EXPLORING OPPORTUNITIES IN THE ENERGY SECTOR
THE MANY ANGLES OF

CENTERLESS GRINDING

This extremely effective grinding process relies on basic geometry for high precision and high-volume applications.

BY DOUG PICKLYK

It's not uncommon to find centerless grinding machines in operation today that have been running for decades. A precision grinding process suited to any cylindrical part that requires a tight tolerance, centerless grinding machines have few moving parts and perform their grinding magic through a miracle of basic physics. What's really changing with today's more modern machines is the addition of computer controls that take a very efficient process and make it even more productive.

Centerless grinding is an outer diameter finishing process that is revered for maintaining a high tolerance for roundness on metal parts and working very quickly, making it ideal for high-volume applications. And it's the relative simplicity of centerless grinding that separates it from other cylindrical grinding technologies.

At first glance the process appears almost primitive. The part to be ground is simply placed on a workpiece rest blade that is situated between two rotating cylinders: a regulating wheel (made of a dense rubber compound that controls the rotational speed and feed rate of the workpiece) and the larger abrasive grinding wheel.

The part simply sits on the work rest blade, no fixturing involved, and then the rotating
regulating wheel engages and spins the part at one speed while pushing it towards the larger grinding wheel that’s spinning even faster—the greater the difference in speed the faster the removal rate.

As unlikely as it may seem, the workpiece is held in place simply by the pressure of the rotating wheels. With the wheels rotating at speeds above 30 rpm, it’s a wonder the parts are not flying out of the machine. But it all comes down to geometry, explains Harry Schellenberg, founding partner of Echo Hill Automation in Beamsville, Ontario, manufacturer of the Tactic 8 centerless grinding machine.

“Centerless grinding is really good at making round parts, because of the geometry that’s involved in it,” says Schellenberg.

To get that roundness the angles that the wheels contact the part are critical.

In most cases the centers of the opposing regulating and grinding wheels are set at the same height on the machine, and the work rest blade is designed so the center of the workpiece sits slightly above the centerline of the wheels. By creating a triangular relationship among the centers of the two wheels with the center of the workpiece at the apex, the force being applied to the part by one wheel is never directly applied to the opposite side of part on the other wheel. This principle allows for the precise roundness to be achieved.

“As long as you have good spindles you’re going to make a round part if your geometry is right,” says Schellenberg. He adds that you can also take a part that’s out of round from a turning machine and achieve roundness in a centerless grinding machine.

Because of the relative simplicity of the process, the speed of centerless grinding is also one of its primary advantages. “You don’t have to fixture each part,” notes Schellenberg. “You simply set it in place, the wheels come together, grind the part and you’re done.”

For this reason, anywhere high volumes of small cylindrical parts are required makes this process a prime candidate. Industries that demand the tolerance and roundness of centerless grinding include aerospace, automotive, defense and medical.

The bolts in a motorcycle chain for instance are ground, notes Ralf Scheurl, sales manager with Mikrosa, the centerless grinding unit of the United Grinding Group. “That’s a lot of bolts,” he says, adding “The centerless grinding process is very good at putting parts into buckets.”

And it’s the consistency of the process; its ability to maintain its tolerance within microns that makes it first class. “I have a background of grinding parts between centers,” says Scheurl, referring to where a workpiece is clamped between two centers before grinding. “When I first came in contact with Mikrosa (centerless grinding) I couldn’t believe it. You can’t compare it with grinding between centers.”

The set up for a centerless grinding job requires first selecting a grinding wheel suited to the metal and the desired surface finish. Tooling required for set up includes a custom work rest blade to suit the part. As mentioned, the height of the work rest blade is critical. The top of the work rest blade generally has an angle of 30-degrees sloping towards the regulating wheel. This keeps the part in contact with—and rotating at the slower speed of—the regulating wheel.
There are two ways centerless grinding machines operate, either infeed (also called plunge grind) or throughfeed. The infeed is used to grind cylindrical workpieces with notches or complex shapes, such as gear shafts. In the setup, the work rest blade needs to be tooled to match the shape of the part. The grinding wheel and regulating wheel must also be dressed—having the part’s desired profile cut into them with a stationary diamond or diamond wheel (this process is done on the machine and takes some time).

To begin, the workpiece is placed on its customized work rest blade, coolant flows, the wheels engage the part, sparks fly, and in seconds the part is removed and the next workpiece is set in place. As the grinding wheel wears it will need to be redressed on an ongoing basis.

For throughfeed grinding, the workpiece travels along the rest blade between the grinding and regulating wheel. The part is driven through by a slight angle applied to the regulating wheel relative to the grinding wheel, basically squeezing the workpiece across the grinding wheel and out the other side. A throughfeed set up is typically used for parts with a consistent roundness across the length of the part.

While centerless grinding machines have been around for decades, new technologies continue improving the process. The introduction of CNC controls and direct drive motors are reducing the time and complexity of the setup and enhancing the already tight tolerance holding capability.

