

## SMART HONING TECHNOLOGY PUTS LIFT IN BUSINESS FOR AEROSPACE HYDRAULIC PUMPS

SHOP'S CUSTOMERS NOTE NEW TECHNOLOGY MAKES A 60 MILLIONTHS TOLERANCE  
LOOK GENEROUS



Sunnens new multi-feed control technology allows the user to select the better tool feed option – rate feeding or force feeding – to suit the workpiece geometry, material and tool type/size.

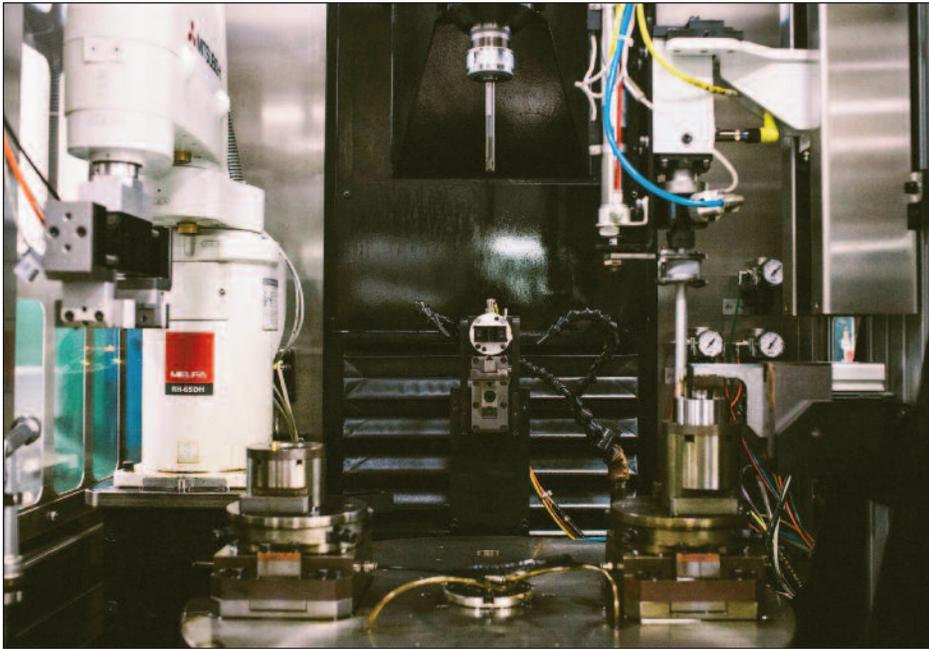
WHEELING, IL – "We don't believe it!" – that's how experienced machinists reacted to their first encounter with a new honing system that produced nine bores per part with only 0.000020" (0.5  $\mu$ m) variation, all day long, with essentially no operator attention. That's 2.21 Cpk process capability. It's game changing technology in a shop like Waltz Brothers, Inc., a precision grinding and machining operation where these parts – flight-critical hydraulic pumps – are produced by the hundreds every year. The machinists' reaction was expected by company president Larry Waltz. He knows how hard it is to hit this tolerance window machining ONE bore per part, much less nine. With nine opportunities to make a micron-sized mistake on an expensive workpiece, it takes great skill and many time-consuming machine/measure

iterations to make these parts on a standard honing machine. The new SV-1015 hone not only produces perfect bores, it also records its final air gaging measurements to track with each serialized part. "When I showed this new machine to a customer for whom we'd been making these parts, they were so impressed they wanted us to commit to a blanket order for all their parts for the next five years," Waltz said. "In that instant, we validated our painstaking decision to adopt this technology."

One of the keys is a patented new smart tooling technology that servocontrols the force on a honing machine's tool feed system. It and other machine automation capabilities, such as robotic part indexing and in-process air gaging, have created a new reality at Waltz, a company that looks at machining through the eyes of a precision grinding shop.

### Machine parts like you'd have to grind them

"We're a second generation grinding business started by my father and uncles in 1939," explained Mr. Waltz. "Our focus is close-tolerance precision parts requiring many operations that typically conclude with grinding, honing or lapping, so we added chip cutting to better control the processes upstream from grinding. Most machine shops don't process blanks in a way that facilitates good grinding, honing or lapping results. For example, if a part is machined between centers, most shops will not be too concerned about variation in the centers, which will affect how  
(continued)



The work envelope of the honing machine shows air-bearing index table in foreground, robot to left, honing spindle and tool upper center, and air gage right.

consistently the part locates in a grinding fixture. We want to control these factors -- straightness, hardness, stock allowance, etc. If grinding is only a side business to a shop's chip cutting, they won't look at things the way we do."

