Application Note

Case study – On-line monitoring strategy at a polyolefin plant gives fast results

Brüel & Kjær Vibro

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ABSTRACT

In today's competitive oil & gas market place, effective asset management is highly dependent on an effective maintenance strategy. Knowing the condition of your machines and how well they are performing is a vital part of this strategy for optimizing safety, minimizing environmental impact, optimizing plant availability and reliability, and minimizing maintenance costs.

The Borealis Porvoo polyolefin plant in Finland has installed a comprehensive plant-wide condition monitoring system to ensure optimal production with minimal maintenance costs for their aging critical machinery. After a relatively short period of service the on-line system has already demonstrated positive results, and Borealis Porvoo is now making plans to extend the system to monitor the polypropylene plant.

Porvoo plant

The Borealis Porvoo plant is a fully integrated petrochemical complex near Helsinki, Finland that produces 480 000 tonnes of polyethylene (PE) and polypropylene (PP) each year. The Porvoo plant has been in operation since 1971 and has been extended at different times to meet capacity requirements. This plant is part of the international Borealis Group, which produces over 3 million tonnes of PE and PP each year.

Monitoring strategy

As many of the critical machines at the Porvoo plant were around 30 years old, it became more important to pay attention to the condition of these machines - both from a safety and production point of view. This was especially true for the high-pressure machines. The existing portable “off-line” monitoring instruments used at the time could not provide early enough warning of a developing fault, so it was decided to use a permanently installed “on-line” system for monitoring the critical machines.

Brüel & Kjær Vibro’s Compass monitoring system was selected to be installed on three of the polyolefin process lines, partly based on the positive monitoring experience of the same system used at two other Borealis plants in Norway and Austria.

Currently two LDPE (low density polyethylene) lines (150k tons/year) and one PP (polypropylene) compounds line (15k tons/year) are being monitored. Nearly all the motor-driven machines monitored in these processes are critical, un-spared machines, this means the process stops if the machine stops.

Machines monitored in the two LDPE lines include:

- Transfer blower
- Reactor mixer
- Secondary compressor (hyper reciprocating compressor - 2100 bar)
- Air compressor
- Main and side arm extruders
- Centrifugal dryer
- Booster compressors (reciprocating compressors)
- Primary compressor (reciprocating compressor)

PP compounds line:

- Mixer
- Extruder
- Centrifugal dryer

On-line monitoring system configuration

The Vibration Monitors continuously monitor machine vibrations via hardwire connections to the transducers, as shown in

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Figure 1. Analysing a plot on the central monitoring system server in the condition monitoring room.

Figure 2. The Vibration Monitor conditions the signals, compares them to alarm limits, and activates alert alarms, danger alarms or machine trips if limits are exceeded. This data is then stored on the Unix-based central monitoring system server database, which is also located on the process instrumentation LAN network. Plots, alarms, set-ups and other monitoring information can be displayed here. Much of the vibration data and critical alarms are also exported from the Vibration Monitor to the distributed control system (DCS), via a Modbus serial connection.

The condition-monitoring group keep an eye on the machines and do diagnoses during normal working hours, as shown in Figure1. The Control Room Operators also receive vibration alarms on their consoles, so they can alert Maintenance to assess an alarm situation during off hours. Imported vibration information is further routed from the DCS to the process management system, where this information is further trended and correlated together with the DCS process data. The monitoring system server can be remotely accessed by other computers ("X-terminals) in the Maintenance room and Control room by Internet browser or on any Windows computer on the network where the user has privileged access.

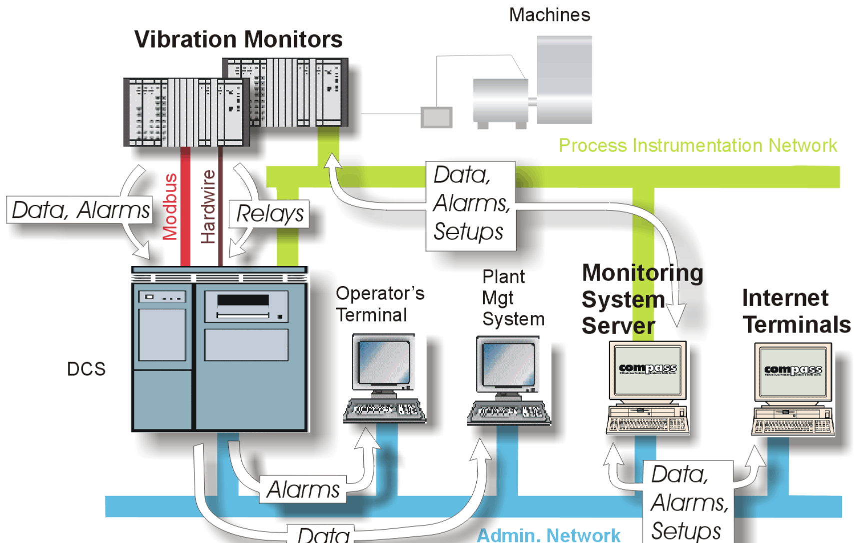

Figure 2. Monitoring system configuration at Porvoo. White arrows show the type of monitoring information that is exchanged between the on-line monitoring system and other systems.

