An Overview of Remote Machine Condition Assessment
by John Bernet

Introduction

Fifty years ago, when labour costs were relatively low compared to operating expenses, managers found that they could simply use more staff to cover the increasing demands of maintaining plant machinery.

As labour rates started to increase and competition drove profitability down, technology came to the rescue. Almost every big company was equipped with a team of vibration analysts with small, portable data collectors that paved the way to increased plant production while lowering maintenance costs. Years later, companies were looking for ways to cut costs in an era of sky rocketing labour rates and the highly paid analysts came into the cross-hairs. Many well established reliability programs fell to the wayside. We are now looking at technology again to bridge the gap between labour and maintenance with new Remote Machine Condition Assessment Programs.

A Brief History

1950s - Most industries began by following a maintenance strategy of Run-To-Failure. Labour rates were low and profits were high. They just let machines run until they failed and then fixed them.

1960s - Labour rates rose and profits shrank. Managers looked for ways to manage their maintenance costs. They first looked at Calendar-based Preventative Maintenance which helped reduce costs.

1970s - Industry leaders found Condition-based Predictive Maintenance which revolutionized maintenance planning. Vibration specialists arose to start up the field of vibration analysis. Data collection was labour intensive but still saved maintenance costs over PMs alone. The equipment was heavy, expensive, fragile, slow and complicated to use.

1980s - Portable data collectors became available which drastically reduced data collection labour. Soon, almost every one of the big companies had a team of vibration analysts and they were enjoying the benefits from increased production, decreased maintenance costs, and energy savings.

1990s - CEOs needed to find ways to cut costs because of dwindling profits from increased competition. Reliability programs didn’t contribute directly to the bottom line and all the CEO saw was the increasing labour rates of the highly skilled vibration analysts. These CEOs were not around during the 70s and 80s, when the CBM programs turned the maintenance industry around and saved millions of dollars, which went straight to the bottom line. So, they cut the reliability programs because the bad effects would not be seen for years, and the cost savings could be seen instantly.

2000s - A global recession and increased competition continues to shrink profits. Maintenance costs are rising and energy costs are eating away at the bottom line. Companies are looking for a way out of this mess and they are making alliances with some unlikely partners - maintenance
with operations; management with IT; customer with vendor. Managers are finding that technology has brought the price of remote monitoring down to the point where the cost is below the rising labour costs needed for portable CBM programs. The Operations manager is willing to provide budget they would have used to hire more labour and give it to the Maintenance manager in order to purchase Remote Machine Condition Assessment programs.

**What Does Online Monitoring Mean?**

Here are several different examples of online monitoring programs:

**Permanent Online Protection** - Many large, critical machines are monitored with overall vibration systems that will sound an alarm or flash a light to notify the operator if a threshold is exceeded. Some of these systems are even designed to shut down critical machines to prevent catastrophic failures if the overall vibration level increases dramatically in a very short amount of time.

**Continuous Overall Protection** - Smaller, vital machines are monitored with less sophisticated vibration systems such as vibration switches and low cost overall vibration systems that will sound an alarm or flash a light to give a warning if a threshold is exceeded. These devices sometimes become a nuisance with spurious warnings that eventually lead to the system being placed in override.

**Remote Machinery Monitoring** - multi-channel systems that are installed to monitor a sensor or two from each machine. This involves a large number of cable runs and vast amounts of data that no one has time to decipher. Some systems are better and involve a sensor or two per bearing from each machine which is wired to a device that transmits data to the network. A network server then sends the data to a remote analyst who diagnoses the machine condition.

**Wireless, Automated Machine Condition Assessment** - sorry to get your hopes up, but we are not there yet. Someday, all rotating machinery will have automated self-diagnostic capability that is integrated into the plant’s control network. Wireless sensors are on the horizon, but not ready for prime time yet. The current technology does not provide the battery life needed to send complete data often enough when compared to wired sensors. Once wireless sensor technology is better, the machine vibration data can be sent directly to a network server with automated diagnostic software. The data is processed and machine condition information is sent to the manager or planner for repairs to be performed.

**Remote Machine Condition Assessment** - Taking data away from machinery is expensive; so, we need to move the diagnostics as close as possible to the source of the problems. There are automated diagnostic programs that have over 25 years of proven experience and consistently deliver benefit-to-cost ratios of over 20:1. These programs are now available with state of the art remote monitoring which makes them price conscious in today’s high labour markets.

**Look Mom, No Hands**

If skyrocketing labour rates are the problem, then Remote Machine Condition Assessment is the solution. Over the years, Condition Based Maintenance (CBM) has been documented to save hundreds, thousands, and for some customers millions of dollars a year in maintenance costs. So what can you do to receive the benefits of CBM but reduce or eliminate the high cost of labour? Taking data away from machines and getting machine condition information from the data can be
expensive. But now, you can choose the amount of labour you want to take on yourself, and either outsource the rest or implement programs using the latest technology.

Remote machines - you can now wire sensors from your machines in remote or hazardous areas to multiplexers. The traditional method is to use portable data collectors which mean high labour costs.

Remote data collector - you can now install remote data collectors right on the machine floor. You can access them remotely using Remote Desktop Connection (MS Windows XP) and control the data collector from the comfort of your office. The traditional method is to use portable data collectors (high labour costs).

Remote analysis - you can analyze the data yourself, or send the data to an experienced analyst to analyze, or pre-configure the data collector with the machine templates and a diagnostic screening program. This way, the diagnostics are being done down on the machine floor and the machine condition information is sent directly to the maintenance planners to schedule repairs. The traditional method is manual analysis which means high labour rates and high expenses for training your staff.

