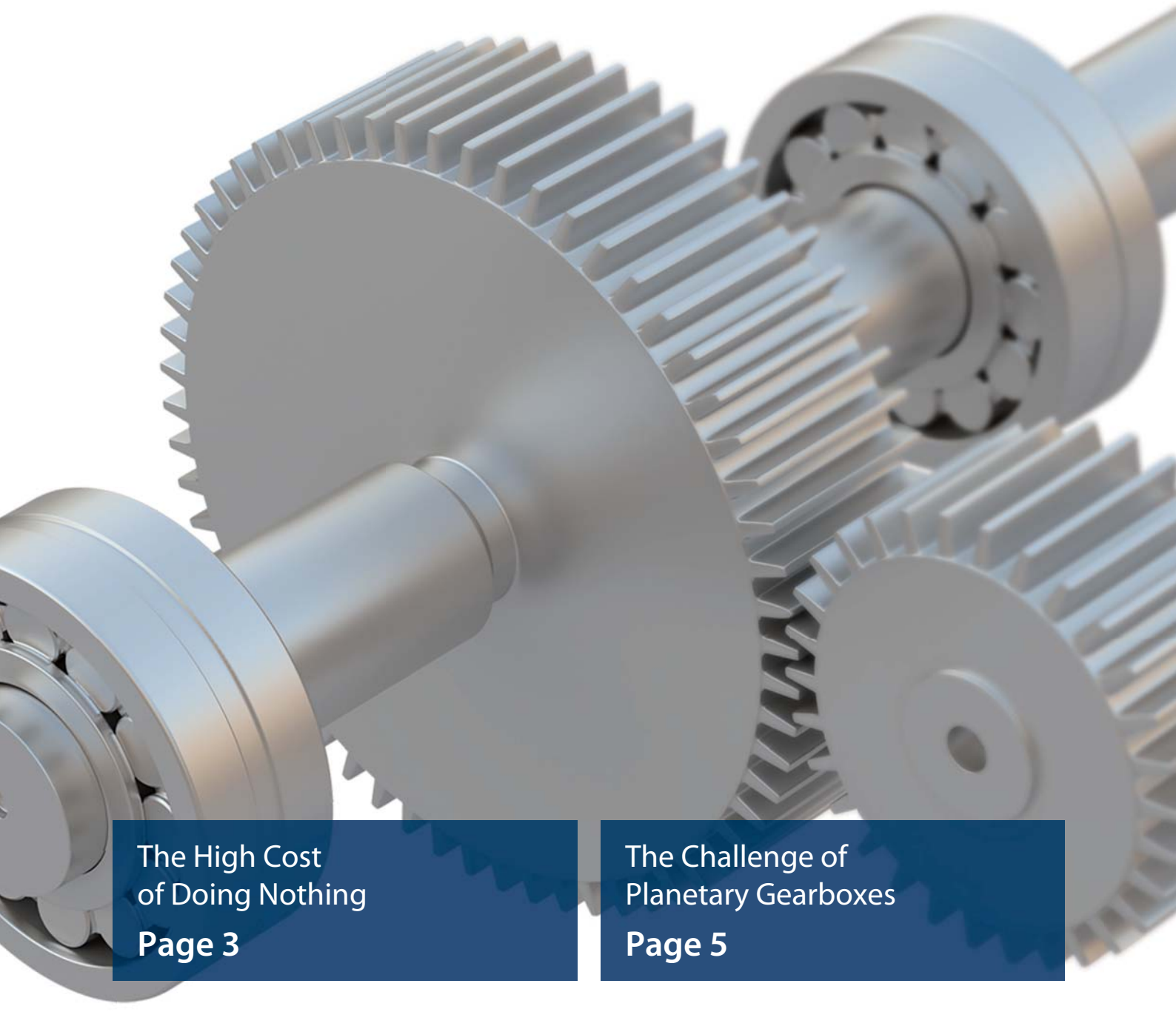
A Publication of PROGNOST Systems

Extruder Train Diagnostics

Essential Capabilities Every Monitoring and Diagnostic System Must Have



The High Cost of Doing Nothing

With a price tag up to $5 million per gearbox, plus another $5 million per extruder, it is easy to see why extruder trains in petrochemical applications qualify for permanent monitoring and diagnostics. The average MTBM of extruder train machinery for most plastic grades is three years (MTBM is shorter for grades with higher abrasiveness). Unforeseen machine stops not only stress maintenance resources, but can also result in production losses of up to $500,000 per day for each extruder. When the stakes are this high, every extruder train needs a dedicated monitoring system.