Monitoring system results - case stories

Within a relatively short period of time of 14 months, numerous faults have already been detected and diagnosed by the on-line monitoring system.

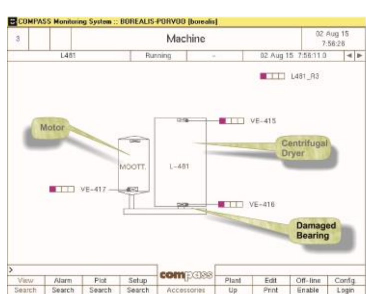

Figure 3. Location (top) and view (right) of the damaged bearing in the centrifugal dryer.

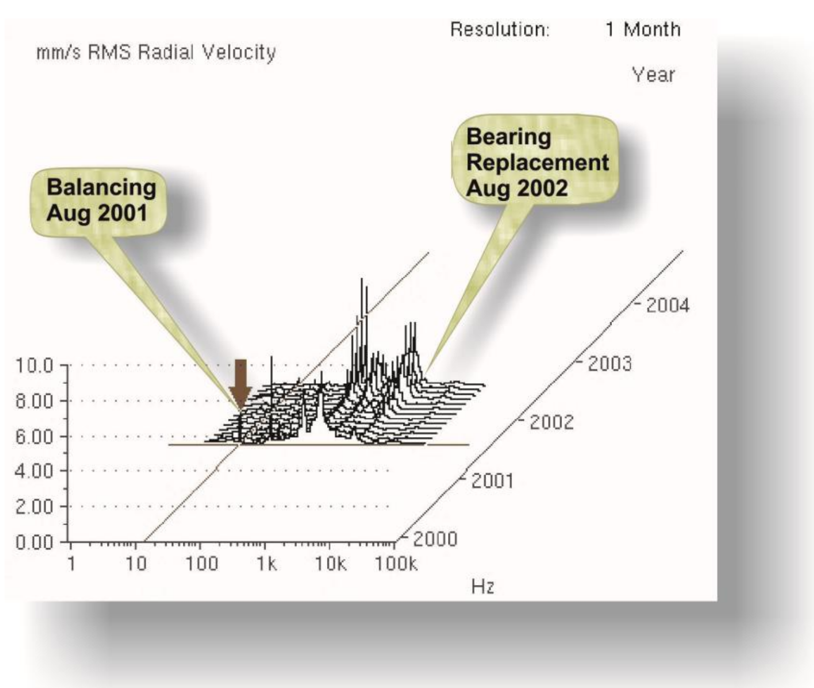

Figure 4. Spectrum plot showing unbalance and bearing damage before and after repair.

Three of these faults are described in the sections that follow:

- Centrifugal dryer - unbalance and a defective bearing
- Reactor mixer - damaged bearing
- Extruder - damaged coupling

Centrifugal dryer - Multiple faults

The centrifugal dryer in the Compound line dries the color injected PP pellets after extrusion and cutting. This critical machine often exhibits unbalance and sometimes pre-mature bearing problems.

Unbalance - The centrifugal dryer has to be washed and balanced often, partly due to fouling. Because of the process this occurs at irregular periods of time and therefore cannot be balanced at fixed time intervals.

Defective bottom bearing - High vibrations were monitored by the on-line system, but the existing portable vibration monitoring instruments used to confirm this indicated normal readings Maintenance was reluctant to open the machine, but investigation revealed that the bearing was indeed damaged (see the plots in Figures 4 and 5). Afterwards it was determined that it was difficult to get a good off-line measurement on this bearing because of difficult access.

Reactor mixer motor - damaged bottom bearing

The reactor mixer is a key process component for ensuring proper LDPE polymerization. The bottom bearing of the motor has several times shown signs of a pre-mature failure before its expected lifetime. Although the mechanisms causing this are still being investigated, it is imperative that such a bearing failure be avoided as it can have grave consequences on the 2100 bar pressurized reactor. Pieces of the bearing can obstruct the narrow discharge passageway of the polymer product, which could possibly result in serious damage and extended downtime. For the 14 months the on-line monitoring system has been in operation, there have already been three pre-mature bearing faults detected.

