

**The Lifetime Reliability Solutions  
Certificate Course in Maintenance and Reliability  
Module 3 – Other Condition Monitoring Techniques for Machinery**

**Sessions 12A  
Condition Monitoring Using Thermography**

**1. An Introduction to Thermography as a Condition Monitoring Tool.**

Thermal Imaging, or ‘Thermography’ as it is generally known has wide application in our modern society. Some of the more popular applications are its use for medical diagnosis and for crime-fighting, in particular the use of FLIR (Forward Looking Infra-Red) cameras on police and rescue helicopters.

Less well known is its application for condition monitoring where it is now firmly established for its ability to quickly and accurately provide temperature profiles of operating plant that could not practically be monitored in any other way. Notable applications are for surveying of power electrical circuits and switchgear, routine inspections of thermal processes for insulation breakdown and, more recently, inspections of rotating machinery for evidence of over-heating.

The technology has developed rapidly in recent years and current generation cameras are about the same size and weight as home video cameras. However, it is still far from being a ‘point and click’ procedure and competent, experienced operators are required to produce quality results.

**The Cameras.**

Thermography in the decade of the 80’s was a manually complex and exacting task. Cameras were relatively bulky and liquid nitrogen had to be carried in a flask to provide the required sensor cooling. The resolution of images was so poor that detailed notes of exact positions of measurements had to be made as well as 35mm pictures taken and developed for correlation during the exacting reporting processes, usually days later.

Nevertheless, the usefulness of the technology was quickly appreciated but the relatively high cost per measurement point, the cumbersome equipment and the relative lack of resolution detail limited the more widespread use of the technique for maintenance purposes in industry. Common use was therefore limited to those applications where cost-effectiveness was readily justified because of its unique non-invasive, non-contact capabilities.

Within the last three years technical advances and improved production methods have made a great leap forward with the arrival of the Focal Plane Array camera.

This system has typically a matrix of 76,800 detectors instead of just one, and ‘stare’ at the image without the need for shutters or rotating mirrors. The method is analogous to the human eye in its operation.

The result is a camera which is easily held in one hand, responds immediately it is turned on and has internal digital memory or PCMCIA cards for data storage. Together with data management software, the whole procedure becomes very similar to the collecting and analysing of vibration data.

The cameras with better condition monitoring features are still very expensive \$60,000 to \$100,000) meaning that the numbers in any one organisation are limited by commercial realities. One might expect the cost of these devices to come down as manufacturing technology improves together with increase in production volumes.

## **2. The Technology.**

The physics of heat transfer and radiation are quite complex and must be appreciated and understood by the person supervising a thermography programme. However, for practical operation of the camera the main concern is the question of selecting the correct ‘emmissivity’ for the image being studied.

Emmissivity is to do with the level of heat radiation from the equipment being surveyed and, ultimately, the accuracy of the temperature measured by the camera. Because many items of equipment being surveyed are similar experience suggests that most cameras are set at an ‘average’ value that produces accurate-enough information for the purpose.

The AINDT in Australia offers a 5-day Certification Course for Thermographic Imaging and it is expected that other training providers will follow suit with accredited training in the near future.

### **Examples.**

On the following pages are 6 examples of thermographic scans selected to show the resolution of the new camera across a variety of applications. Unfortunately, for reasons of economy, we have not been able to reproduce them in colour but overhead transparencies in colour will be used for the presentation.

Before looking at these examples, a few comments in relation to the application of thermography to the condition monitoring of mechanical plant.

- a) Each report shows a digital camera image. In most cases the resolution of the thermographic image is such that to a person familiar with the equipment would immediately recognise and interpret the data. However, it is a very simple and low cost ‘extra’ to add the digital camera image. The detail of mechanical plant may be particularly important for accurate diagnosis.
- b) The established non-mechanical applications for condition monitoring by thermography have mostly not required reference to ambient temperature conditions. Temperature differences between what seems to be ‘normal’ and something that is seen to be hotter than normal has been the basis for fault detection.

Obviously ambient temperature changes will shift the ‘normal’ temperature of most objects diurnally and according to the prevailing weather and season. The heating effect of sunlight can also be very significant on mechanical objects. Therefore from survey to survey the background temperature level will change, often quite significantly.

However, as the use of thermography in mechanical condition monitoring is more widely applied, reference to ambient temperature will be needed to make sense of some situations. An example would be the monitoring of a ‘hot’ bearing on a periodic basis. The measured temperature of the bearing will change according to the temperature difference between the bearing surface and the ambient air temperature.

- c) Another important consideration if ‘true’ temperature measurements are required is that the emissivity of the surface of the object being measured has to be estimated. There are tables of emissivity values available from camera manufacturers for numerous objects that are likely to be surveyed.
- d) Condition monitoring using vibration measurements and oil sampling rely heavily on ‘trending’ of measurements to produce evidence of unacceptable changes in values.

As the use of thermographic surveys on mechanical plant increases, it is likely that there will be a desire to correlate measured values with vibration and oil sampling trends. Route-based software is available from at least one manufacturer but we have had no experience with the use of that product. There is no question that there will be a growing demand for good data management software of this kind.

### **3. Discussion of Examples.**

**Example 1.** This is a distant view of a grinding mill and associated plant. The resolution of the image is so clear that the digital camera image would not be needed as a reference.

**Example 2.** This example of power distribution monitoring shows the resolution available to identify small, high intensity faults from a distance of some metres in an outdoor, bright sunlight situation. The long-wave camera functions well in these conditions.

**Example 3.** One end of a pump bearing barrel is running hot. Why? Vibration analysis is not easy because of the broadband energy in the pump together with moderate cavitation. Thermography clearly shows that the impeller-end bearing is running hot and that it is not likely to be coming from any other source than the bearing itself. The bearing assembly will need to be inspected.

#### **Summary.**

The current generation of infrared imaging cameras have new levels of portability, ease of use and image resolution that are enabling much wider applications across industry.

The particular application for monitoring the condition of mechanical plant has been shown to have potential, either as a stand-alone technique or in conjunction with other condition monitoring methods.

However, it is also evident that to achieve quality outcomes for mechanical plant monitoring requires a good level of technical understanding at the time of taking the measurements and possibly significant engineering input to the analysis and reporting.