Remote support - you can contract an experienced analyst or an engineering company to access your database remotely to fine-tune and mature your baselines, set up parameters, and provide a full machine condition report. The traditional method is to pay high rates for annual service and support contracts.

Machine Condition Assessment - not just overalls for warning or protection, and not just a bunch of data that you don't have time or experience to analyze. This is a proven data screening and machine fault diagnostic program loaded right on the computer of the remote data collector. The traditional method is manual analysis.

**What Do You Need to Implement a Successful Program?**

Before you rush right out and order your own Remote Machine Condition Assessment program, you should do your homework - look at the four main topics that will ensure you receive the benefits for years to come:

1. Collect complete and accurate data - To get the best results, you need more than overall vibration levels. Overalls are fine for protection systems, but diagnostic systems need more detailed FFT spectral data.

   You also need more than one sensor per machine in order to accurately diagnose machine condition. At a minimum, you need one vertical or horizontal reading from each bearing and one axial reading per shaft.

   In order to save on cable installation costs, you should use multiplexers that combine sensor wires from multiple locations to a single multi-pair cable. The multi-pair cable is then daisy-chained from multiplexers to a small network device with a data acquisition card. The diagnostic fault templates and individual machine baselines are loaded right onto the mini-computer on the machine floor. Data is screened on the machine floor, and then machine condition fault exceedances are transmitted over the company network.
2. Turn the data into useful machine condition information - many programs for data screening, analysis and diagnosis are labour intensive. You need to find a program that can analyze more machines in less time.

Figures 1, 2 and 3 show three screening methods (left side of the figures) with their respective report outputs (on the right).

Using an expert system does not replace the human analyst, but provides a powerful, accurate and proven screening tool to reduce hours required to analyze machine data. Recent studies on a mature program found the expert system was 98% accurate in identifying no-fault machinery and 86% accurate in fault identification compared to a senior engineer. The automated diagnostic program was 8% more accurate than manual data review by analysts with 2-4 years of vibration experience. Most significant was the time saved - the expert system could analyze more than 300 machines and produce a report in 20 minutes versus 3 man-weeks utilizing manual review techniques without producing an equivalent report.

3. Distribute machine condition information to the right people - paper reports get filed away into folders. Use the company network, web pages, email and pagers to get the word out.

Use Remote Desktop Connection (part of MS Windows XP) to remotely access your data acquisition computer down on the machine floor from any computer on your company network. Use MS Excel and Internet Explorer to view your machine condition information from any computer.

Use web-based software (Figure 4) to review reports, vibration data, and machine condition trends from anywhere in the world. Monitor your freezer compressors in Seattle, your wind turbines in North Dakota, your oil rig pumps off the coast of Brazil, your nickel mine crushers in Labrador - all from the comfort of your office.

Integrate multiple technologies on the same web page from various data collection sensors - vibration, oil, motor current, pressure, speed, temperature, power generated, efficiencies, etc. Information from different sources can give the operator priceless insight when faced with making tough decisions about securing machinery. Multiple indicators supporting a suspected fault can save thousands of dollars in repair costs or lost production.

Today, many companies are combining the results from online and portable systems with the same software program. You can use the same hardware to support diagnostic programs (machine condition) and protection systems (catastrophic failure). You can combine wireless and wired sensors in the same machine condition assessment program. Some examples of combining protection and diagnostic systems are:

a) If you already have sensors on your machines going to a protection system, then you can tie into the connections on the back of the panel and run wires to a multiplexer which can then feed a remote data collector. The results would then be the sent to a diagnostic software program.

b) If you install new sensors on your machines for a diagnostic system, you can use a channel of the multiplexer to send a signal to a relay output adapter. This could then flash a light or sound an alarm.
c) If you are implementing a new diagnostic and protection system, you could use dual mode sensors. One part of the sensor would be 4-20mA signal to a PLC for warnings and the other signal would be from an ICP sensor to the multiplexer for the diagnostic software.

4. Get support from inside and outside your company - in order to build a solid program, you will need support from the following groups:

Management - budget to invest in equipment, support and training

Operations - start and stop machines for data collection

IT - company network and server assistance

Maintenance - run program and make repairs

Engineering Vendor - program implementation, training, support.

Many vibration programs in the past failed over the years due mainly to changes in company priorities or lack of support from their vibration vendor. The longest lasting and most successful programs were developed with full engineering support during program implementation, during the first year to fine-tune machine fault templates and develop baselines, and through the years with annual database/program audits. Select machines in small groups as you develop your Remote Machine Condition Assessment program - critical first, vital second and important third. Consider remote and hazardous areas that pose access problems when trying to collect data with portable programs. If you spend a little time and resources ensuring the successful implementation of your program, then it will take less labour and resources to keep it going over the years.

Conclusion

With all of the additional pressures being placed on today’s maintenance staff, and the demands for improved financial performance with fewer resources, you need to choose the right partners and the right tools. Technology has shown us ways to bridge the gap between maintenance costs and skyrocketing labour rates in the past, and the latest advances will lead to fewer analysts performing analysis on more machines. Portable data collectors and manual analysis will transition to remote monitoring with proven automated machine condition assessment programs. Someday, wireless sensors will transmit complete data directly to our network programs and detailed machine condition reports will automatically be sent to the worker to make the repair.

In fifteen years at Azima/DLI, John Bernet has worked in technical support, sales, training, and installation of Machine Condition Assessment programs. Prior to Azima/DLI, John served in the US Navy for twelve years where he operated and maintained nuclear power plants. John can be reached at jbernet@azimadli.com or 206-842-7656 x1019.