Focus: Extruders

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Total productivity maintenance (TPM)

Condition Monitoring on the rise

"Condition Monitoring Systems" is the name of the special exhibit being staged this year by the German Engineering Federation (VDMA) at the "Motion, Drive & Automation" show of the Hannover Fair. Machine operators and manufacturers will be able to observe first hand the advantages of condition monitoring – both as a component of the TPM approach and as an essential element of an integrated service program. With only a small portion of their market remaining in Germany, machine manufacturers in particular have a growing need for service and remote monitoring, especially as establishing a global service organization is costly and complicated. An effective alternative is remote monitoring with intelligent online systems. This method is rapidly gaining in acceptance and will significantly alter the nature of service in the future.

In this issue:

Diagnosis in action: A field report

Bearing damage from misalignment

Dr. Edwin Becker, Flender Service

A particular single-screw extruder repeatedly experienced premature drive shaft bearing damage. Flender Service was contracted to measure and analyze the situation in several identical extrusion systems, evaluate the vibration condition and suggest steps to assure high machine availability.

But let's start at the beginning. Worldwide, some 60,000 single-screw extruders are used in industry for the compounding and processing of plastics. Usually the extrusion system manufacturer specifies the machine and drive configuration. The gear manufacturer then constructs gears that reach the specified speeds and loads throughout their specified service life and are able to take up the extremely large axial forces that arise during extrusion. On the market we find gears of various designs where the thrust bearings for taking up the axial extrusion forces are located either in front of, behind or even within the gearbox. In addition, there are extruder drive designs in which the motor directly or indirectly drives the gear via a belt drive. One of the advantages of a belt drive is that process speeds can be precisely set by adjusting the diameter of the belt pulley.

Figure 1 shows the belt drive of a single-screw extruder after removal of the protective enclosure. Clearly visible are wear debris and oil leakage at the gear drive shaft seal. Experts know that wear debris and leakage often result from inordinate strain due to alignment error or excessive belt tension.

Figure 1: Belt drive of single-screw extruder after removal of protective enclosure

These types of forces will shorten a roller bearing's service life. Usually, bearing play will increase first before the outer races begin to rotate. Premature bearing, shaft and tooth damage are the result. The drive configuration of the single-screw extruder described in this report is shown in Figure 2. The motor is mounted on the gearbox. The belt tension is adjusted by tilting the motor mounting base.

With the protective hood of the belt drive removed, it is a simple task to check the alignment of the motor pulley and gearbox pulley using a laser alignment system for pulleys.

While the belt alignment shown at the bottom of Figure 4 was within tolerance, the parallel shift in the laser beam seen at the top of Figure 4 indicated a significant offset in the position of the pulley. It was this extruder that exhibited the leakage and substantial wear debris not-

Figure 2: Drive configuration of damaged single-screw extruder

ed in Figure 1. These machines had simply not yet reached the point of actual bearing damage. Figure 3 shows the frequency analysis of the vibration velocities of both extruders measured at the start of the study. While the amplitudes measured at the gearboxes are small at less than 1 mm/s in both cases, what is significant in the finding is that they differ from the amplitudes of the rotational frequency at the gear drive shafts.

Conclusion

What conclusions can we draw from this experience? To identify belt misalignment by measuring vibration, your equipment must be capable of high resolution readings and analysis. Ensure that technicians use devices such as PULLALIGN® when mounting and maintaining equipment. Also, make it a point to check the alignment of your belt drives yourself as part of a comprehensive reliability-oriented maintenance program.

