e-SPINDLE Monitors Cutting Processes in Real Time

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MANUFACTURERS HAVE BEGUN USING sensors and actuators to monitor their cutting processes and adjust parameters to optimize tool life and workpiece quality. However, traditional monitoring systems have some drawbacks. They typically involve sensors being integrated at different locations in the spindle, which can negatively affect machining capabilities.

For example, a spindle being instrumented for effort measurement may lose rigidity and/or provide poor data collection. Efforts have to be significant enough to be detected, which doesn't work well in monitoring machining processes because small process changes must be detected for the system to be useful.

Also, it is vital to maintain measurement close to the tool/part interface. The further the sensor is from the interface, the worse the signal quality. This is applicable to all physical measurements (such as vibration, temperature, pressure).

Actuation capabilities in traditional monitoring systems can be limited to either one single active tool or one single vibration frequency. In these systems, there is no flexibility to monitor different tools or frequencies to extend device capability.

Typically, manufacturers overlook integrating solutions to visualize the machining process and give operators a clear view of spindle operations. For example, the spindle may vibrate but there is no way to display the frequency or make sure the signal is as accurate.

A New Approach

The electro-spindle, or e-SPINDLE, from Absolute Machine Tools partner PCI-SCEMM, Saint-Etienne, France, provides a different solution. This smart, or closed-loop, system integrates sensors and actuators to monitor cutting processes and adjust parameters to optimize tool life and workpiece quality. The e-SPINDLE was developed in France in collaboration with the Technical Centre for Mechanical Industry and the Aix-en-Provence campus of the French Arts et Métiers engineering and graduate school.

The e-SPINDLE remains a standard spindle, with the same machining capabilities. Specially equipped cutting tools are installed on the spindle and provide connectivity for all e-features. These tools enable users to monitor and drive the process while standard tools can be used for the rest of the process when there is no need for measurements and data collection.

The e-SPINDLE system integrates sensors on the cutting tools and/or toolholders (not on the spindle) so the sensors are close to the cutting area or designated measurement area in order to ensure high-quality data collection and processing. When standard tools are used, the spindle will act as a standard, non-connected spindle.

Almost any kind of sensor (accelerometer, effort gauge, thermocouple) or motion generation devices (piezoelectric actuator, electrical drive, thermal drive) can be used with the e-SPINDLE, as well as any kind of device that would need power (signals such as 0-10 V, 4-20 mA, IO-Link, and power up to 5 kvA, 1,000 V, 5A).

One example of this process involved monitoring a 6-mm diameter deep drilling operation in a PSA cylinder head on a PCI machine using MQL. As the tool heats up, aluminum sticks to the tool, leading to deteriorating quality of the drilling operation and synchronized chip evacuation. The e-SPINDLE audits spindle temperature and vibration to detect irregularities during that specific machining process. Spare gun drills are inventoried inside the machine's tool stocker to exchange automatically whenever a deficiency like the one described above is detected. Microanalysis of this simple operation minimizes scrap part rates and tool repairs, permitting costly tooling to be salvaged and placed back into production, all the while avoiding production interruptions.