Acoustic Emissions in Predictive Condition Diagnostics

Kari Aura
Automation Solutions
Sales & Application
Manager
ANDRITZ OY

kari.aura@andritz.com

Tuomas Nikula
Maintenance Engineer
Outokumpu Tornio
Works

tuomas.nikula@
outokumpu.com

In the past 20 years, acoustic emission technology has developed into a tool for predictive condition diagnostics. The tool has improved reliability and is easier to use. A measurement unit certified by TÜV and applicable in explosive environments has also been included in the program.

Acoustic emission (AE) is a technology using the very susceptible piezoelectric crystal, which senses high frequencies to produce an electric signal. The crystal directly converts high-frequency vibration to an electric signal.

The ACU measurement unit developed and manufactured by ANDRITZ is completely remote-controlled and serves as a complete diagnostic solution.The signal produced by the piezoelectric crystal is first processed in analogue form; it is amplified and filtered in the manner chosen.

Afterwards, the signal is converted to digital form and can be upgraded through any known method. The sampling frequency and data processing capacity of the ACU unit is dimensioned to cover all requirements.

In the measurement unit, the signal is handled by very rapid FPGA (field programmable gate array). A sufficient amount of RAM memory is also available, together with a separate processor that handles the data transmission and control of the entire measurement unit. The produced data is transferred to an AE server to be saved for viewing and follow-up.

In the application delivered to Outokumpu, a piezoelectric crystal that is the most susceptible to the 150 kHz frequency is used. Naturally, the "sector" of the used crystal is broader—it is able to pick up signals from a wide area. The frequency range used is the greatest difference compared to conventional measurements, the operating ranges of which are much lower, typically 10-20 kHz. For the sake of comparison, the human ear senses low-frequency vibrations traveling through the air, and its sensitivity ceases at around 20 kHz.

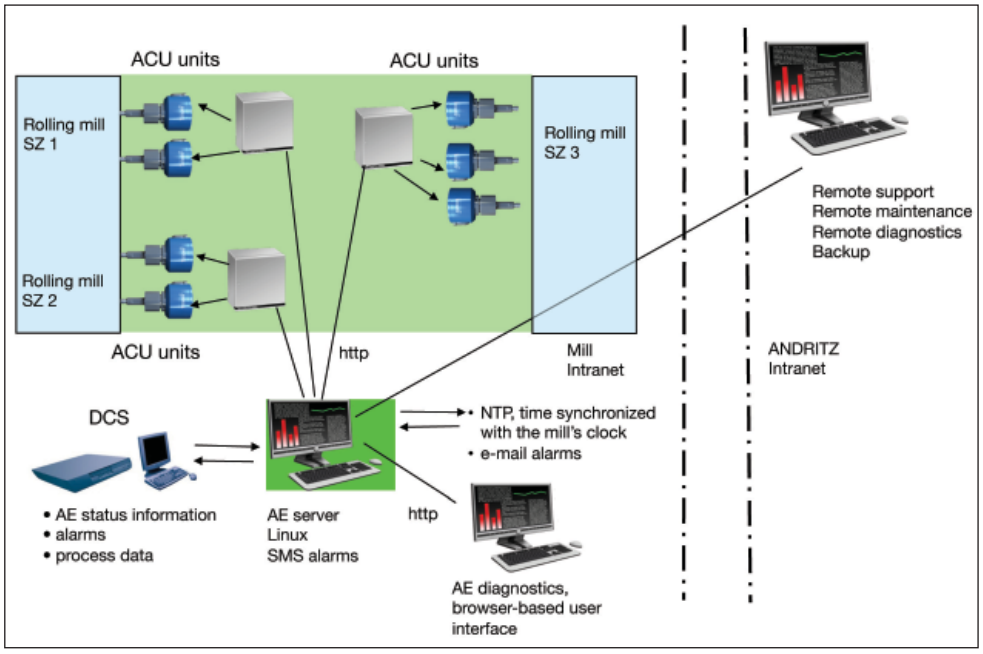
ACU measurement unit

The ACU measurement unit registers the high-frequency AE signals that rapidly advance in a metal structure. The most typical producers of a burst signal in static structures (such as pressure vessels, tanks, piping, valves, crane girders) occur when these structures overload, causing deformation or breakage.

In rotating and moving equipment, a continuous AE signal is generated, identifying bearing friction, the friction between gears, and the gliding friction between surfaces moving in relation to each other. Should a lubrication film fail, there is a steep increase in the signal level.

Thanks to our customers, we have gained invaluable experience from many processes and different production equipment in various industrial sectors. The AE technology is typically used in locations where conventi-

▼ ACU system operating diagram, Outokumpu,Tornio, Finland Sendzimir rolling mills.



onal techniques cannot be utilized or where a desired final result has not been achieved. Many of our applications have been made-to-order for a customer requiring a permanent solution and savings in locations experiencing high maintenance costs. In these cases, previous concepts were not able to achieve successful predictive condition monitoring, often because of a slowly rotating piece of equipment and/or a slide bearing.

Typical AE applications include difficult-to-reach locations where it is necessary to extract the signal through a conveying structure from a very long distance. At best, tens of bearings are monitored using one single

Applications of the AE technology at the Outokumpu steel works in Tornio

The Outokumpu steel works in Tornio has a long experience with the ACU technology based on acoustic emission delivered by ANDRITZ. This technology is applied at the RAP5 line and at the Sendzimir cold rolling mills, among others.