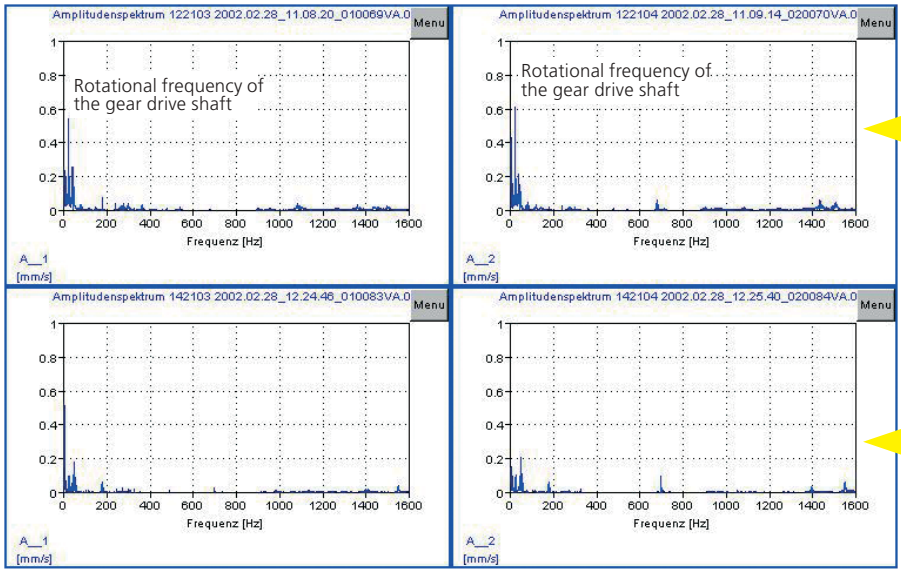

Figure 3: Vibration velocity spectra of the gear drive with poor belt alignment (top) and good belt alignment (bottom)

Figure 4: Alignment measurement results

Condition monitoring application:

Vibration-based condition monitoring of single and twin screw extruders

Dr.E.Becker, Herne, and R.Schühle, Ravensburg

Thanks to advanced measuring techniques and database-supported evaluation software, vibration-based condition monitoring is a very user-friendly measurement method. There are two basic types – offline condition monitoring and online condition monitoring. Both work on the basis of signal analysis and measure, diagnose and monitor trends in the condition of machines, gears and roller bearings. This also applies to extrusion drives.

As part of a condition-oriented maintenance program, the operator initially determines the priority of each machine. Then a decision can be made on which procedural approach and condition monitoring system (CMS) to implement. Extrusion systems of priority A should be equipped with an online CMS. Machines of priority B and C can be adequately monitored by routine offline condition monitoring.

Offline condition monitoring

The simplest approach is to perform vibration analyses at regular intervals using a mobile FFT data collector. Figure 1 shows an example of a directory tree created for measurements on a twin-screw extruder. In this particular case, characteristic measurement locations were defined on the motor, power distribution gear, transfer case and extrusion component. Each was assigned specific measurement diagnosis functions. The measurement results could then be collected at regular intervals with VIBXPERT® or GearController®. Alternatively, machine operators or technicians can collect the data on inspection runs. The measurement results can then be downloaded directly into the company network using the networking capabilities of the mobile data collector. A diagnosis expert evaluates the results in the control center.

Online condition monitoring

In large high-capacity extruders it is standard for an online CMS to be installed on the equipment for continuous measurement. VIBROWEB® XP or VIBNODE® can be used as a CMS on smaller variable-speed extruders. All measurement operations are triggered and fully automated with these online systems. The OMNITREND® software evaluates the results.

By consistently using CMS in company networks or transferring data to the Diagnostic Center by eMail, the results can be easily processed and systematized. The plastics manufacturer must decide who should have access to the measurement results, and whether the measurement results should be sent from the condition monitoring system directly to specialists at the company headquarters and stored centrally. Figure 2 shows the system configuration of a CMS. This particular system includes explosion protection.

In the following two examples, we will describe our experience with two very large extrusion systems and provide some insight into the CMS results and procedures.

