Shake, Rattle & Roll – Where There's Heat, There's Probably Vibration

Richard L. Harrison, Consolidated Diesel Company, Whitakers, North Carolina

Vibration analysis has been used for many years to assess machine condition and to predict potential failures. There are times, however, when one does not have appropriate access to a machine or an additional diagnostic tool. In the past, for example, I have used oil analysis and even ultrasonics to verify a machine's 'health.' Then I discovered infrared thermography.

This article presents the relationship between vibration analysis and infrared thermography. It describes how an IR scan of a normal looking motor and pump set shown in Figure 1 detected a serious problem, and how a failure was avoided. Using a process pump as an example, it will show how infrared technology was able to detect a potential coupler failure and how vibration analysis verified that a problem did exist. In addition, it will explain how both vibration and infrared analysis verified the machine's health after repair.

These examples demonstrate how the combination of two diagnostic disciplines could provide a company or customer the dual benefit of cost avoidance and reduction of unscheduled downtime. My recent work with infrared thermography has led me to conclude, "Where there's heat, there's probably vibration."

Example. Many wear mechanisms, such as insufficient lubrication, bearing wear and misalignment, can contribute to premature machine failure. Lubrication problems are detected when a machine makes loud noises or seizes up, and misalignment may cause an overstressed bearing to fail or a coupler to be damaged. In most of these cases, because of the high ambient noise levels in most manufacturing facilities, the noise from a failing machine blends in and goes unnoticed. Such is the case presented – a location difficult to access next to a machine that runs blowers 24 hours/day.

Detection. An IR scan was being performed on an electrical panel located on a catwalk above a parts washer. I was experimenting with the FOV (Field of View) from the catwalk, which led me to scan in the direction of the pump. I noticed an apparent temperature rise at the coupler of the pump but doubted the accuracy since I was high above. From ground level I rescanned the pump at a closer distance. This allowed for better focus, range and distance – the main ingredients needed for a precise thermal image.

Figure 1 shows the coupler area of interest. I was not alarmed at first with the apparent temperature at the coupler, a mere 110° F. I have learned from experience, however, not to jump to conclusions but to gather the data. The expectations, data comparisons or trending performed during analysis will determine the diagnosis. I decided to do a full analysis on this pump based on a 'gut' feeling – something most analysts deny having, but use quite frequently.

After viewing the thermogram, I decided to do a slow motion study. A slow motion study is done using a strobe light set to the shaft's rpm; this simulates a frozen view of a shaft for inspection. I discovered the coupler appeared to have movement that was contrary to its design. In other words, the coupler halves appeared to be slapping into one another, which seemed impossible since there is a flexible member between the two coupler faces.

Something was definitely wrong here but more information was needed, so vibration data were taken and compared with previous data. The vibration data in Figure 3 show classic mechanical looseness and misalignment. Mechanical looseness is represented as high amplitude vibration (spikes), separated by 1× shaft rpm. Angular misalignment is represented as high amplitude vibration (spikes) at 3× shaft rpm.

The next step was to see how the heat in the infrared image related to the vibration. The answer to this question was found in the form of a damaged spider that evening during scheduled downtime.

The purpose of the flexible member (spider) incorporated between the coupler halves is to compensate for slight misalignment between the pump and motor, and to eliminate metal-to-metal contact. In order for a spider to function properly, it must have a snug fit and be properly aligned within a few thousandths of an inch.

The damaged spider shown in Figure 4 was removed from the coupler. Inspection of the spider revealed 4 of the 8 legs to be seriously damaged, and the damaged legs caused gaps in the coupler (looseness). These allowed the coupler halves to make contact (rubbing), producing high vibration and excessive heat. A new coupler and flexible member were installed and the pump was realigned and placed back in service. Vibration data were acquired again (see Figure 5) and showed an 80% reduction in vibration amplitude and elimination of misalignment.

