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ULTRASOUND AND INFRARED COOPERATE to Find Transformer Failures

Processing steel requires heavy-duty electrical systems that consume massive amounts of energy. A single electrical component failure can be all it takes to completely stop production, resulting in the loss of crucial time and money. Maintenance crews rely on condition monitoring technologies like ultrasound and infrared imaging to help them predict electrical component failures.

MOST ELECTRICAL FAULTS are the result of partial discharge, which is defined as "a localized electrical discharge in an insulation system that does not completely bridge the electrodes." A discharge is described as either an "arc" or a "spark" and can be phase-to-phase, or phase-to-ground. Partial discharge is destructive to the conductor or insulator and, over time, will cause the component to fail. The integrity of insulators can be further damaged by corrosive gases like nitrous oxide. The time it takes for a system component to fail can be affected by system voltage, the shape of the void from phase-to-phase, ambient temperature, the condition of the insulation material, and environmental conditions such as pollution and humidity. The higher the voltage, the more destructive the partial discharge becomes.

One stage of partial discharge is termed "tracking." Tracking is difficult to detect since it doesn't demonstrate any heat build-up. Like corona discharge and arcing, tracking exists only to seek a path to ground. Dirt, dust and moisture help tracking follow this path, which is why simple maintenance like cleaning is effective in prolonging the service life of electrical systems. Cleaning should be done on a planned schedule, but not a planned calendar schedule. Since hiring a cleaning crew represents a cost, it is more efficient to first detect the need for cleaning with ultrasound, and only schedule the crew based on the condition of the electrical system.

Tracking begins with a low buzzing and crackling and builds in intensity until it reaches the point of flashover. After flashover occurs it becomes quiet again. It is this constant build up in intensity and discharge that leads to insulator breakdown and eventually, the progression to more destructive arcing.

The Combination of Two Technologies for Electrical Applications with Gerdau Ameristeel

The earlier an electrical fault is detected, the easier, and less expensive it is for the electrical repair crew to schedule and perform maintenance. Early detection of an electrical fault could be the difference between a simple dusting and cleaning, or minor parts replacement and a costly overhaul and total repair/replacement of the machine. Skip Young, a certified infrared thermographer (IR) and ultrasound inspector (UT) works for Gerdau Ameristeel in Calvert City, KY. Mr. Young provides us with a good example of how combined predictive inspections can prevent transformer outages and help schedule simple PMs.

Typically, electrical faults only generate heat once they have reached an advanced stage. Relying solely on IR may result in a missed diagnosis but not for Skip Young. While conducting all scheduled IR scans, Young includes ultrasound measurements. He knows that acoustic energy is generated at all stages of discharge and that by combining ultrasound and infrared scans he finds all faults.

Faults Found with Ultrasound

Figure 1 displays an example of an electrical problem detected in its early stages with Ultrasound. The insulator was damaged with tracking which indicates the presence of an equipment fault. When caught at an early stage, it can often be fixed with simple maintenance procedures.

Thermal images from several 161kV to 13.8kV step down transformers were provided to us by Young. While using infrared imaging there was no visible hot spots on the A, B and C phase bushings as shown in Figure 2, but an ultrasound measurement taken produced a sound file with obvious indications of early tracking shown in Figure 3.

The top image illustrates the time domain showing the build-up and release of the ionization discharge as it finds a path to ground. Ultrasonically, we hear the build-up and then a neutralization of the air surrounding the problem. Heat does not build up here until the situation progresses and there is sufficient flow or current to produce heat along the discharge path.

The bottom image illustrates the spectrum domain from Young's ultrasonic data. There are two things to note here. First, the obvious repetition of 60 Hz events clearly tells us that, in addition to tracking, there is a presence of nuisance corona. Secondly, the noise level between the 60 Hz peaks confirms there is tracking activity.

Similar tracking activity was discovered from the B and C phase bushings, while neither showed any signs of heat when scanned with an infrared camera.

After the Successful Diagnosis with Ultrasound

Once the diagnosis was made on the suspect transformers, the decision to perform simple maintenance during the next planned outage was made. Since the problem was discovered at an early stage the simple maintenance could be done on the terms of the maintenance crew rather than dictated by asset failure.

According to Young, the simple maintenance merely included a cleaning and tightening of all connections on A, B, and C phase bushings. Looking at the time signal in Figure 4 and the frequency signal in figure 5, we can see that simple maintenance definitely improved the condition of the electrical assets. Since tracking is a stage of partial discharge that causes damage to connectors and insulators, it will be necessary for Young to continue vigilant ultrasound scans on the transformers.

The combination of two predictive technologies while monitoring for electrical faults ensures that imminent problems are detected at the earliest possible stage of failure. Young's detection of early tracking with ultrasound led to maintenance crews at Gerdau scheduling planned maintenance to fix their problems on their terms. Most significantly, the only maintenance required was a simple cleaning and re-tightening of connections. No costly purchase of parts was required and the effects of the maintenance performed was instantly seen. They are depicted in figures 4 and 5.

Ultrasound and infrared technologies performed well together on Gerdau's transformer issue, and there is no reason why the pairing should not be considered a winner for observing partial discharge on insulators, MCC panels and high voltage transmission and distribution lines. ■

Figure 1: **This insulator was damaged by tracking and eventually arcing. The problem was detected early with ultrasound inspection.**

Figure 2: **Thermal Images of A-phase bushing on this 161Kv to 13.8Kv step down transformer showed no apparent hot spots.**

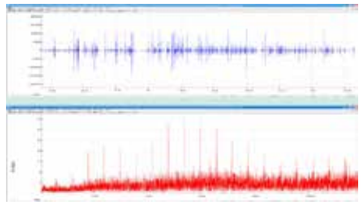

Figure 3: **The sound file can be viewed in both the time (top image) and spectrum (bottom image) domain. The top shows tracking picked up in the ultrasound range from the A-Phase bushing of the transformer.**

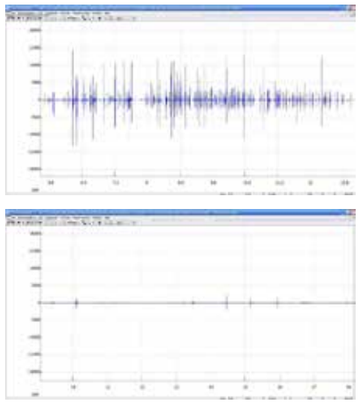

Figure 4: **Time signal of ultrasonically detected tracking on A-Phase bushing before (left) and after (right) the simple maintenance of cleaning and tightening of connections.**

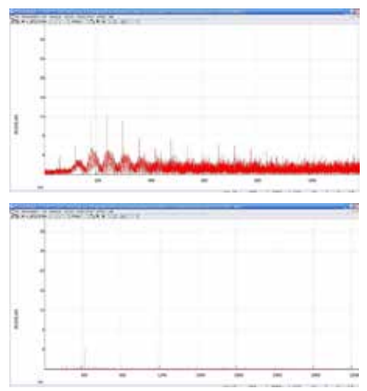

Figure 5: **Frequency signal of ultrasonically detected tracking on A-Phase bushing before (left) and after (right) the simple maintenance of cleaning and tightening of connections. Dominant 60hz peaks are gone, as is the tracking noise between peaks.**