Condition Monitoring on the world's largest single-screw extruder

Figure 3 shows a single-screw extruder that was equipped with a condition monitoring system at the factory. Only a few days after the extruder was put into operation, the installed CMS sent the vibration velocity frequency spectra, the vibration acceleration frequency spectra and the envelope spectrum to Germany by eMail. On the basis of this measurement data, diagnosis specialists were promptly able to check the machine and gear running characteristics of this new

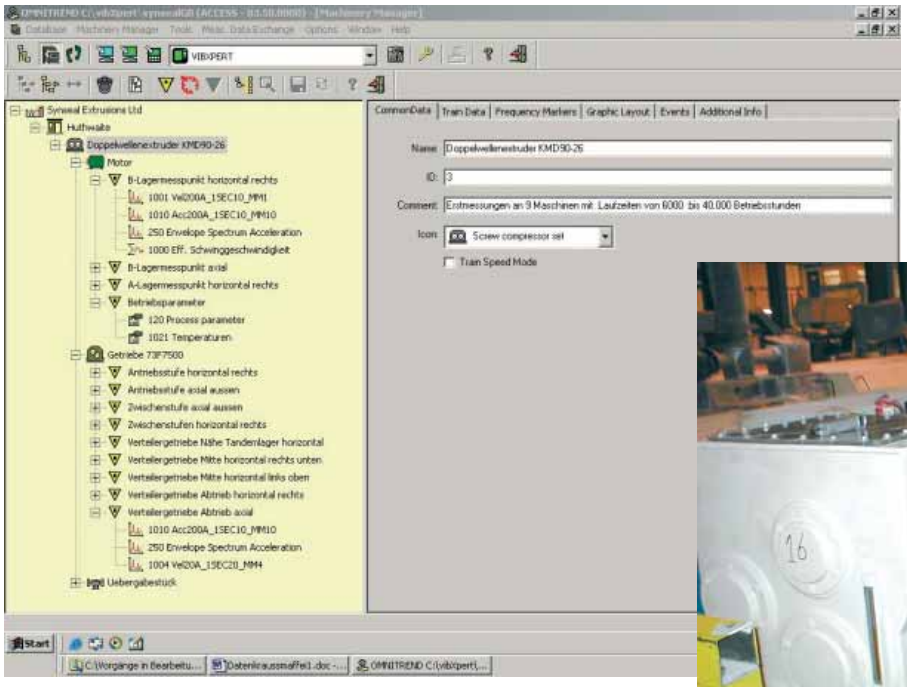

Figure 1: Directory tree, measurement locations and view of a measurement being made with VIBXPERT® in England

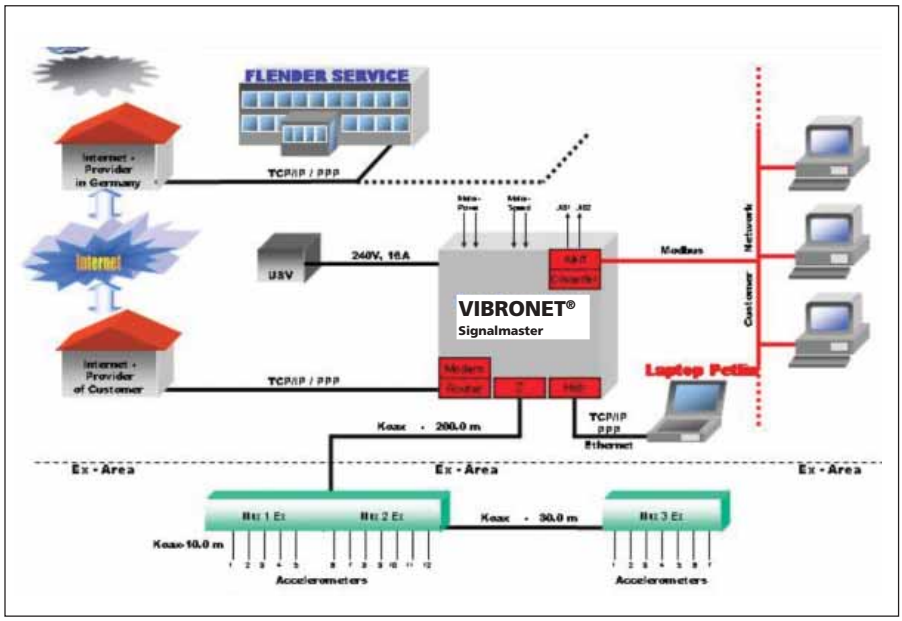

Figure 2: Teleservice configuration for the world's largest single-screw extruder

