Preventing Rotating Asset Failure on Rubber and Other Product Manufacturing Equipment

Predictive Maintenance Systems Allow Facilities to Automate the Process of Monitoring Their Rotating Assets

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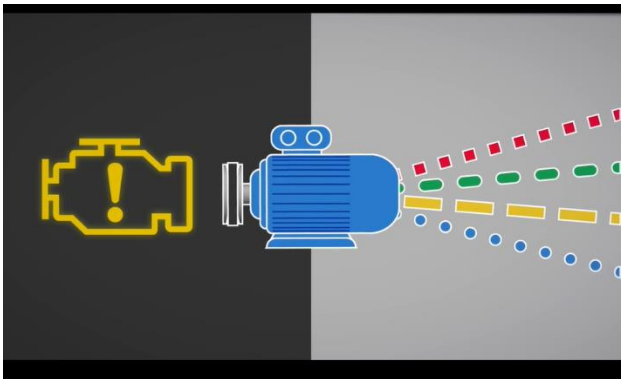
It's on the mind of every plant manager: the possibility of a catastrophic failure when a production asset goes down without warning, halting production, and jeopardizing revenues. Manufacturing facilities may have hundreds of rotating assets such as motors, mixers, pumps, fans, compressors, and gearboxes. It's a complex task to ensure they're all healthy and running properly. This white paper discusses how to prevent rotating asset failure in rubber and other product manufacturing plants, using condition monitoring systems. These systems include sensors and vibration analysis tools that detect temperature rise and vibration abnormalities on a continuous basis.

With the ongoing supply chain challenges of recent years, manufacturers aren't always able to get replacement parts as quickly as they used to. This means there's a more critical need to foresee maintenance problems earlier to ensure there are no sudden failures that stop production. The huge mixers and massive gearboxes in rubber plants can have a replacement lead time of up to two years, and gearboxes can cost as much as $200,000. It's critical to monitor this equipment closely and rectify problems before they cause failure and downtime.



Vibration monitoring systems track asset performance trends and send alerts and alarms when equipment health declines.

The practice of ***Reactive*** *Maintenance*, or running assets until failure, has long ago been replaced in most facilities by ***Preventive*** *Maintenance*, which prescribes routine checks and upkeep at preset intervals. With preventive maintenance, vibration monitoring is conducted by a technician walking the plant floor and visually checking and lubricating rotating equipment and or collecting vibration data with a mobile sensor. While this is much better than the former method, there are drawbacks. Even if a plant checks its assets every month or two, that still leaves 30 to 60 days between checks for something to go wrong. And routine checks don't always reveal gradual degradation of a component. In addition, the process is labor intensive and costly.

Predictive *Maintenance* (or condition-based maintenance) is the practice of placing sensors on the rotating assets and sending performance data to a controller for analysis and trend reporting. This method positively evaluates the health of the asset by continuously monitoring it, and the method is the safest approach of the three.

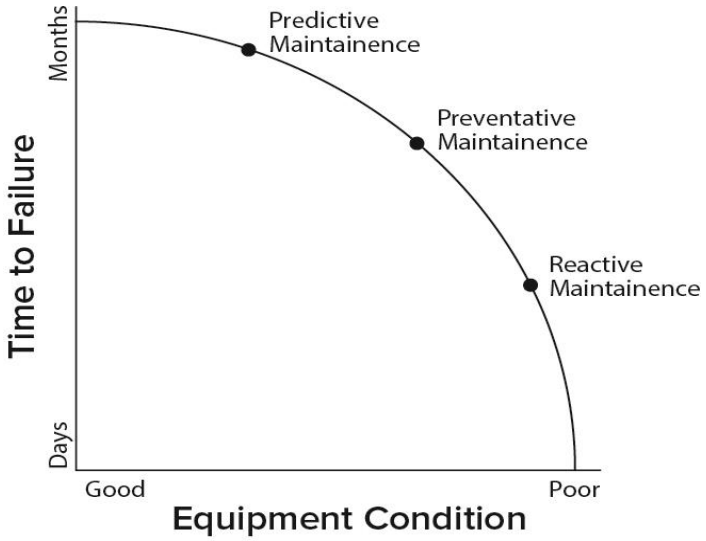
Predictive improves upon preventive maintenance in two important ways. The fact that monitoring is continuous ensures there's no gap of time in which problems can surprise users. And the process is automated, which eliminates the difficulty of tracking a large number of assets.

