Optimising the grinding process

Grinding process monitoring, pre- balancing, fully-automated balancing and in-process measurement control must all go hand in hand in order to improve the cost effectiveness of grinding machines and to reduce the risk of spindle damage. DITTEL has a range of modern solutions on offer.

[Adalbert Sporer]

The steadily increasing demands placed on the grinding process have led to the introduction of several new technologies over the last few years.

Sensor technology is the key to make full use of potential grinding capacity at increasingly high cutting velocities. These sensors monitor threshold values during the grinding and dressing processes and provide the system with signals to take appropriate action before tolerances are overstepped or before the process worsens – without the need for operator intervention.

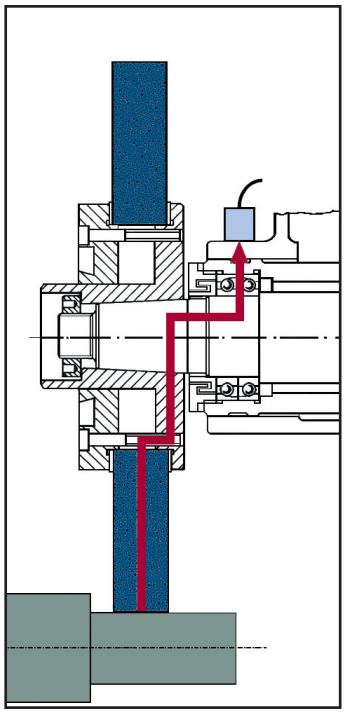
Acoustic emission sensors (AE sensors) have proven themselves in these situations and have a number of major advantages in comparison to conventional sensors: they are highly sensitive, cannot be overloaded, are resistant to cooling lubricants, remain stable over a wide range of temperatures, and are robust and waterproof. It is also very easy to integrate these AE sensors into existing machines, which is why they are ideal for monitoring and controlling grinding processes. They are less expensive than sensors based on other physical measuring principles that could be used for the same application.

Acoustic emission (AE) is a highly dynamic signal with a large number of characteristic process values. The quality of the measured signal depends to a great extent on the sensor being mounted very close to the source of the acoustic emission, i.e. as close as possible to the actual grinding or dressing process.

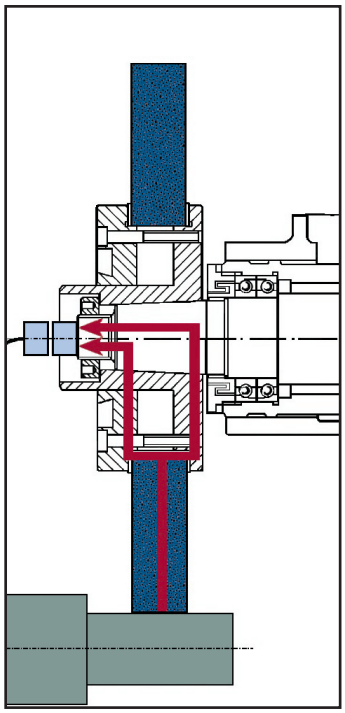
Superimposing background noise

Besides the basic cutting process, a machine will generate a variety of background noises that superimpose with the original 'pure' emission generated by the machining process. Bearing noise or electromagnetic waves generated by pulse width modulated drive controls can, for instance, cause the sensors serious problems. Ground loops caused by poorly grounded machine components can also make it difficult to evaluate the sensor signals. In developing its AE sensors, DITTEL has therefore paid particular attention to eliminating the effects of interference so that the sensors can be used under demanding conditions. Active AE sensors must also comply with the regulations governing electromagnetic compatibility (EMC) in order to produce secure evaluation signals. The point is to amplify the acoustic emission signal already on the rotating shaft to make it resistant against EMC interference.

Stationary AE sensors ('S sensors') (Picture **1**) are mounted conventionally onto the spindle housing. AE signals must therefore travel from the source (between workpiece and grinding wheel), through the grinding wheel, the flange, the spindle and the bearings before reaching the measuring sensor.



1. The S-Sensor is particulary well-suited for stationary tools, such as single-point dressing tools

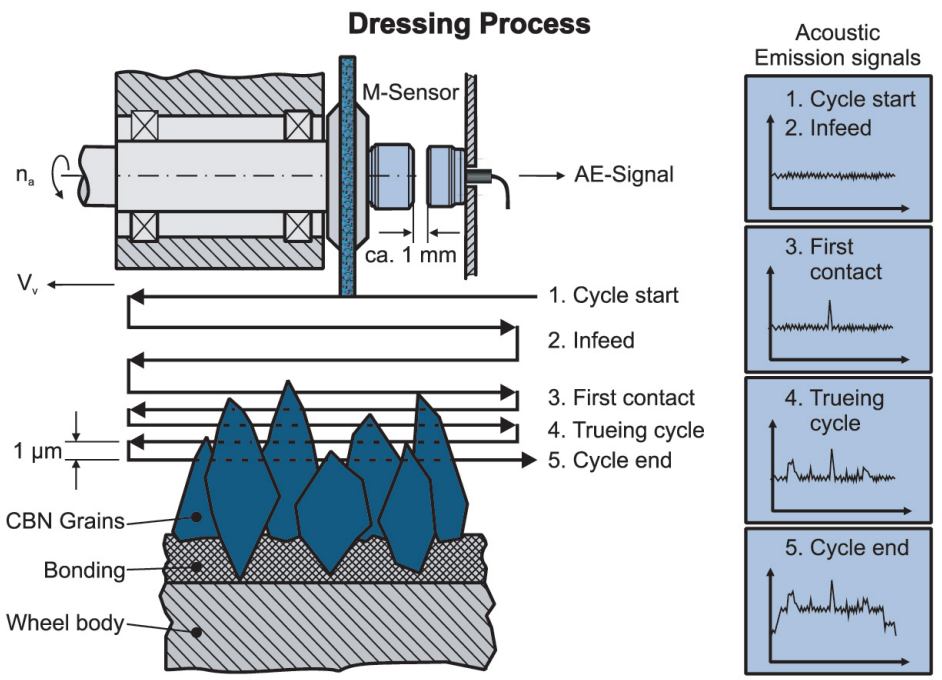


2. The M-Sensor is picking up the AE-signal on the rotating spindle shaft

Unmistakable bearing signals

The bearings act as a filter, attenuating the signals – the higher frequency signals are attenuated more strongly than the low frequency signals. The bearings also generate significant interference caused by defect frequencies and cage noise.