Figure 3: The world's largest single-screw extruder

type of extruder. After several months of careful monitoring, the results were final. All characteristic machine and gear frequencies were stabile and the machine could be handed over to the customer without qualms. In the two years since then, the extruder has continued to operate trouble-free.

VIBRONET® Signalmaster on a twin-screw extruder gear

In the plastics industry, twin-screw extruders are generally used for compounding plastics. Extruder gears are highly complex and require extensive experience that very few gear and system manufacturers have available to them. The largest twin-screw extruder models have a drive power of over 10,000 kW. A special control gear ensures screw drive moments on the order of 2x 200 kNm. When high performance gears such as these are first put into operation, this presents a good opportunity to install a system to continuously monitor vibration and gear conditions.

In 2004, a VIBRONET® Signalmaster was installed on a gear in Belgium. The measurement results are collected automatically, transmitted to the Diagnostic Center by eMail and automatically converted into the OMNITREND® database. Ten months have passed since installation, and the monitoring system has been operating smoothly. A temporary rise in the amplitudes at the tooth mesh frequency of the drive stage was promptly transmitted by eMail, but subsided again after a few days (Figure 4).

The new gear did not require downtime or time-consuming disassembly. The only step taken was to increase its diagnosis priority.

Figure 4: Trend progression with a brief rise in amplitudes of the gear mesh frequency of the drive stage. The rise was automatically transmitted by eMail.

Condition monitoring technology

Frequency-selective monitoring of extrusion processes

Dr. Edwin Becker, Flender Service

Extrusion systems are used in plastics engineering for compounding and processing plastics. Mixing, dispersion, filling, strengthening, blending, degassing, filtering and granulation are common compounding methods employed by process engineers to attain the desired product characteristics. The plastics are then processed by one of various methods: extrusion of semi-finished products – such as plates, pipes, films or profiles – injection molding, blow molding or calendering. What the manufacturing process is lacking is an online monitoring system that detects changes in the extrusion process throughout production.

On the basis of the specific requirements, the process engineer decides whether the required performance is best achieved by a single-screw extruder, a corotating twin-screw extruder or a counter-rotating twin-screw extruder. Screw geometry and the cylinder casing also have an effect on throughput and production quality.

A notable advancement is that frequency-based vibration analysis is now also suited for process monitoring of rapid extrusion systems. We will illustrate this procedure using twin-screw extruders with a two-stage or three-stage design. In the two-stage design, torque measurements revealed that the second, fourth and eighth harmonics of the extrusion rotational frequency were particularly pronounced in the torque spectrum. These harmonics are generated by the dynamic loads that arise when plastic is melted with the kneading blocks. Kneading blocks usually consist of individual offset kneading disks. In addition, the rise in torque fluctuations generates structure-borne vibrations with increased amplitudes at sharply-defined frequencies. Consequently, acceleration sensors are just as well suited for process monitoring as the more costly torque measurements or specially installed load cells.

The continuous measurement of structure-borne vibration amplitudes is an easy task for the VIBRONET® Signalmaster, which is capable of monitoring vibrations throughout production. This method is equivalent to the monitoring of tooth mesh amplitudes. Care must be taken that the right measurement locations are used and that measurement times are of sufficient duration. More information is available on request.

Figure 2: Installation of new extruder screws

Figure 1: Two-stage and three-stage designs generate typical excitation vibrations whose amplitudes can be monitored throughout production

Glossary of terms

Did you know?