Robotic automation to load and unload the workpieces is also speeding up the process and ensuring accuracy, while automated gauges, set up at the delivery end to measure part diameters are ensuring accuracy and keeping the variance from part to part in the low micron level. These advancements are all making centerless grinding a cut above when it comes to finishing round parts.
Like many technology invention stories, this one begins in the garage. Brothers Harry and Dan Schellenberg grew up around Beamsville, Ontario in the southeast tip of the province—wine country. Both brothers are mechanical engineers with a knack for tinkering and fixing things, so 20 years ago they started a business doing design work and operating a small machine shop in their Mom’s garage. Their main projects involved working for area machine shops, a lot of machine tool rebuilds including adding automation, specialty handling machines, and integrating servo motors to old machines.

A lot of their time was spent reconditioning centerless grinders, automating technology that was built years ago for manual operation. They custom designed loading systems for these machines, but they knew there was more that could be done to improve productivity. So the brothers opened up their notebook and took a clean sheet approach to the design of the centerless grinding machine.

In 2009 the first prototype of their new design was built and running, and in the spring of 2011 they sold their first machine. This year they have nine machines slated to be installed, accounting for 20 machines sold and counting. Harry Schellenberg estimates that roughly 150 million parts have been ground on their centerless grinding technology so far.

The Schellenberg’s company, Echo Hill Automation, no longer works out of a garage. They’ve been in their 14,000 sq. ft. Beamsville facility for 10 years where all of the machines are manufactured and assembled. “We do almost everything in house,” says Harry. The nine-person company operates a complete machine shop including a recently-installed Milltronics vertical machining center purchased from Mitcham Machine Tools along with additional machining centers to create parts, wire EDM and waterjet for cutting, and welding is done in-house. The castings for the frames of the 12,000-lb. machines are done in nearby Brantford, and the bending of the machine’s exterior sheet metal housings are sent out to a local shop.

Called the Tactic 8 (Tactic stands for: total automatic compensation through integrated control), the Echo Hill centerless grinder is a turnkey CNC-driven system that has automation built into most every function of the process.

Beyond the grinding operation at the heart of the machine, the Tactic 8 has an integrated handling system for feeding and removing parts. The servo-driven loading/unloading system is also capable of handling multiple parts at once, a productivity enhancer. On the back-end the system has an in-line Keyence optical micrometer taking 1,000 reading per second. This inline gauging ties back into the system’s controller, so any variance detected can be addressed by the machine without any operator involvement.

The system’s Beckhoff controller is the brains of the operation, integrating all of the functions. According to Armando Afonso, technical sales manager with Echo Hill, the intelligent controller in the machine is like “basically having a built-in operator.”

The grinder’s set-up assistant allows for
operators with very little grinding experience. The machine can be set up to run lights-out.

The most unique feature on the Tactic 8 is the positioning of the motors driving the grinding and regulating wheels. The patented "powered from above" design places the linear motors on an overhead roller rail system. Both the grinding and the regulating wheel move, and the control of the linear motors keeps the accuracy high. The cast iron frame filled with a polymer concrete base also dampens any vibration. According to Schellenberg the machine can hold a plus/minus 2-micron tolerance. Another benefit of the overhead motors is it keeps the motors clean, as coolant and debris flow down through the system.

Also, because both wheels are on rails, their machine dresses the grinding and regulating wheels in the center, along the same contact line as the part. And because of the tight tolerance and gauging system tied into a feedback loop with the controller, the machine can run multiple parts at once across its 8-inch grinding wheel width.

Before automation, traditional centerless grinders required many hours for set up. And while the centerless grinding process is best suited to high-volume applications, because of the fast set up time on Echo Hill's machine it makes smaller batch runs more economical.

"In the past, shops would have up to 12 grinders set up," explains Harry. "They would be dedicated to specific parts. Shops would run one for a day, and then it would sit idle because they didn't want to have to change it over."

"We built a system that's flexible, so that you can change it over more easily," says Harry. "We have companies running 10 or 12 different jobs on one grinder. And these are high-volume runs, because they can run up to four parts at a time."

Most of Echo Hill's centerless grinding machines are going into the U.S. Repeat orders are a great endorsement, and Echo Hill has one customer who has confirmed an order for his eighth machine.

Once companies install machines, Echo Hill also supplies tooling packages to set up the grinders for a particular part. The packages include the work rest blade suited to the part, a software program for dressing the profile into the grinding and regulating wheels, and tooling for the handling system including grippers. Depending on the complexity of the part, packages are put together in a few weeks. Harry says they've supplied about 100 different tooling kits to accommodate about 100 different parts.

The company has sold to companies for a variety of applications from automotive, to aerospace and it's making inroads in the bearings industry, anywhere parts require precision grinding for high tolerance and roundness.

Schellenberg says that centerless grinding is widely used across North America. He estimates there may be some 13,000 machines in operation on the continent, but the technology on most of those shop floors has been around for decades. The systems Echo Hill Automation is building today are a far cry from the manual grinders Harry and Dan had been refurbishing for clients in their Mom's garage. Their home-grown innovations, digitizing and automating the process, are playing role in modernizing the art of centerless grinding.

Echo Hill Automation designs and handles most every aspect of manufacturing for its TACTIC 8 centerless grinding system in-house. The latest addition to its machine shop is a Milltronics VM16 vertical machining center used for making parts.