Using vibration and temperature sensors, predictive maintenance develops baselines during normal running conditions and tracks performance data trends over time. This process can detect gradually degenerating bearings and other rotating components early by analyzing and reporting changing vibration conditions. Current transformers may also be added to motors to monitor current draw, another key indicator of asset health. Predictive maintenance allows for the assets to be serviced during planned downtime. Its main benefit is the elimination of unplanned downtime due to unexpected asset failure.

Industrial automation equipment makers offer a range of wireless monitoring devices that identify early problems in rotating assets by collecting and analyzing vibration and temperature data. These devices make it cost effective to monitor asset performance parameters, set benchmarks and warning thresholds, chart trends, and trigger alarms.

Advantages of condition monitoring include:

- Allowing advanced notice for corrective maintenance scheduling
- Reducing the possibility of asset damage and the associated unplanned downtime
- Easily collecting data from remote locations via wireless communication and sending it to the cloud for remote access
- Offering the ability to review data trends over longer periods of time
- Having a more strategic approach to maintenance, which reduces stress and uncertainty



Predictive maintenance affords the most advanced notice to correct problems before they become critical. The sooner the problem is remedied, the less it costs.

Vibration Parameters

Banner Engineering offers a condition monitoring solution called the Vibe-IQ® to help implement a predictive maintenance program. Although most users of this solution use three key parameters (vibration acceleration, vibration velocity, and temperature) to gather performance data, a total of nine parameters are available for the more advanced user.

- RMS Velocity
- RMS High Frequency Acceleration
- Temperature
- Peak Velocity
- Peak Velocity Frequency (frequency at which the peak velocity occurred)
- RMS Low Freq Acceleration
- Kurtosis
- Crest Factor (peak high frequency acceleration divided by the RMS high frequency acceleration)
- Peak High Frequency Acceleration

Velocity and Acceleration

Condition monitoring equipment can identify component defects by evaluating the vibration parameters of velocity and acceleration. Velocity is the measurement of how fast an asset is moving back and forth (or *vibrating*) on multiple axes. Acceleration is the rate at which the velocity increases from one speed to another. Vibration sensors can detect a rotating asset's vibratory movement: side to side, up and down, or back and forth. Once the acceleration waveform sample is collected by the sensor, the velocity measurement data can be viewed as well. Faults found using the velocity parameter will typically be vibrations that can be felt but are not audible. Faults found using the high-frequency acceleration parameter will be vibrations that cannot be felt and may or may not be audible.

Temperature

Condition monitoring equipment also evaluates rotating asset health by monitoring bearing temperature trends. Awareness of temperature rise is an important part of the predictive maintenance regimen. While vibration anomalies first appear in the early stages of bearing-health decline — long before damage begins — rising bearing temperatures appear in the later stages. Unlike vibration parameters, there is no baselining of temperatures calculated by typical condition-monitoring systems. Default thresholds are normally set at about 70° C / 158° F for a first "alert" and 80° C /176° F for a "warning." Motor manufacturers specify temperature ranges for the asset, so users can change the default bearing-temperature thresholds as needed.

Sources and Symptoms of Bearing Performance Decline

Bearing degradation is typically the result of improper installation or improper maintenance and can be detected via vibration and temperature sensors. Bearings can be under- or over-lubricated or fouled with dirt, dust, or liquids. This causes friction and heat, which will lead to bearing failure if undetected. When bearings lack proper lubrication, they will exhibit four stages of deterioration. Each stage has a distinct warning symptom, but these warnings will go unnoticed without the proper monitoring sensor to collect and report the data.