Data exchange via OPC
OPC stands for **O**peness, **P**roductivity and **C**onnectivity and is an established global industry standard for the exchange of data between application programs (e.g. process visualization) and measurement and control devices. The OPC standards were defined by the OPC Foundation, an organization with a membership of over 350 international companies and institutions (ABB, Microsoft, Mitsubishi, Shell, Toshiba, Siemens, Rockwell...).
On the measurement and control system side, there exist a multitude of interfaces and protocols that can be harmonized by applying the OPC standards. In addition, PC programs – so-called OPC servers – act as a translator between the devices and application programs (clients).
On one side, the OPC servers are compatible with the device-specific interfaces and protocols, and on the other side they communicate with the application programs according to the OPC standard. The OPC server is capable of communicating with several application programs at once. Likewise, the application programs can communicate with more than one OPC server at a time.

Modbus/TCP
Modbus/TCP is a field bus protocol used in conjunction with other TCP/IP-based protocols such as HTTP or SMTP within the same network. This eliminates the need for manufacturer-specific field bus components and enables the use of economical Ethernet components throughout the company – from office to factory floor. Many application programs (e.g. process visualization) are capable of using the Modbus/TCP protocol directly. Also, an OPC server software is available that translates Modbus/TCP into the OPC standard.

Web service
A Web service makes services available on networks (Lan, Intranet, Internet). W3C protocols are used for communication and support. The special feature of Web services is that, because they all use the same open standards for communication, they are mutually compatible and can be interlinked.

Web service security
SSL (Secure Socket Layer) encoding with key lengths of up to 1024 bits ensures transport security of Web services without requiring additional hardware. Firewalls and VPN routers can be easily implemented as well. Access to Web services can be limited to individual users or user groups.

Condition monitoring application

Monitoring kneaders during raw rubber production

M.Luft, Freiberg

The cyclical operation of kneaders and the strongly fluctuating loads and torques that arise during mixing present condition monitoring systems with a considerable challenge. In this article we will describe the kneading process, the special features of a suitable condition monitoring configuration and some of the measurement results.

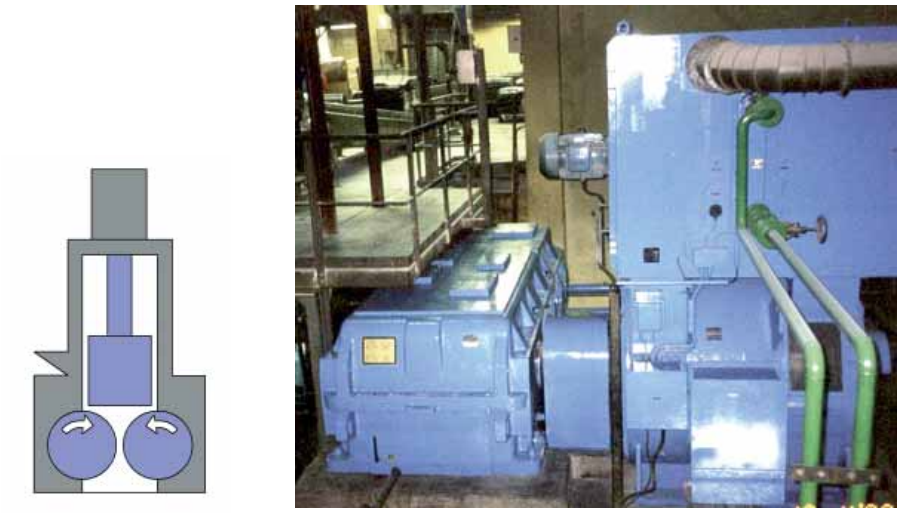

Figure 1: Schematic diagram and photo of a kneader

Raw rubber is manufactured using so-called kneaders that mix various raw materials under specific processing conditions. The feed, dosage, pressure and temperature are precisely defined by the recipe. Usually, the mixing process is time-controlled and is also regulated when the mixture reaches the defined temperature. The process consists of alternating phases of ram pressure and aeration (ram pressure equal to zero). Some recipes also vary the mixing speed. Mixing is completed after several minutes and the raw rubber is discharged.