Main LDPE extruder- worn coupling

The main extruder extrudes the polymerized LDPE into long strings that are later cut and dried. The gear coupling showed signs of damage as seen in the plots in Figure 10. A new coupling was ordered, but in the meantime the damaged coupling was cleaned and re-greased to reduce vibrations until the new one arrived.

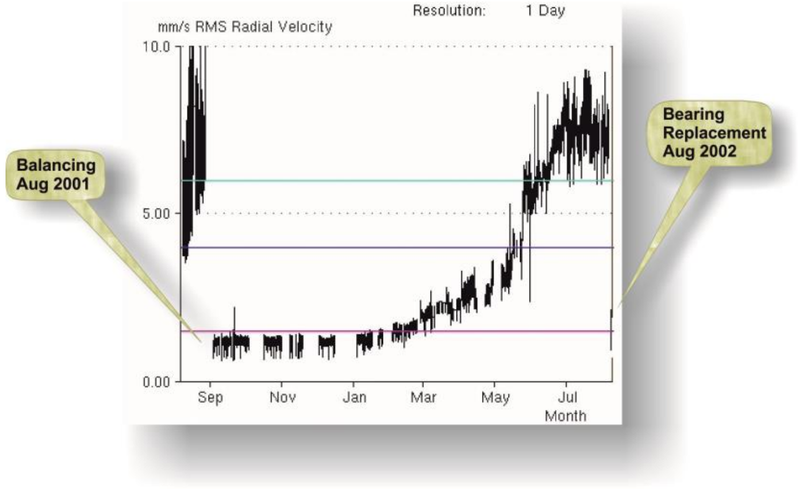

Figure 5. Bandpass vibration trend plot before and after balancing and bearing repair.

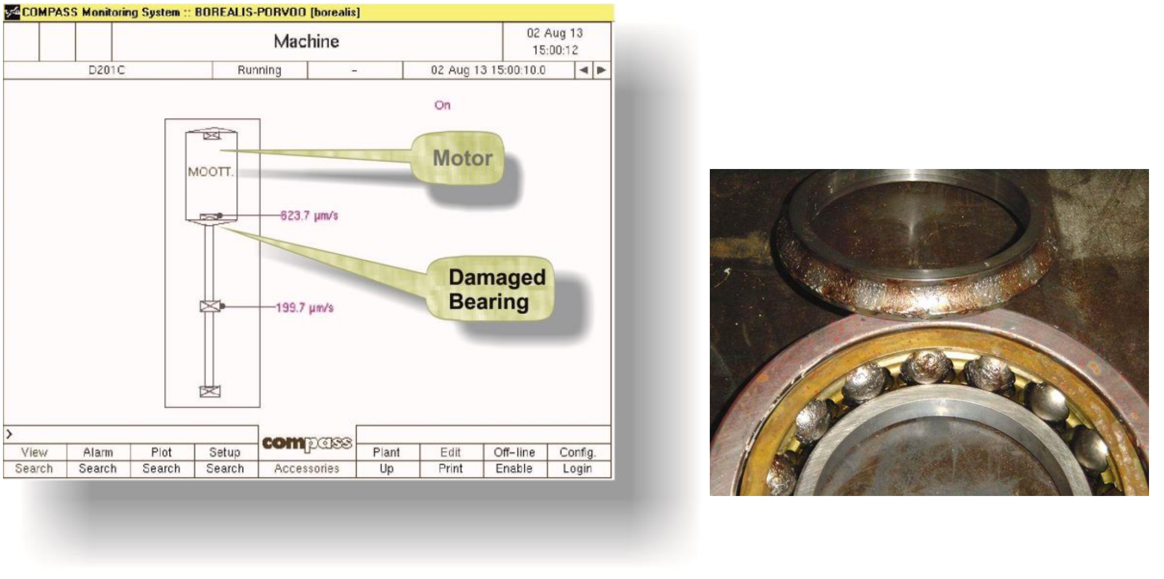

Figure 6. Location (left) and view (right) of the defective reactor mixer motor bearing.