'R sensors', or ring sensors, are used for particularly demanding conditions or when a very high signal quality is needed. These sensors are tailored to meet customer requirements, i.e. are modified to fit the design of the client's machine.



3. Automated dressing processes: An M sensor is fitted to the front end of the dressing wheel with the corresponding receiver mounted maximum 1 mm away on a bracket

DITTEL therefore already developed the 'M sensor' in 1990, which picks up AE signals directly at the rotating spindle shaft (Picture **2**). The unwanted signals are low here and avoid most of the bearing noise. An inductive, non-contact transmitter ensures that the signal is safely transferred to the static receiver. This transmission from the rotating sensor to the stationary receiver and its amplifier is resistant to cooling lubricants and works irrespective of the rpms.

A good AE signal is not only characterised by its high amplitude, but also by a good signal-to-noise ratio. Each type of sensor fulfils therefore a specific function: the S sensor can be mounted to stationary workpieces or dressing tools, such as dressing plates or single point diamonds.

M sensors are suitable for automated dressing processes. An M sensor is fitted to the front end of the dressing wheel with the corresponding receiver mounted maximum 1 mm away on a bracket (Picture **3**). In this example, the dressing unit 'meanders' over to the CBN grinding wheel and one observes some background noise on the monitor.

Here, the process signals travel the shortest distance between the source and the R sensor. The R sensor is far more sensitive than other sensors as it has a larger surface area over which to receive the AE signals. Under extreme conditions, the sensor is integrated directly in the workpiece holder.

Initial dressing contact

The signal peaks upwards when the dressing roll first comes into contact with the grinding wheel. This information is passed on to the machine controls, which then reduce the dressing feed to 1 µm. The dressing process is stopped as soon as a continuous signal is present across the complete width of the wheel.
Typically, dressing feeds of between 2 and 5 µm are selected when using CBN grinding wheels, which is only possible if the first micron of contact is detectable. Our system is capable of achieving this while meeting the criteria mentioned above. One must bear in mind that there is no precise definition for the initial contact – and this is true, whether the first grain or the first ten wheel grains are involved in the contact.

DITTEL also produces an AE sensor system for high-speed spindles – the Micro-M sensor – which is designed for speeds of up to 140,000 min1. Leading spindle manufacturers already use the Micro-M sensor to reduce 'air grinding time' and to monitor the dressing process.
Balancing becomes increasingly important as cutting speed continue to increase, i.e. as grinding wheel rpms increase. Spindles are becoming ever smaller in order to reduce the mass to be moved and to minimise interference contours, but this makes it almost impossible to fully automate the balancing process. DITTEL therefore decided to pre-balance the grinding wheels on the machine.

The pre-balancing process is very user-friendly and easy to perform as the imbalance is measured on the machine itself, eliminating the need for balancing scales or a stroboscope lamp – quite simply, the display shows where to move the balancing weights to. Another advantage: the spindle runs up to the final speed with only a very small imbalance, prolonging the spindle's operating life.

Balancing quality also improves due to the fact that the electromechanical balancing head can balance in very small 'doses' and prevent over-compensation – at less balancing weights but constant motor increments.

Process monitoring and remote control

When the balancing heads are equipped with AE sensors the AE6000, M6000 and H6000 electronics units are ideal for process monitoring. The AE sensors do not increase the size of the balancing heads. Data is transferred via a bidirectional transmission channel. The rotating section of the signal transmission receives the energy to drive the balancing motors and the control commands while transmitting the acoustic emission.

The receiver can also be mounted directly onto the balancing head and transmits the signals to the grinding wheel end of the spindle without making physical contact. The advantage of this combined system: the size of the balancing head and the signal transfer unit remains unchanged once the AE sensor is installed and the sensor can be mounted in a prominent position that ensures a good signal-to-noise ratio.

Interface to the Control

DITTEL provides various remote control and display options – the DS6000 (DITTEL SYSTEM 6000), for example, displays the balancing process, AE and measurement signals either on the machine monitor or on a remote control unit with LCD display. (Picture **4**)

The data on the monitor can be downloaded onto any PC and printed off. DSCC (DITTEL SYSTEM CONTROL CENTER) software allows the user to save all PC and machine settings in an XML file and transfer this via an RS232 interface, Ethernet or USB to other machines. This means that series production can be commissioned relatively quickly and it is also relatively easy to reset the system to its original default settings.

All devices are autonomous, can be cascaded and used simultaneously. The electronics unit can be integrated into a control cabinet and operated via remote control.

The Movomatic in-process measurement controls for high precision diameter and positioning measurements can also be visualised and operated using the DSCC software. An easy-to-use operating software is therefore available for four 4 applications. ■

4. The DS6000 (DITTEL SYSTEM 6000) displays the balancing process, AE and measurement signals either on the machine monitor or on a remote control unit with LCD display

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