Kneader drives have a drive power of up to several megawatts. Drive speeds of approx. 60 rpm for both mixer shafts require a multi-stage, power distribution reduction gear. Figure 1 shows a kneader on which PRÜFTECHNIK installed the VIBROWEB® XP online condition monitoring system.

Potential types of damage in kneaders are wear and tear in the rapidly running gear input stages and damage due to the large forces that arise in the output stages. The vibration characteristics fluctuate strongly during the mixing cycle (Figure 2). In particular, the varying load conditions caused by the alternation of mixing phases with and without pressure lead to distinct variations in the vibration level.

Therefore, to be able to record a trend curve and detect damage at an early stage, an exact correlation is needed between the operating cycle and vibration measurements.

The frequency spectrum shows various superimposed gear tooth mesh frequencies (Figure 3). In undamaged systems, it is typical for tooth mesh frequency levels to decrease from drive to output. Therefore, the amplitudes of the gear input stages dominate the overall level.

Consequently, it is essential for monitoring to be frequency-selective with narrow frequency bands. Also, because many mixing programs work with variable speeds, it is important for the rotational speed to be tracked. Order analysis is suitable for this purpose.

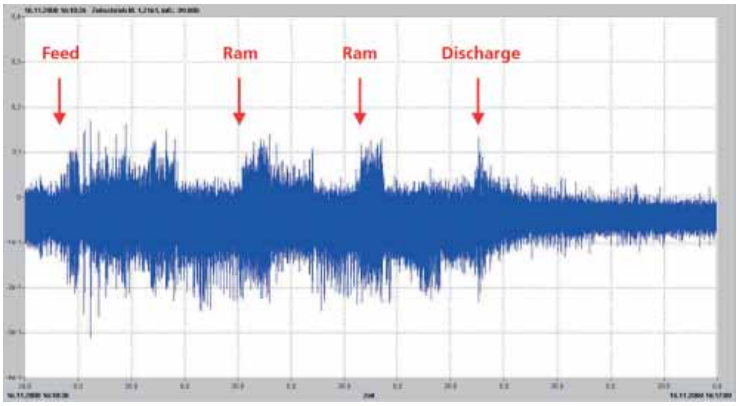

Figure 2: Time signal changes during a mixing cycle

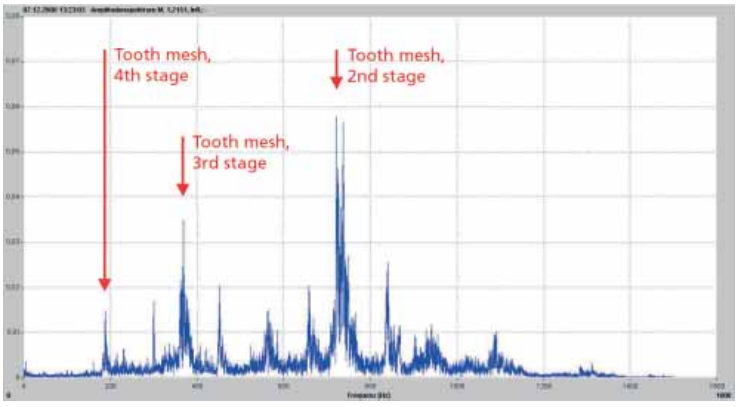