A Straightforward Guide to Extruder Train Diagnostics

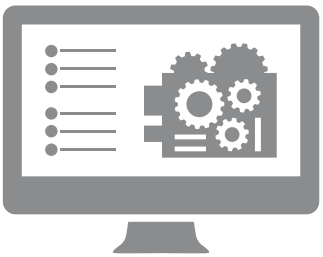
Monitoring takes place on the gearboxes of the extruder, melt pump (gear pump), pelletizer, dryer and associated motors. All critical bearings and gear wheels must be monitored to detect and identify impending failures at an early stage and avoid costly downtime.

For this specialized application, there is no "one-system-fits-all" solution. Several factors make extruder train monitoring a unique challenge:

- Variability in load and vibration amplitude due to process changes
- Wide range of shaft speeds in gearboxes due to the many stages of gear reduction
- High number of different faults to track in complex gearboxes
- Variable-speed operation of the melt pump

So what factors are essential for effective extruder train diagnostics? This document will guide you through the most challenging aspects operators face when selecting a system and vendor, with practical advice to help you invest wisely in a system truly meeting your requirements.

Component Centric Visualization



WHY it matters

Monitoring complex machinery with many components in the smallest spaces requires understandable and meaningful visualization. On a gearbox, you need a comprehensible machine sketch that displays all monitored components, such as bearings, shafts, and gears. This allows you to identify bad-acting components at a glance without wasting time checking data of properly operating machine parts.

THE BEST approach

The solution is an interface that allows users to be informed and not puzzled. Monitoring systems that follow the latest software ergonomics guidelines allow users to zoom from the machine view to the component view, and finally, to the analysis and its diagnostics results. This should not take more than three mouse clicks. Ask your potential vendor if they offer a component centric user interface to provide maximum ease-of-use.

Automated Diagnoses & Messaging

WHY it matters

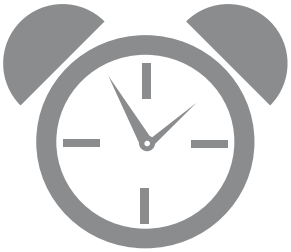
Detecting the presence of an anomaly is one thing. Defining and pinpointing it is another. Your monitoring system should not only warn you about problems, but also provide an accurate diagnosis with specific component identification, location, and indication of the extent of damage. Armed with this information, you can make well-founded decisions about the maintenance procedures you need to take and when you need to take them.

THE BEST approach

There are no shortcuts in developing a system for automated diagnoses. An accurate, detailed understanding of a problem is acquired only through extensive experience in machinery monitoring. The reason is clear: When a monitoring system detects an anomaly, it compares its characteristics with an integrated, database of fault frequencies. A match of this anomaly with a real-life failure pattern leads to an accurate, reliable diagnosis.

Equally valuable is the message your system communicates to you. In the event of a positive failure pattern match, alarm, or shutdown, you need answers. State-of-the-art systems should provide clear communication about the cause for the alarm. For example, the message "Extruder G > Bearing 550 > Outer Race Fault" gives the cause of the problem and location of the problem. Two additional considerations: First, be wary of systems that claim "expert diagnostics routines," but lack dedicated machinery know-how. Precise diagnoses cannot be performed without powerful and intelligent algorithms. Second, think about the importance of receiving notifications when you are away from your desk. Your vendor should be able to offer a mobile information service you can easily access with your smartphone.

Detecting Failures in Early Stages



WHY it matters

Early failure detection prevents machine damage, enhances safety, avoids unplanned shutdowns, and reduces costs of operation. Success depends on the ability to accurately identify mechanical defects at an early stage without issuing false alarms.

THE BEST approach

One method of detecting component defects before catastrophic failures is spectral analysis of the vibration produced by the machine. Faults such as shaft imbalance, misalignment, looseness, bearing faults (e.g., cage, roller, and race), and gear faults produce characteristic fault signatures. A common diagnostic technique is to sum the spectral energy at the specific fault frequencies and compare it against a threshold level. If the total band energy exceeds a threshold level, an alarm is issued.