Since the vibration levels on this

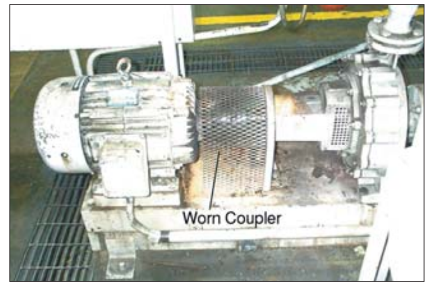

Figure 1. Photo of pump and motor assembly.

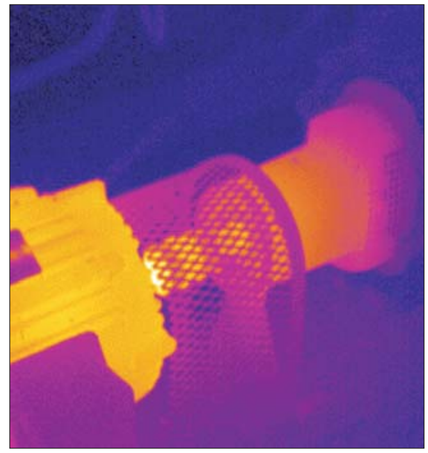

Figure 2. IR scan of pump and coupler.

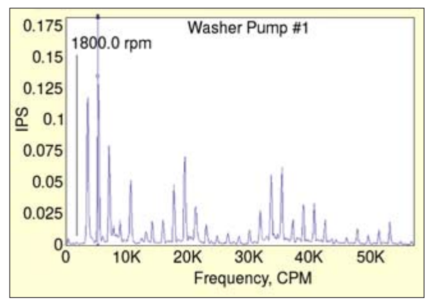

Figure 3. Vibration spectra of washer pump.

equipment were considered within normal limits, a second IR scan was taken. This image was compared with the prior image, to determine if there was a relationship between the heat and vibration before and after repair. If there was a considerable ΔT, that would support the theory that the heat and vibration were closely related in this case, and would establish a method for determining a machine's health (see Figures 6a and 6b).

A comparison of the thermograms of Figures 6a and 6b illustrates a ΔT of 22.2° F between the temperature at the coupler before repair and the temperature at the coupler after repair.

- Vibration data revealed mechanical looseness.
- IR scans revealed a temperature rise at the coupler.
- Visual inspection of the coupler revealed oddly worn/damaged members, which is associated with misalignment.

Conclusions. The use of an infrared-imaging camera allowed the detection of heat generated by abnormal conditions in a coupler. This made possible the early

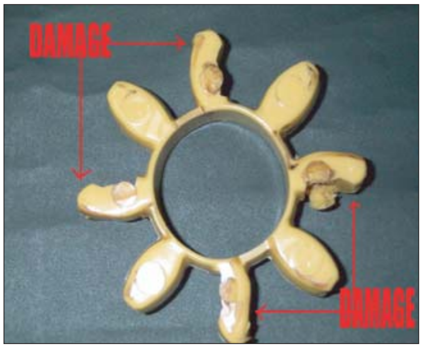

Figure 4. Damaged flexible member (spider).

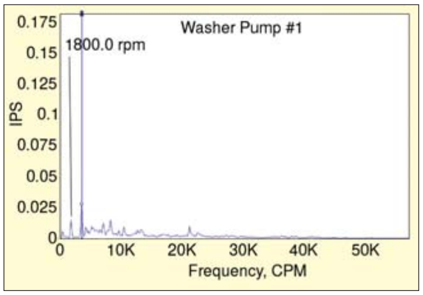

Figure 5. Vibration after repair is shown to drop from an overall level of 0.134 IPS (inches per second) to 0.027 IPS.

detection of a potential catastrophic failure supporting the theory: "Where there's heat, there's probably vibration." In the process, unscheduled downtime was avoided.

The author can be contacted at: richard.i.harrison@cummins.com.