### **Business niche is pumping**

One specialty at this 60-person company is manufacture of parts that go into aerospace hydraulic actuation systems. "Piston pumps are a good niche for us," Waltz says. "These are the most critical parts we make. There's great variation in materials, design details, process flow and assembly requirements, but the parts do have fundamental similarities."

The heart of the pump, called a cylinder block or rotor, starts as a turned blank up to eight inches diameter. Then, nine circumferential piston bores from 0.1875" to 1.5" (4.8 - 38.1 mm) diameter are roughed in on a machining center, and the part may be heat treated. The piston bores are not through holes, but have small kidney-shaped slots cut through the bottom. Some designs call for heat treating, use of bronze bore liners, or

bronze plating on the bottom of the part, its running face. Liners may be cast in or produced on Waltz's screw machines, then anchored into retaining grooves with a ballizing process or swaging.

"Nine bores are common to most all pump designs," Waltz explained. "We buy the raw stock and manufacture the cylinder block blank complete. We also manufacture several different parts that work within the final actuator assembly, including the pistons and 'slippers.' The pistons have a total diameter tolerance of 0.000120" (0.003048 mm), while the bore ID's on the cylinder block have a total diameter tolerance of 0.000240" (0.006096 mm). We must also maintain tolerances of 0.000020" (0.5  $\mu$ m) for bore roundness, 0.000040" (1  $\mu$ m) straightness, 4-8  $\mu$ in (0.1 - 0.25  $\mu$ m) Ra bore finish, and less than 3  $\mu$ in (0.07  $\mu$ m) surface on the pistons. We have three Zeiss CMM's that can scan the piston bores at various levels for cylindricity, too. All these parts are serialized, traceable to the material and processes used to create them.

"During prototyping, we determine where to leave needed stock on the part, but we fine tune the stock allowance over time and tweak our processes to be as efficient as possible. For example, heat treated parts are often carburized which creates only a thin layer of surface hardness at about 54 HRC. Thus, we want to remove as much metal as possible before hardening, so we aim for 0.0010" to 0.0015" (0.0254 - 0.0381 mm) honing stock in the bore in the hardened state. Parts with bronze bore liners are, of course, a different story."

### **Hone, measure, repeat...a lot**

Waltz had been using standard horizontal honing technology from Sunnen, where outcomes are heavily dependent on the operator's skill. "The *(continued)*



After each bore is honed and air-gaged as acceptable, a robot inside the honing machine's work envelope rotates the workpiece to align the next bore for the honing tool

operator would hone one bore, clean the part, air gage it at three different levels and then at 90 degrees bottom/middle/top to see if there's any issue, such as taper at the bottom of the bore which would have to be feathered out," he explained. "There's a tremendous amount of back-and-forth to complete nine bores, and if you blow one bore, you've scrapped a part valued at several hundred dollars. After honing, we must have confirming CMM inspections on each

part, each bore, and this becomes part of the manufacturing history for each block. Honing and inspection could easily take two hours per part.

"Our challenge to Sunnen was to automate everything, including part indexing, air gaging, and recording of gage readings for the part's history. We achieved all this with the new Sunnen SV-1015, but it was one of the new patented standard features in this machine – multi-feed honing – that has played a role in taking our honing process capability to a new level."

#### **What is multi-feed honing?**

The new patented multi-feed honing capability gives users a choice of tool-feed modes to achieve the shortest cycle times, lowest part cost, and longest abrasive life. Multi-feed combines Sunnen's new