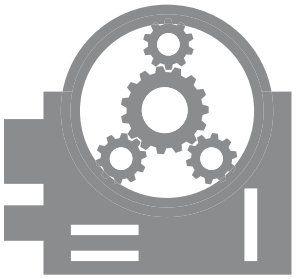
There are two main reasons why this spectral amplitude sum technique alone is inadequate for complex extruder and melt pump gearboxes:

1. There can be interfering vibration sources that produce a vibration frequency which falls into one of the summed frequency regions.
2. Overall spectral background amplitudes may rise due to process changes, thereby increasing the sum of all spectral amplitudes within the summed frequency regions around the theoretical fault frequencies.

The limitations of amplitude thresholding can be overcome by employing a Two-Factor alarm logic. In addition to the total band amplitude, Two-Factor alarm logic calculates a Confidence Factor. The Confidence Factor quantifies the similarity of the measured spectrum to the theoretical fault signature. If identifiable spectral lines are present at all frequencies of the theoretical fault signature, the Confidence Factor is 1. If there are no identifiable lines at the theoretical fault frequencies, then the Confidence factor is 0. If only some of the lines match, then the value will be between 0 and 1. To declare an alarm status, Two-Factor alarm logic requires both, an increase in summed amplitude and a high Confidence Factor.

Insist that your vendor employs Two-Factor alarm logic. It not only enables reliable early detection, but also provides accurate identification of the failing component and prevents false alarms.

The Challenge of Planetary Gearboxes



WHY it matters

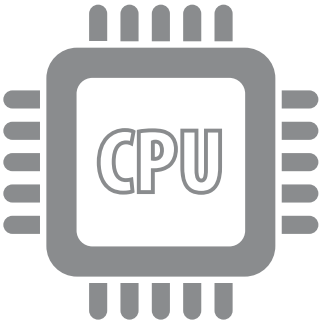
Some extruder gearboxes are planetary gearboxes. This type of gearbox is driven by one motor: turning the sun gear through several stages of gear reduction. For monitoring and diagnostics, this gearbox requires special handling.

THE BEST approach

Be sure your monitoring system accounts for two critical factors. First, the analysis frequency for many components in a planetary gearbox is a function of motor speed. The monitoring system must be aware of the special formula required capable to compute the inherent fault frequencies of every machine element within the planetary gearbox which is a complex function of the input speed.

Second, the diagnostic system must provide a comprehensive and reliable analysis of the influence of design, production technology, operation and change of condition factors on vibration signals.

Processor Performance



WHY it matters

Reliable monitoring of complex production assets not only requires precise analyses and intelligent algorithms, but also powerful processing hardware. Your hardware must satisfy the demands of multiple sensors permanently acquiring data for processing a high number of analyses at different spectrum frequencies in real-time.

THE BEST approach

Be sure the monitoring technology you choose is backed by the processing horsepower you need. Specialized hardware is available to run hundreds of analyses in parallel, 24 hours a day, 7 days a week, providing more than 12,000 FFT lines in less than 1 millisecond.

Ask you vendor for detailed proof. For example, a six megawatt gearbox driven by a single motor should not be diagnosed with fewer than 600 analyses in parallel. Let your vendor explain his hardware layout and how it is capable of providing the processing power your asset needs.

Application Experience

WHY it matters

By themselves, a sophisticated monitoring system and powerful hardware are not enough to assure effective extruder train diagnostics. You also need the expertise to properly implement that system and support your needs. For this, there is no substitute for application experience and expert customer support.

THE BEST approach

Select a vendor with extensive practical experience in successfully monitoring complex gearboxes. You will see the advantages in many ways.

Sensor planning and placement is critically important. Acceleration and proximity sensors, phase probes and pulse tachometers are all part of the required instrumentation. Due to the unique components on an extruder train, your monitoring system must collect all data simultaneously on every channel and perform data integrity checks in parallel. Additionally, temperature and process data need to be integrated. Besides the variety of sensors, the physical footprint of sensors is a challenge. Defining and utilizing a minimum number of sensors is crucial not only for cost efficiency, but also in proving whether your vendor truly understands your application.

Choose a vendor that provides uninterrupted services. Evaluate training programs. Make sure support teams are available 24/7 hotline and provide as much diagnostic service as you require. Remote access allows the monitoring vendor to provide individual support based on the real-time data of your machines.

Conclusion

Advanced monitoring technology gives you the ability to reliably detecting developing failures and informing operators to intervene before breakdowns have an opportunity to occur.

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