▶ BY TIMOTHY M. FINN, SAINT-GOBAIN ABRASIVES INC.

Process monitoring helps toolmakers shorten their grinding cycles.

Faster Cycling

You may not know it, but there's money in your tool and cutter grinder. You just need to know where to look for it.

Where it won't be found is in what you save buying a cheaper wheel or workpiece material. Chances are, that will only cost you more in the long run.

No, you'll find the money within the grinding process itself.

When manufacturing cutting tools, the largest cost drivers are labor, overhead, raw materials and abrasives. To become more cost-competitive and profitable, many manufacturers opt for low-cost raw materials and lower-priced abrasives. Using less expensive materials and abrasives, however, usually results in low-quality tools.

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Sophisticated toolmakers reduce manufacturing costs not by purchasing a cheaper grinding wheel, for example, but by evaluating the wheel cost per part. They select wheels that allow cycle optimization.

This optimization is achieved through a systematic approach to grinding—where machine tool, workpiece material, abrasive and operational factors are evaluated together, as a complete grinding system. Machine tool factors include machine dynamics, controls and sensors, feed systems, and dressing and coolant-delivery systems. Workpiece material factors include the material's microstructure, abrasion-resistance, and mechanical, thermal and chemical properties. Wheel geometry is defined as wheel/part conformity and wheel shape and profile. Part-to-part consistency is also examined.

In addition, grinding wheel selection (the abrasive, bond, core material and wheel design) becomes a key component of the grinding cycle, especially in light of the new workpiece materials being processed by manufacturers.

Operational factors must also be evaluated. They include fixtures; wheel balancing; truing, dressing and conditioning; grinding cycle design; coolant application; and inspection methods.

The systematic approach to grinding, which now incorporates sensor-based, process monitoring devices operated by knowledgeable application engineers, enables cutting tool manufacturers to optimize their toolmaking operations.

Field Instrumentation System

One sensor-based device for measuring and analyzing the grinding process is the Field Instrumentation System, developed at Saint-Gobain Abrasives Inc.'s Higgins Grinding Technology Center, Worcester, Mass.

The FIS measures and records the system variables, or "vital signs," of the grinding process. It also measures the impact the machine tool, workpiece material, abrasive product and operational factors have on part quality.

The system incorporates Hall-effect current probes and a linear variable differential transducer to measure and monitor power consumption, slide position, cycle time and product behavior over time. The transducer signals are collected by a data-acquisition system and converted to quantitative process data by the FIS software. The data is stored on a laptop computer.

With this data, the user can calculate and compare a wide range of conditions, such as grinding cycles for different machines, operators and abra-

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sives, as well as power trends over several cycles. The FIS data also allows the user to calculate average power consumption, grinding times, rough and finish infeed rates, material-removal rates and the machine's dynamic stiffness.

For example, the system can monitor spindle power and feed rates to determine the optimal mrr for an application. If the grinder is operating at a slower-than-optimal mrr, abrasive grains in the grinding wheel will dull prematurely, reducing overall productivity. When operating at a faster-than-optimal mrr, abrasive grains are crushed, causing excessive wheel wear and a poor surface finish.

Benefits of Optimization

The uses and benefits of FIS in grinding-system optimization include the ability to collect baseline cycle information; reduce cycle time and abrasive cost per part; test and introduce new abrasives to the system (e.g., CBN vs. conventional abrasives); test the machine's stiffness and accuracy; and optimize the dressing and grinding processes through acoustic emissions.

The FIS has allowed tool manufacturers to streamline their processes. What follows are actual case studies of such process improvements:

■ In fluting, pointing and clearing operations for 0.312"-dia. carbide drills with a 2.375" flute length, the FIS allowed the author to provide one manufacturer the opportunity to eliminate a second fluting pass. This change drew 15 percent less power by decreasing the feed rate from 3 ipm to 2.2 ipm (Figure 1). The company also eliminated a power spike at the end of that pass. The result was a decrease in cycle time of 133 seconds, or 43 percent. The abrasive cost per part did not increase as a result of the decreased power draw, and the number of times the wheel entered the cut was reduced from four to two.

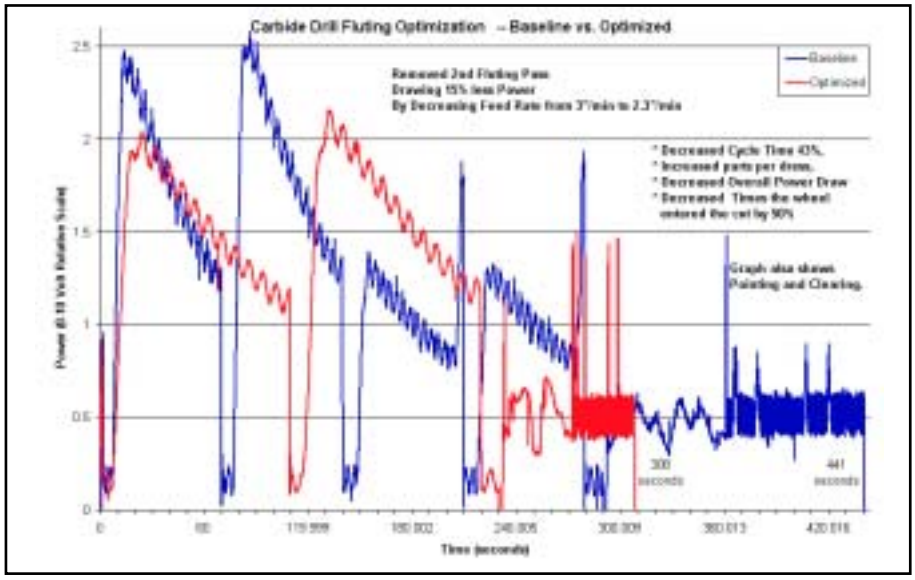

Figure 1: The FIS lowered power consumption 15 percent for one toolmaker, which cut cycle time by 43 percent.