Figure 3: Spectrum showing the various tooth mesh frequencies

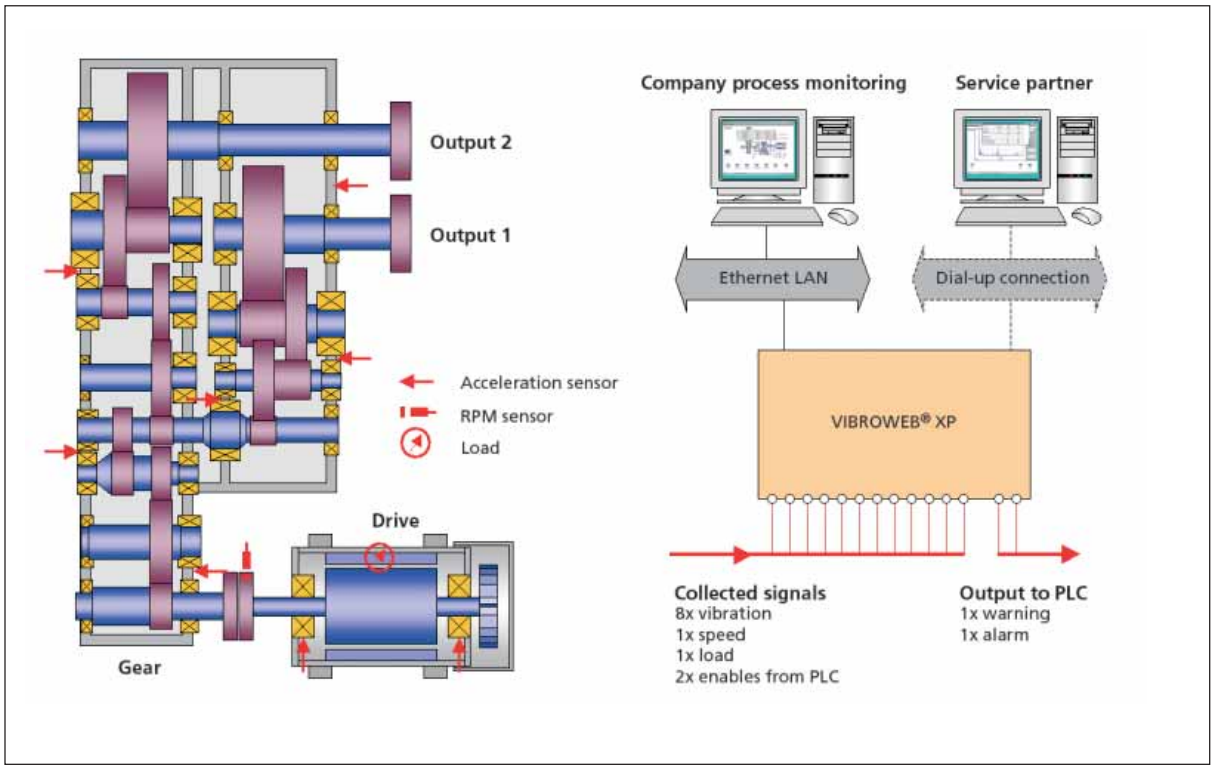

Figure 4: Online monitoring system for kneader drives

In addition, the tooth mesh levels are strongly load-dependent. Therefore, the current point in the operating cycle must be determined and vibration measurement must always take place at a specific point within the cycle. For this purpose, speed and load must be among the parameters measured by the CMS. Vibration measurement is then activated within a specific speed window in combination with a specific load window. This reduces the fluctuation width in the trend to an acceptable level and the trend progression becomes easier to read.

Because of the trigger conditions mentioned above, kneaders are difficult to monitor using mobile measurement methods. It is far more effective to install online monitoring systems such as VIBROWEB® XP (Figure 4). Up to two operating points can be defined and correlated with specific threshold values. At the first operating point, kneader drives can be monitored under load to gain information on the gear toothing. The second operating point can be used to trigger measurements when idling, primarily for the purpose of detecting roller bearing damage, which is overshadowed at the first operating point by the tooth mesh level.

Kneader speed and load are checked continuously to detect the operating points. Also, there is the option of receiving additional enable signals from the PLC or to have the entire measurement procedure controlled by the PLC.