1. Bearings exhibit a high-frequency vibration, not audible to the human ear but detectable with vibration sensors.

2. The bearing vibration will generate a frequency spectrum composed of bearing cage vibration and "false spin" vibration. It's at this and subsequent stages that typical vibration sensors are able to detect the onset of bearing problems.

3. Deformities will appear on the outer and inner bearing races, which will cause another level of vibration that generates a telltale band of frequencies.

4. Vibration may become audible, at a high pitch, and bearing temperature begins to rise.

Problems with lubrication can be detected with condition-monitoring systems by analyzing high frequency acceleration, peak acceleration, and bearing temperatures.

Sources and Symptoms of Gearbox Performance Decline

For rubber manufacturers, gearboxes may be the single most critical asset to monitor due their long replacement lead time and their high cost. Declining gearbox performance can be caused by various factors. Besides bearing degradation, gearbox problems may be caused by insufficient oil level, incorrect motor/gearbox installation, gear wear, or lubrication contamination caused by overused oil, metal chips, or water. Condition monitoring equipment can detect vibration and heat caused by these various conditions. Each condition has its own unique vibration characteristics, known as the "vibration signature." Based on this signature, the condition monitoring system can identify the problem's cause and send an alert to the maintenance team, allowing it to intervene before the condition becomes a serious problem.

Source of Gearbox Problem	Symptom of Problem, Detectible with Condition Monitoring Equipment
Improper Lubrication	• Increase in gearbox vibration amplitude at certain frequencies • Increase in vibration acceleration and velocity • Presence of abnormal high frequency vibrations • Irregular vibration patterns due to unreliable lubricating qualities caused by either mixture of water with gearbox oil or mixture of two incompatible oils • Increased friction on components, leading to higher temperature
Misalignment between Motor and Gearbox	• Higher than normal axial vibration in motor or gearbox • Radial vibration in motor or gearbox, with a frequency of one or two times the machine's running speed • Uneven wear on motor shaft bearings or gearbox shaft bearings • Elevated heat due to increased load on bearings and resulting friction (detected by analyzing velocity and the bearing temperature)
Damaged Gearbox	• The presence of gear mesh frequency harmonics • Changes in the vibration frequency spectrum, such as the presence of new peaks • Change in existing velocity and/or acceleration amplitude • Increased amplitude of broadband frequencies as gears wear • Irregularities in the vibration signature: These may present as peaks or dips in the vibration amplitude • Changes in gear mesh frequency, including generation of harmonic frequencies
Broken gearbox-motor rotor bars	• Possible increased vibration levels in the lower frequency range

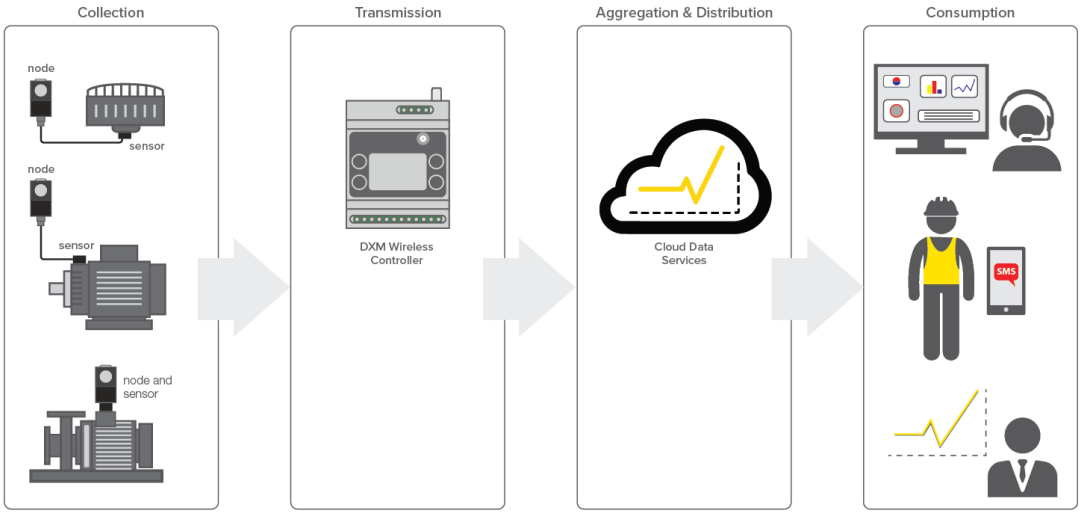
Rubber product manufacturers sometimes opt to install several temperature and vibration sensors on a gearbox to monitor a range of rotating components. This allows them to keep an eye on parts, such as input shaft, output shaft, couplings, bearings, gears, and others to address declining performance before it leads to serious problems. Sensors may be wireless and have optional magnetic mounting hardware, so applying many sensors to a gearbox is quick and easy.