■ A manufacturer of wood-chipper blades made from tool steel applied the results of FIS testing to its creep-feed grinding process and realized a $200,000, or 40 percent, savings in abrasive costs. By using a vitrified CF grinding wheel, this manufacturer reduced costs 12 percent and achieved a 20 percent reduction in cycle time. In a second test with the FIS, the toolmaker reduced the abrasive cost per part on the same type of blade another 10 percent. In addition, optimization allowed the company to decrease the dressing depth by almost half, from 0.009" to 0.005", while eliminating chatter and improving part quality (Figure 2).

■ For a fluting operation, FIS results showed a round-tool manufacturer how to save $3.089 per component by optimizing its grinding process. The mrr was doubled without any degradation in part quality, and the G-ratio was increased by a factor of four. The result was a fourfold increase in wheel life and a 75 percent decrease in abrasive cost.

■ FIS evaluation enabled another toolmaker to reduce the cycle time on a flute-grinding operation for endmills from 12.45 minutes to 8.51 minutes, with no microchipping. Produced on a custom-designed machine, the tool was made from a 1"-dia. car-

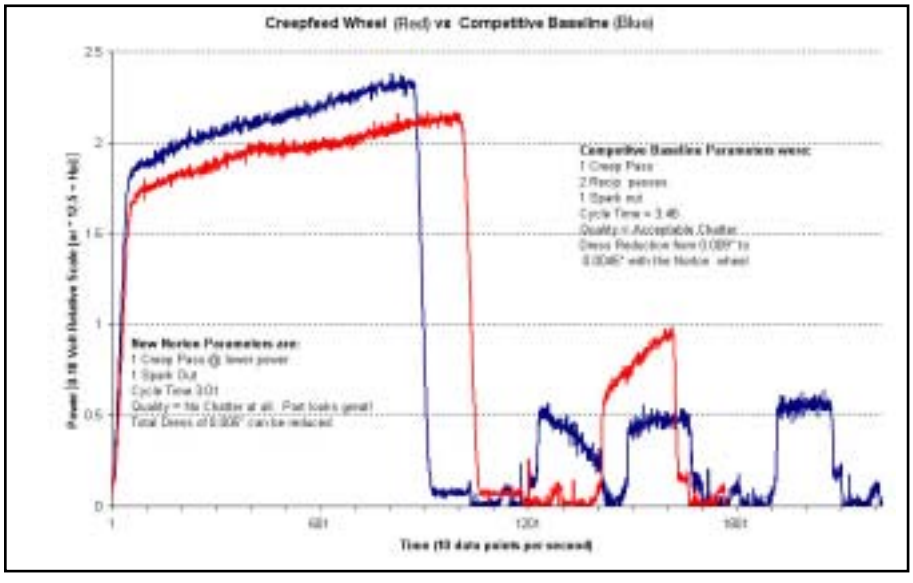

Figure 2: In addition to reducing cycle time, FIS can also save money. In a creep-feed grinding operation, a toolmaker realized a $200,000, or 40 percent, savings in abrasive costs.

The author (right) demonstrates the FIS.

bide blank. These productivity improvements did not decrease wheel life or increase the abrasive cost per part.

■ In yet another example, the author's use of the FIS allowed a carbide-insert manufacturer to realize a 44.52 percent cost savings. In this case, the abrasive cost per part was significantly less than the previous wheel, due to an increase in parts per dress—334 vs. 197. Average parts per wheel rose to 157,648, from 92,984, and abrasive cost per part dropped from $0.0301 to $0.0167.

■ Data points collected at a tool manufacturer producing 0.375"-dia., straight-flute taps enabled the company to compare the performance of a standard seeded-gel grinding wheel with an advanced-porosity, SG, ceramic aluminum-oxide wheel. The resin-bond wheel was designed for grinding the flutes of HSS tools. In this case, the new abrasive tripled the mrr of the standard SG product, doubled the G-Ratio and cut the cycle time in half.

Clearly, process monitoring enables cutting tool manufacturers to eliminate unnecessary steps, thereby enhancing their productivity and saving money. The realization of these benefits, however, often requires a change in company culture and the ability to recognize the benefits of shorter grinding cycles.

Some of the information in this report was provided by Dr. K. "Subbu" Subramanian, director of grinding technology at the Higgins Grinding Technology Center. To learn more about Saint-Gobain's products and services, call (800) 543-4335, or visit the company's Web site (www.nortonabrasives.com).