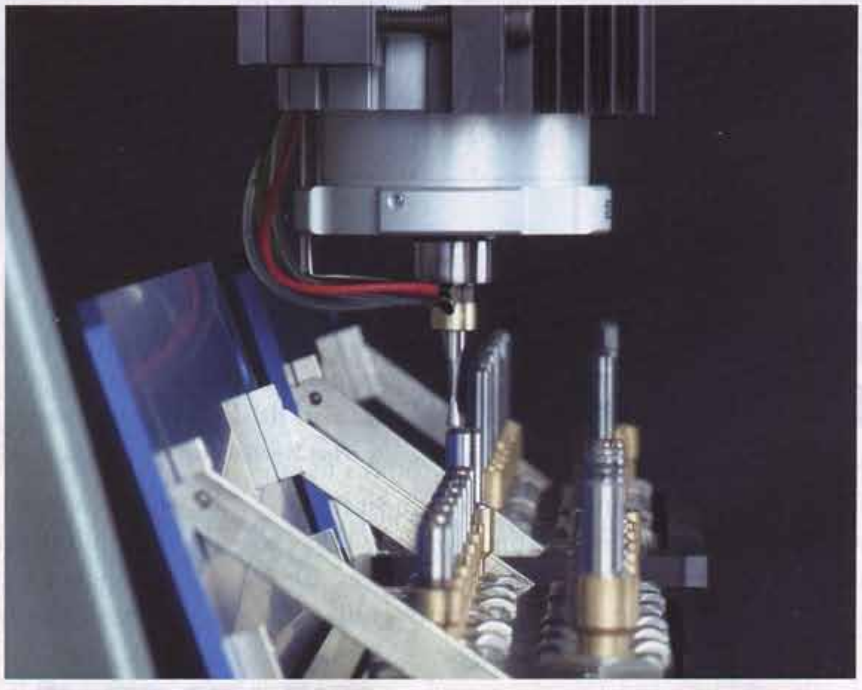
To maintain product uniformity, Hypertherm has developed a process of constant measurement and testing of lava blanks. Density varies from one blank of lava to the next and growth occurs during the baking process. Each box of bars is tested, and machining variables are established for the QDCS (Quality Data Collection System) and lathe control. Through testing the bars and getting the growth properties for each lot, tolerances can be adjusted based on what will happen to the blank during baking. Operators simply enter the variables for a given lot of blanks into the Datron control and hit go.

"Drilling has to be very accurate, because any inaccuracy will be compounded by growth resulting from the firing process later," McCarville



Datron's Automatic Tool Management performs regular tool checks automatically after every 10–20 parts worth of code based on a macro.

explains. "Bolt circles are going to grow, and the location can shift on the part. A radial hole can shift laterally on the part and open up the bolt circle as well as the drill hole. You've got three potential problems. So, if you're the slightest bit off on the drilled hole to begin with, it just gets worse in baking." Once the tolerances have been determined, only half of tolerance span is used during the drilling process. McCarville explains: "That keeps us just inside, so even if we use all one side or the other of tolerance at machining, we still have half our tolerance left to accommodate excess growth."

Hypertherm, which has embraced 5S methodology, relies on Datron's Automatic Tool Management (ATM) system in its ongoing efforts to minimize waste. The ATM is made up of three separate components: the tool checker, the tool changer, and the software. The tool checker is a mechanical sensor that measures tool length and detects broken tools. The tool changer is a rack or tray that has space for spare tools and sockets where the machine places broken tools before picking up a replacement. Operators can stock the rack with spare tools, thereby having a ready supply should tools break during untended operation. The software is a macro program that can be set up to run a tool check after executing a number of lines of code.

"If you're the slightest bit off on the drilled hole to begin with, it just gets worse in baking."

The ATM system gives Hypertherm the option of setting up for a piece count. McCarville explains: "If you have a batch of real grainy lava, you can change the program for where your drill failure is. By preemptively scheduling a tool-length check, you eliminate tool breakage and scrap in

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your process. I have three ranges that I check for, based on drill diameter. For 0.011–0.015" [0.28–0.38 mm], I'll check every 10 pieces. With a larger drill, every 20 pieces, and no more than 25 pieces regardless of drill size. Since the tool check is automated and fast, we can afford to do that, and we can't afford not to, considering the reduction in scrap. Now, that's not 25 holes, it's 25 completed parts, which is generally 150 holes."

The machine will shut down automatically and warn the operator with a flashing light if tool length or wear are lower than parameters set in the control. This is essential to waste reduction because these parts can't be re-drilled. If a worn or broken tool is detected and the part is put down on the baking sheet, it can't be re-drilled even if the part is deemed to be accurate thus far in the machining process. "If I can lose only one part, or better yet, set the tool check more frequently and lose none, that's huge," says McCarville. "That said, we don't want to check the tool after every part or even too frequently, because that's non-cutting time that is not beneficial to the process, and loss of time is also considered waste."

The M8 machines that Hypertherm purchased for micro hole drilling are versatile and have been employed all over the world for a range of applications requiring milling and engraving. "We have two Datron machines, and if one of them is not busy and our lathes are backed up, we can move some of their work, like drilling face holes, over to the Datron, and it can drill those holes as well as the back holes and radial holes. All the way around, these machines have given us a lot better throughput. Not only because the pick-and-place automation works so well for our application, but they can also take parts from another place in the process and still get the product through in a timely manner," McCarville concludes. ■ Circle 222

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