Implementing a Predictive Maintenance Solution with Condition Monitoring

Manufacturers offer a range of solutions that incorporate sensors, controllers, software, and associated equipment to monitor rotating assets for anomalous vibration patterns. Banner Engineering offers various vibration analysis solutions, including a self-contained condition monitoring kit, which is fully pre-programmed and includes everything needed for a complete solution. The kit includes a VT Series vibration and temperature sensor paired with a DXM Controller and vibration monitoring software.

Some devices combine vibration and temperature sensing into a single unit.

The DXM Controller is central to Banner's vibration monitoring solutions. The controller connects to a wireless sensor network and hosts the Vibe-IQ vibration analysis software. Through a Banner Solutions Kit, the controller can locally deliver data to an HMI for visualization of asset health. The DXM Controller can also deliver information directly to the cloud using the company's Cloud Data Services for IIoT connectivity. Banner Cloud Data Services auto-generates dashboards that reveal the health of rotating assets and can send alerts for work orders via SMS or email.



Example of an end-to-end condition monitoring system used for predictive maintenance

Banner vibration sensors can monitor RMS velocity (10 - 1000 Hz), RMS high frequency acceleration (1000 - 4000 Hz), and temperature on rotating equipment. Through a wireless node they can send data to the DXM Controller from a remote asset.

The Vibe-IQ software analyzes the vibration data using RMS velocity and RMS high frequency acceleration values to chart trends and report on the assets' current condition. The Vibe-IQ program automatically creates the baseline for normal operation as well as the warning and alarm thresholds.

The vibration solution's greatest value is that it sends alerts and warnings (via email or sms text) that trigger work orders for maintenance on assets that need attention.

The DXM Controller processes data at "the edge" of the factory's network (i.e. *near the source of the data*) which allows the delivery of asset-health details to either local servers or via internet to a remote, cloud-based monitoring service for easy consumption. The DXM Controller and Vibe-IQ software do all the work, so when the data arrives, no calculations or interpretations are needed.

Adding an Overlay Network to Pull in Additional Data

Adding an overlay network, like Banner's Snap Signal, can extend a system's monitoring capabilities by gathering from other production machines, data such as oil pressure, oil quality, ambient temperature, tower light status, and much more. Using small inline converters, Snap Signal converts machine data of nearly any communication type into a single, common protocol and sends it to the controller, enabling visibility into machines that otherwise wouldn't supply data.

Summary

Keeping the rubber product plant running smoothly so it can generate revenue is the most important job of facility managers, while unplanned production shutdown is their biggest concern. Although *preventive* maintenance is better than waiting for equipment to fail, *predictive* maintenance is best able to help managers avoid damage to rotating assets.

Predictive maintenance employs continuous condition monitoring systems, primarily comprising sensors, a controller, and specialized vibration monitoring software. By continuously monitoring equipment, predictive maintenance techniques let plant managers "see" rotating asset health trends and keep equipment well maintained, extending its life.

Considering that assets like motors, pumps, fans, and gearboxes are the life of the automated factory, moving to predictive maintenance is a relatively low-cost investment that enables managers to stay well-ahead of maintenance issues and eliminate crises. Predictive maintenance will pay for itself many times over by keeping equipment productive longer and preventing unplanned factory downtime.

For more information, visit Banner Engineering at: bannerengineering.com.