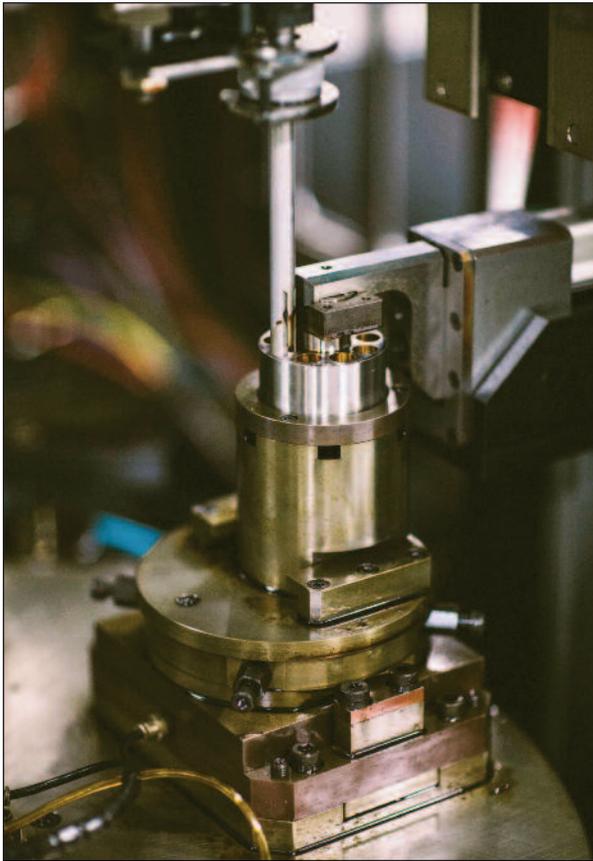
controlled-force tool-feed with its existing controlled-rate feed system. The two different modes allow the user to select the better option to suit the workpiece geometry, material and tool type/size.

Typically, a production honing process is set up to use an abrasive tool with a combination of grit size and bond optimized for specific part conditions. Tool expansion to achieve the desired results and final size is programmed based on rate of time. However, when a batch of parts comes in with a different heat treatment, distortion or a size variation, the operator must intervene because the tool may expand too quickly and be damaged. In the



The heart of a hydraulic piston pump, called a cylinder block or rotor, starts as a turned blank up to eight inches diameter. Then, nine circumferential piston bores from 0.1875" to 1.5" (4.8 - 38.1 mm) diameter are roughed in on a machining center, and the part may be heat treated.

opposite case with a softer-than-normal or oversize workpiece, the tool will still expand at its programmed rate, when it might have been able to expand faster to reduce cycle time. Expansion at too slow a rate may also result in glazing of the  
*(continued)*



Based on measurements taken by the air gage (shown in photo), the honing tool is automatically adjusted to maintain a precise diameter. Compensations can also be made for taper, barrel shape or bell-mouth conditions by adjusting the spindle's stroke position or length. The gage has auto-mastering capability. At an adjustable interval, the mastering ring (dull chrome at top of probe) moves down the probe over the air jets and the gage zeroes to the master.

honing stones, which won't self dress if the cutting force is too low. Typically, the operator tweaks a rate-feed system periodically to compensate for these variables.

By servo-controlling the force in the tool feed system, however, the machine can sense and compensate for these variables. The controlled-force feature, which works in concert with the machine's standard rate-feed system, functions like cruise control to maintain the optimum cutting load on the honing abrasive throughout a cycle, irrespective of the incoming part's hardness,

geometry or size variation. "In effect, the machine adapts the tool to what is happening in the bore when the abrasive contacts it," Waltz said. "This 'smart tooling' is an advantage when we are honing rotors with sleeved bores, because the liner sometimes has a little memory and can spring back. The new machine recognizes these variations, adapts, and produces bores with exceptionally consistent size control. It may even shorten or lengthen the normal cycle time as it adapts to part conditions."

### Smarter honing

Waltz's new SV-1015 vertical CNC honing machine has a single 5-hp AC spindle with 10-hp servo stroking system and X-Y air bearing table. The operator loads the workpiece in a dedicated fixture that uses the part's kidney slot as a locating feature. After each bore, the table indexes 90 degrees to an Etamic air gaging station where the necessary readings are taken and stored. If the bore passes inspection, the table moves the part to a robot that indexes it for the next bore, duplicating this routine eight times to complete a part. A fixed position master set ring inside the machine's work envelope ensures correct gage calibration for current environmental conditions.

"On a recent project with an allowable bore tolerance of 0.000240" (0.006 mm), we easily held a tolerance range of 0.000060" (0.001524 mm) – that's 25 percent of the total allowable tolerance, and we tripled the previous production rate, while reducing the labor component by 80 percent so the operator can do other work in the cell," said Waltz. "We know from re-inspecting the parts on our CMMs that the results correlate well. The process capability and data reporting features in the machine have been a great advantage to us and our customers, allowing that data to be downloaded to a spread sheet or SPC software.