External service partners that perform in-depth diagnoses can easily be integrated in the process by using Internet technology for external communication. When required, VIBROWEB® XP is able to automatically send measurement data to service partners by eMail, eliminating the need for external access to the company network. The operator has the advantage of being able to involve external specialists in complex diagnoses if suitably trained personnel is not available in-house.

Preview

Our next issue will focus on marine technology:

Diagnosis experience: Cause analysis for tooth breakage in marine main gearboxes

Technology: Natural oscillation analysis in marine drives and order analyses using the resampling method

Application: Dynamic alignment monitoring

News

WinTControl® & OMNITREND® now certified

Flender Service has gained certification for WinTControl® and OMNITREND® from Germanische Lloyd WindEnergy. The requirements for certification were more stringent than those in tests at the Allianz Zentrum Technik (Allianz Center for Technology). In addition to an expanded operating manual, separate manuals had to be created for assembly, startup, installation and maintenance. It quickly became apparent that these manuals had to incorporate the experience made out in the field during the installation of actual projects. Printed copies of the manuals may be obtained in English or German for a nominal fee of EUR 50. Please send an eMail to: info@flender-cm.de.

The certificate was handed over during an innovation forum in Hamburg.

VIBRONET® Signalmaster for Iran

In August, Flender Service punctually delivered a VIBRONET® Signalmaster for a new single-screw extruder in Iran. Even in this country, Flender Service and PRÜFTECHNIK will be able to provide an experienced PRÜFTECHNIK specialist on location to assist with the installation.

VIBXPERT® now with even more diagnosis functions

The coast-down analysis available in VIBXPERT® lets you identify critical resonance points during machine startup and shutdown. The coast-down curve can be measured on one or two channels. Machine faults that have a direct effect on shaft vibration characteristics and influence the shaft orbit can easily be detected using orbit measurement. Cross channel phase measurement in the two-channel VIBXPERT® opens the door to entirely new diagnosis capabilities for extruders. For example, large security couplings can even be balanced under operating conditions.

VIBNODE® passes field test

At the beginning of 2005, VIBNODE® was introduced to the market as the newest member of the PRÜFTECHNIK online system family. It has since proved itself many times over in the field – such as in the automotive and paper industries.

With its 6 or 12 channels, this compact system is ideally suited for monitoring individual machines or smaller powertrains. VIBNODE® monitors the overall condition of the machine using broadband overall values. It can also be used for frequency-selective monitoring of specific damage frequencies.

VIBNODE® includes an Ethernet interface and eMail capabilities. The data are archived in OMNITREND® and can be transmitted to the control system via Modbus/TCP and OPC.

PRÜFTECHNIK goes offshore

In May 2005, as part of the CONMOW* research project sponsored by the European Union, PRÜFTECHNIK will be equipping three wind turbines in the 'Wieringermeer' wind farm in Holland with condition monitoring equipment and will evaluate the measurement data. The aim of the two-year project is to develop new methods and algorithms for the condition monitoring of offshore wind farms. Each wind turbine will be equipped with a VIBROWEB® XP system, which measures 6 acceleration signals, rotational speed, wind speed and load. VIBROWEB® XP features special measurement and analysis functions that are ideally-suited for use in machines with highly variable operating characteristics.

*CONMOW = CONdition Monitoring for Offshore Wind Farms

SAP IBIP export implemented

To enable the transfer of data from OMNITREND® to SAP, the IBIP export format has been developed for a leading manufacturer in Germany. OMNITREND® is now capable of transferring information such as measurement data, alarm status and messages to SAP. Systems that support text file import are able to communicate with OMNITREND® as well.

Dates

Visit us at the Hannover Fair 2005:

PRÜFTECHNIK AG
Hall 24 Booth D 29

FLENDER AG
Hall 26 Booth E 08

Special exhibit at the MDA
'Condition Monitoring Systems'
Hall 24

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