RAP5 line

The RAP5 line integrates the most central partial processes of the stainless steel cold rolling mill: cold rolling, annealing, and pickling. The RAP5 line comprises a three-high tandem cold rolling unit, a continuous annealing/pickling line, and a finishing mill.

The annealing/pickling line comprises both electrolyte and mixed acid pickling. Depending on the requirements of the customer or the applications, the products are manufactured in one single processing pass or in two processing passes. The finishing and stretch leveling rolls are located at the end of the line and are mainly used in the second manufacturing pass.

Sendzimir cold rolling mill

The Sendzimir cold rolling mills are located in cold rolling mill plant 1. At the Sendzimir cold rolling mill, the steel strip is fed from the feed coiler through the rolling mill to coiler 2 and from there back to coiler 1. Between the coilers is the rolling mill section that rolls the strip thinner and thinner for each pass. To reach the required thickness, the steel strip must be run through the rolling mill in several passes. After rolling, the roll goes to further handling.

When handling a hard product that is difficult to form such as stainless steel strip, strong static and dynamic forces are directed towards the rolling mills. The forces required for the forming create considerable stress on the mechanics of the rolling mill. In addition to that, the vibration generated by the process and the low-viscosity roller oil used in forming pose their own challenges to the chosen electrical components.

The above mentioned issues pose requirements of their own on the underlying technology and the maintenance of the rolling mill. Hence it is very important to get an indication of imminent bearing damage at as early stage as possible – an unexpected interruption to production can result in long production breaks and expensive damage to the machinery. At best, a bearing damage is detected in good time, and all that then needs to be done is to change the damaged bearing to a new one.

Condition monitoring of critical rolling mill bearings

The use of AE in the rolling mill predictive condition monitoring was initiated in 2003. The maintenance people had previous experience of different techniques for the monitoring of critical rolling mill bearings and, of the tested techniques, it was the ACU technology based on Acoustic Emission that best met the requirements. The AE system was first taken into use in condition monitoring at the Sendzimir rolling mill 3. Later on, the system was expanded to also include the Sendzimir rolling mill 1 and SZ 2. At the RAP5 line, the AE technology was taken into use in 2004.

In connection with the modernization of the Sendzimir AE system in 2010, benefits could be derived from the jointly achieved long-term experience. Andritz provided the required additional training and start-up support. The Outokumpu staff handled the installation of the ACU measurement units, the trimming, and the adjustment of the warning/alarm limits. The alarms were taken into use immediately; hence, there was no break in the condition monitoring in connection with the modification of the system.

Advantages achieved by using acoustic emission

Outokumpu has eliminated sudden bearing damage almost completely; the exceptions have been in the form of unexpected problems posed by the material. Along with the condition based change of bearings, the production time has increased and the costs of breakages have been reduced.

AE measurement unit. Despite the rapid correction of the primary problem, new insights are being learned all the time and the advantages to customers continue to increase as more experience is achieved.

Installation of a rolling mill is demanding

A rolling mill condition monitoring project can be classified as more challenging than most. There are vibrations, limited space, fluctuating temperatures and, during operation, sensors are partly under continuous exposure to rolling-mill oil—a highly penetrable type of oil. Additionally, some places are difficult to access. It is hard to forget the descriptive and humorous comment made by the head of our first AE project about his first installation: "Only the bottoms of our safety shoes were visible on the gangway."

The most demanding bearings to be monitored are located on the standing axis inside the rolling mill and their only lubricant is rolling mill oil mist. Oil is not primarily designed for the lubrication of the bearings, but for the needs of the milling out. Hence, the oil has a low viscosity. Additionally, no measuring unit can directly be taken to these bearings and therefore it is necessary to register the signal from a longer range through the transmission of the rolling mill structure.

Implementation and use of the AE system

The bearings to be monitored and the installation modes of the AE measurement units were determined by utilizing the experience gained by both parties. The AE system is always in operation, producing simplified data on a trend curve that reveals unwanted discrepancies in the bearing operation. The length of the monitoring period can be freely chosen by the user.

In addition to the AE data, the condition monitoring personnel also have plate quality data and rolling mill running data at their disposal. This data has a direct effect on the bearing loading and is important for making the right diagnosis. It is also possible to set bearing-specific alarm limits in the AE system.

Development during 2003 to 2010

At the end of 2010, we updated the measurement points of the Sendzimir rolling mills in the cold rolling mill and the entire system with state-of-the-art ACU technology. We had updated the RAP5 system previously.

The system installed in 2003 generated one parameter per second. The state-of-the-art technology produces 100 parameters for every second as a standard. Additionally, the amplification and filtering technology and the signal processing have also been improved.

The new ACU system is integrated in the data network of the mill and AE data is available to all users via a browser. The bearing-specific limits set within the system provide warnings and alarms. The messages are sent to the users as plain language text in the manner required—as text messages to cell phones, as e-mails, and via the mill's data network direct to the systems of the mill. ANDRITZ handles the normal maintenance of the system level remotely. Controls and adjustments are conducted by the mill personnel.

This article originally appeared in the Finnish publication, *Promaint Magazine*, in January 2011.

ANDRITZ AUTOMATION Inc.
Atlanta, GA, USA
Phone: +1 (404) 370 1350