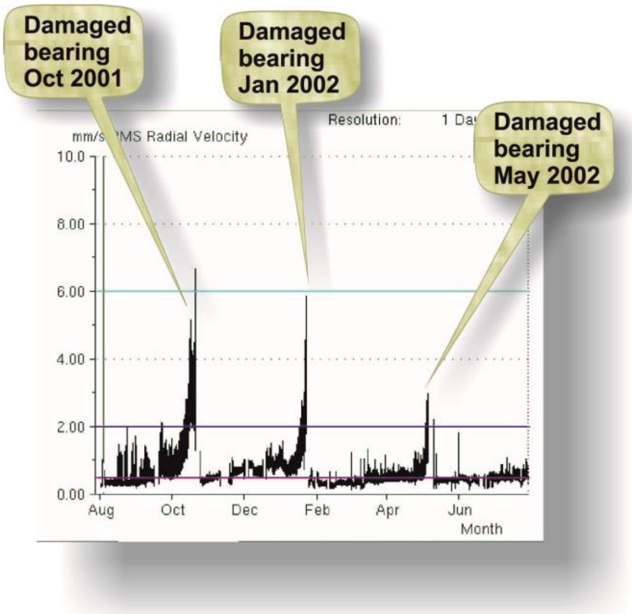

Figure 7. Bandpass vibration trend before and after three different bearing replacements.

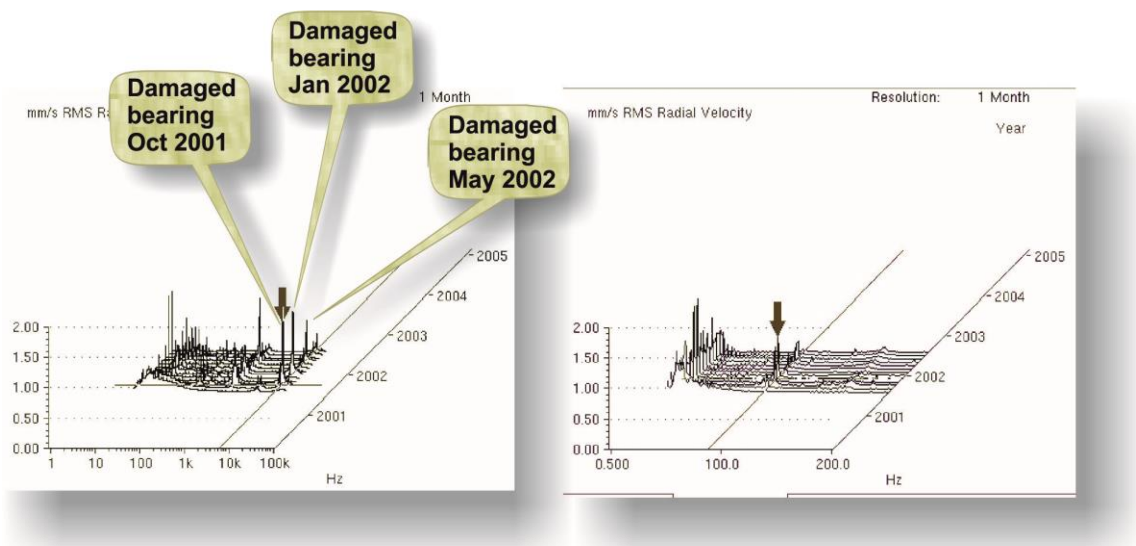

Figure 8. Spectrum plots before and after three different bearing replacements.

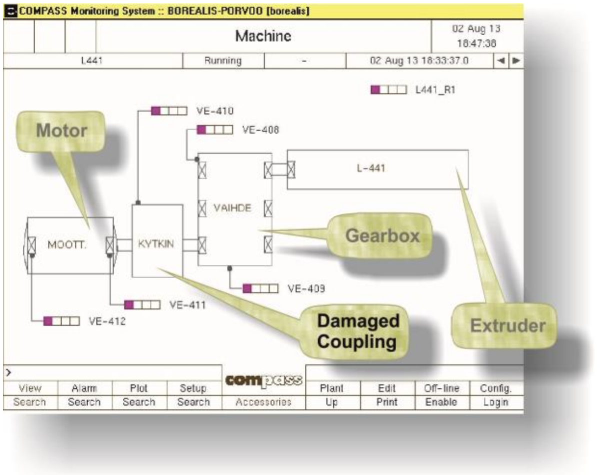

Figure 9. Location of damaged coupling on the main extruder.