"It took us a long time to make the purchase decision on this machine after it was designed, but with our volume and mix of parts, it has proved easy to justify, especially now that we've seen customers as excited about it as we are."



ABOVE AND BEYOND HONING

A LEGACY OF EXCELLENCE SINCE 1924.



## WORLDWIDE

Our global manufacturing, distribution, and sales and service network allows us to deliver quality Sunnen solutions worldwide.

And our state-of-the-art Technical Services Centers allow our technical experts to develop innovative solutions to customer application challenges. The Centers also provide answers for customer questions and training for Sunnen representatives around the world.

### SUNNEN PRODUCTS COMPANY

St. Louis, MO - USA

World Headquarters

Phone 1.314.781.2100

Fax 1.314.781.2268

Toll Free 1.800.325.3670

Email [sunnen@sunnen.com](mailto:sunnen@sunnen.com)

[www.sunnen.com](http://www.sunnen.com)

### SUNNEN AG

Ennetaach - Switzerland

Phone +41 71 649 33 33

Fax +41 71 649 33 34

Email [sales@sunnen.eu](mailto:sales@sunnen.eu)

[www.sunnen.eu](http://www.sunnen.eu)

### SUNNEN ITALIA S.R.L.

Arese - Italy

Phone +39 02 383417 1

Fax +39 02 38341750

Email [sunnen@sunnenitalia.com](mailto:sunnen@sunnenitalia.com)

[www.sunnenitalia.COM](http://www.sunnenitalia.COM)

### SUNNEN SAS

Saclay - France

Phone +33 1 69 30 0000

Fax +33 1 69 30 1111

Email [info@sunnen.fr](mailto:info@sunnen.fr)

[www.sunnen.fr](http://www.sunnen.fr)

### SUNNEN BENELUX BVBA

Kontich - Belgium

Phone +32 3 880 28 00

Fax +32 3 844 39 01

Email [info@sunnen.be](mailto:info@sunnen.be)

[www.sunnen.be](http://www.sunnen.be)

### SUNNEN PRODUCTS LTD.

Hempstead Herts - United Kingdom

Phone +44 1442 393939

Fax +44 1442 391212

Email [hemel@sunnen.co.uk](mailto:hemel@sunnen.co.uk)

[www.sunnen.co.uk](http://www.sunnen.co.uk)

### SUNNEN DO BRASIL LTDA.

São Paulo - Brasil

Phone +55 11 4177 3824

Fax +55 11 4362 3083

Email [sunnen@sunnen.com.br](mailto:sunnen@sunnen.com.br)

[www.sunnen.com.br](http://www.sunnen.com.br)

### SUNNEN POLSKA SP. Z.O.O.

Warszawa - Poland

Phone +48 22 814 34 29

Fax +48 22 814 34 28

Email [sunnen@sunnen.pl](mailto:sunnen@sunnen.pl)

[www.sunnen.pl](http://www.sunnen.pl)

### SUNNEN RUS LLC

Moscow - Russia

Phone +7 495 258 43 43

Fax +7 495 258 91 75

Email [sunnen@sunnen-russia.ru](mailto:sunnen@sunnen-russia.ru)

[www.sunnen.ru](http://www.sunnen.ru)

### SUNNEN S.R.O

Strakonice - Czech Republic

Phone +420 383 376 317

Fax +420 383 376 316

Email [sunnen@sunnen.cz](mailto:sunnen@sunnen.cz)

[www.sunnen.cz](http://www.sunnen.cz)

### SHANGHAI SUNNEN

MECHANICAL CO. LTD.

Shanghai - China

Phone +86 21 58133990

Fax +86 21 58132299

Email [shsunnen@sunnensh.com](mailto:shsunnen@sunnensh.com)

[www.sunnensh.com](http://www.sunnensh.com)

Sunnen reserves the right to change or revise specifications and product design in connection with any feature of our products contained herein. Such changes do not entitle the buyer to corresponding changes, improvements, additions, or replacements for equipment, supplies or accessories previously sold. Information contained herein is considered to be accurate based on available information at the time of printing. Should any discrepancy of information arise, Sunnen recommends that user verify the discrepancy with Sunnen before proceeding.