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BY PIERRE PAHUD, ROLLOMATIC SA

BEARING THE LOAD

Hydrostatic bearings improve 6-axis tool grinding.

Advances in high-speed machining and hard milling continue to create the need for better and better cutting tools. However, the required concentricity and accuracy of the tools are reaching levels increasingly difficult to meet with standard 5-axis tool and cutter grinding machines.

High-precision tool grinders have traditionally been reserved for small cutting tools. After all, to grind a 0.002"-dia. endmill takes an exceptionally accurate machine. To obtain the same accuracy from a grinder used for large cutting tools—say, 1" in diameter or larger—necessitated development of a new type of grinder. Specifically, one that incorporates hydrostatic bearings.

Hydrostatic technology has already been successfully used in surface, OD and crankshaft grinding machines, mainly on a single slide, as well as on the main slide of precision lathes.

Machines that have linear guide rails with ball and roller bearings have a major weakness—they only offer nonconstant stiffness. When load is applied to the linear guide rail or ball bearing, less bearing surface is in contact, meaning surface pressure is high. Therefore, the stiffness is rather low and heavily dependent on the load applied. This is the cause of vibrations and poor damping.

"Fully hydrostatic" technology provides an answer for this: better distribution of load through infinite contact points created by the molecules of a thin film of oil. This fosters high stiffness.

To obtain a precise trajectory during 6-axis tool grinding, the guide-rail system, rotary axes and grinding spindle *all* need hydrostatic bearings. On existing hydrostatic machine tools, such as lathes or profile grinders, only one axis is hydrostatic.

Hydrostatic Basics

With hydrostatic technology, there are no contact elements such as balls or rollers in the bearing elements. Instead, pressurized hydraulic fluid is forced into a pocket and then through a small gap between the closely matched guide surfaces, creating a film of oil on which the upper part of the slide "floats." The gap distance and pressure vary, depending on the slide design. The gap is usually a few microns.

A hydraulic pump supplies oil to the hydrostatic pockets. The force of the oil as it is being delivered pressurizes the pocket. When the load is increased due to grinding and acceleration forces, the flow controller increases the

The CNC6000XL grinder features hydrostatic technology.

All images: Rollomatic

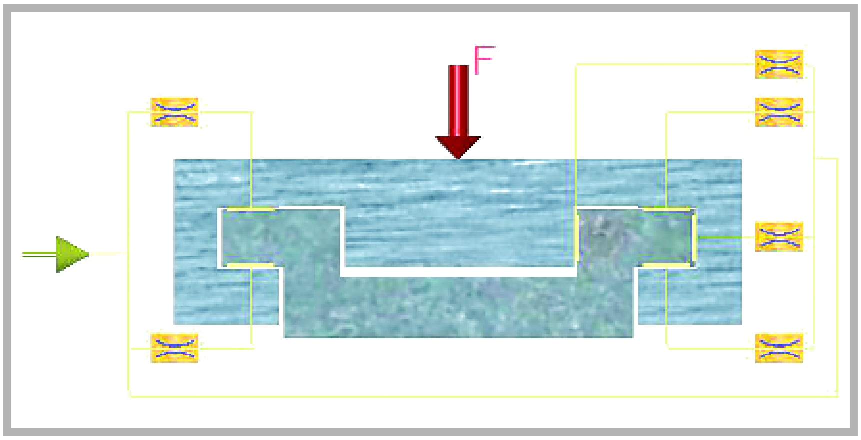

Figure 1: A hydrostatic slide typically incorporates six pairs of hydrostatic bearings.

pocket pressure and the flow to keep the gap constant.

The friction is almost zero. Zero friction eliminates "stick-slip" or "static friction" inherent with ball and roller guide ways. This allows incredibly heavy slides to be moved manually or slowly and incrementally.

Hydrostatic guide ways are used for linear and circular motions. The slide is firmly maintained in one direction between a pair of pockets. By controlling the oil pressure to the pockets, high loads can be tolerated and high stiffness can be achieved. In order to suppress 5 degrees of freedom to a carrier and ensure a CNC-controlled 6th movement or degree of freedom, a minimum of five pairs of bearings are needed. For symmetry, six pairs (12 hydrostatic pockets) per carrier are often used (Figure 1).

The high damping ability eliminates all vibrations and makes it possible to grind faster, more accurately and with less wheel wear than occurs with a mechanical bearing system.

Rotary axes are designed in the same way. There is an inner and outer shaft. Hydraulic oil, which serves as a bearing surface, pressurizes the gap. The axes offer extreme stiffness and vibration damping. In rotary axes with ball bearings, vibrations and the resultant harmonics are usually amplified.

The bearing in a hydrostatic spindle also consists of a thin film of pressurized oil. The oil is supplied to the spindle pockets, through flow controllers, by a high-pressure pump (Figure 2); there is one flow controller for each hydrostatic pocket. The shaft is suspended in the housing in an oil film. When load is applied to the shaft, via grinding forces, for example, the pressure in the pocket opposite the force increases to keep the gap constant and recenter the shaft, thus maintaining a high level of stiffness.