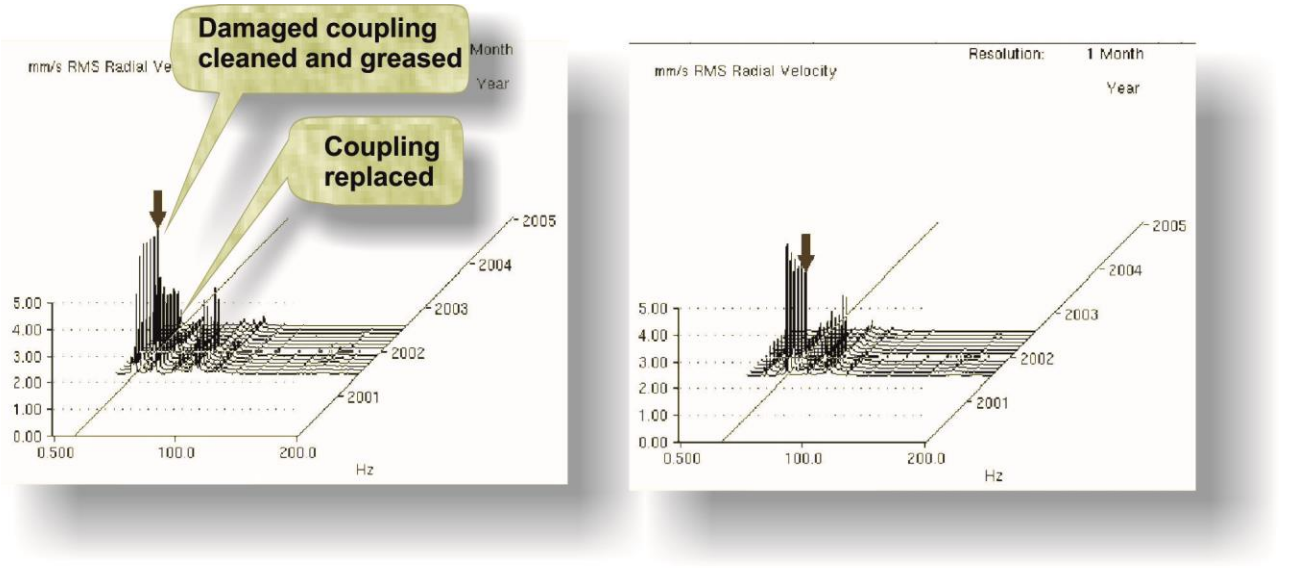

Figure 10. Series of spectrum plots before and after coupling replacement.

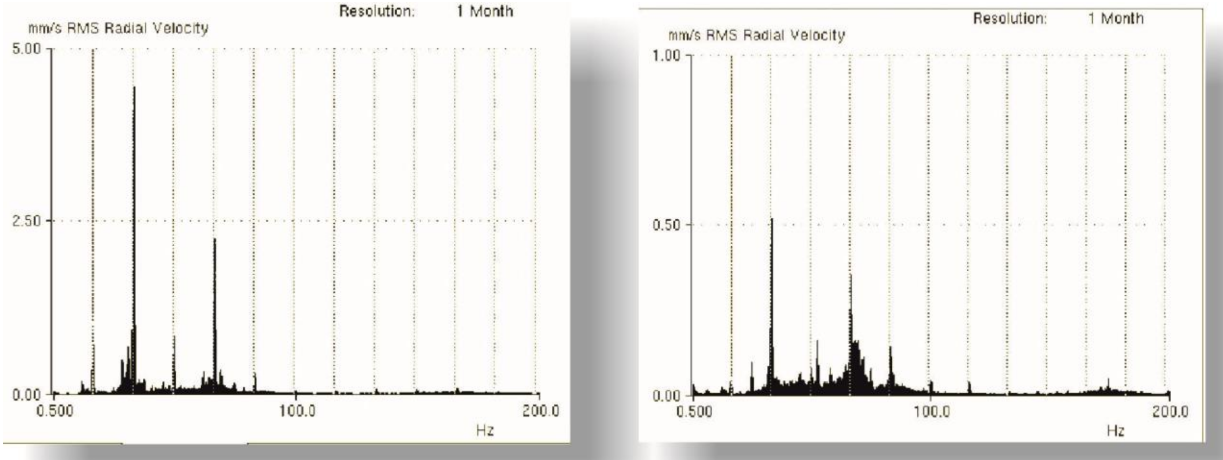

Figure 11. Single spectrum plots before and after coupling replacement.

Conclusion

The on-line system proved to be a beneficial investment for the short time the system has been used, in terms of improved safety, reduced maintenance costs of the critical machines and less downtime. Many developing faults - some of which were considered pre-mature and long before their expected lifetime - were detected reliably and early enough so maintenance could be more cost-effectively planned ahead of time.

The maintenance resource demands of the aging critical machines required a continuous monitoring solution. The off-line vibration monitoring instruments that were used before the new system still play an important role in the overall machine condition monitoring strategy at the plant, but mostly on machines other than the critical ones. The example with the centrifugal dryer demonstrates the potential limitations of the off-line systems with regard to accurate measurements in areas where there is difficult access.

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