Concentricity of the rotating spindle arbor only depends on its roundness. A highly concentric arbor, or shaft—say, one manufactured to a roundness of 0.000020"—will not deteriorate over time when hydrostatic bearings are used because there is no shaft wear.

And because a film of oil is much thinner than a standard bearing, the shaft of a hydrostatic spindle can have a much larger diameter than the shaft in a standard-bearing spindle. A hydrostatic spindle can be six times stiffer than a standard spindle (Figure 3).

Benefits

The benefits of a tool and cutter grinder that incorporates hydrostatic technology include:

■ Lower cost per tool. Because of high stiffness, higher stock removal can

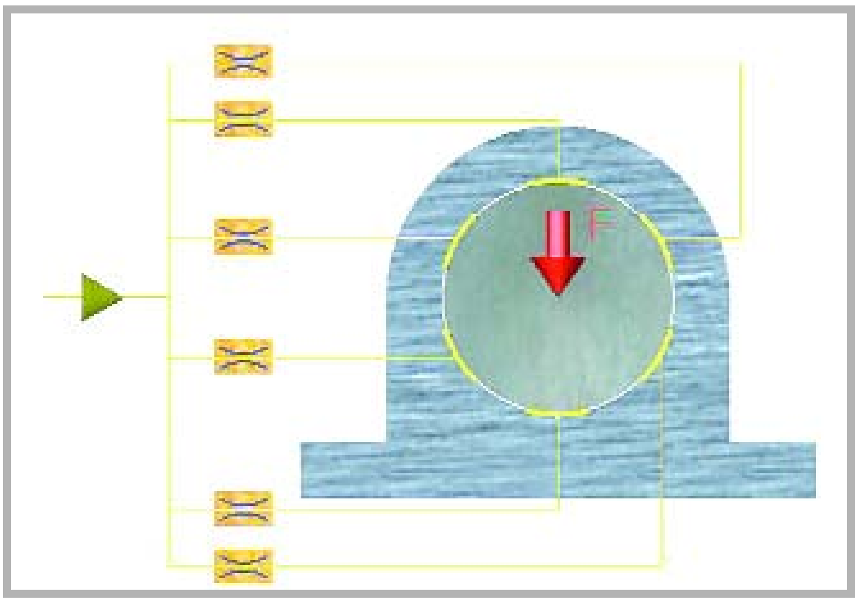

Figure 2: A hydrostatic spindle with six pockets.

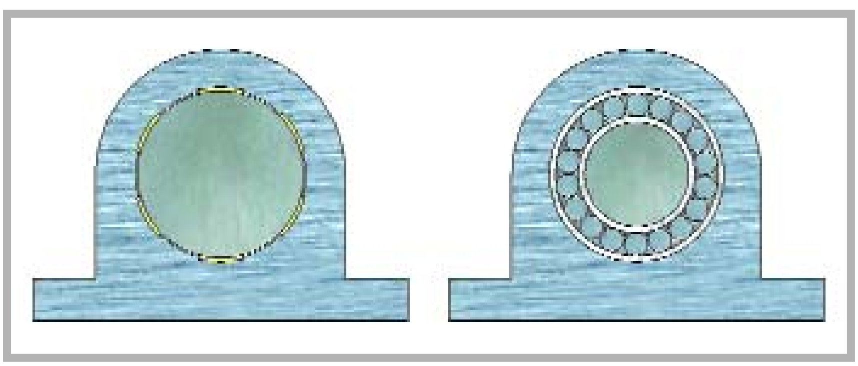

Figure 3: A hydrostatic spindle (left) can be six times stiffer than a comparably sized standard spindle because its housing can accommodate a larger diameter shaft.

be achieved, compared to traditional systems, without sacrificing quality.

■ Better surface finish. Because damping is 10 times greater than with traditional systems, the surface finish is finer and, therefore, cutting edges are sharper. This means much less chipping for carbide tools.

■ Wheel life. Much higher damping also means less sticking and reduced wheel wear, providing a much more stable grinding process with fewer production interruptions for wheel dressing and truing corrections.

■ No wear. Through the noncontact and friction-free guiding elements, the slides and rotary axes never wear. The grinder performance never deteriorates or changes over time, regardless of how hard, fast and long the machine is used. This also means fewer maintenance interruptions.

■ Machine stability. The hydrostatic oil is chilled and temperature-controlled and, therefore, has a cooling effect on the entire machine. This makes fully hydrostatic machines more thermally stable, which, together with the use of chilled coolant oil, provides the perfect combination for reducing heat.

■ Tool geometry. Errors associated with roller bearings are eliminated by hydrostatic guide ways. The straightness of axes movement is improved, giving a more accurate interpolated trajectory. The result is perfect tool geometry.

A perfect tool is the goal of cutting tool manufacturers. Hydrostatic bearings can help them attain it.

About the Author

Pierre Pahud, Ph.D., is senior R&D engineer at Rollomatic SA, Le Landeron, Switzerland. For more information about the company's grinding equipment, call (847) 281-855 or visit www.rollomaticusa.com.