

Process Operators and Maintenance Staff Work Hand-in-hand with DCS-embedded Condition Monitoring

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ABSTRACT

The capabilities of an on-line condition monitoring system have been embedded in a distributed control system (DCS) which uses common I/O hardware, signal processing hardware and software, engineering configuration tools, information trending and alarming. Machine operators and a maintenance staff are now able to see quickly developing vibration and process pulsation problems and determine their causes, using a unified user interface which is combined with process control functions of the DCS. With this facility, operators are alerted quickly to developing problems so effective corrective action can be initiated. This operator-initiated maintenance combined with regular monitoring of machinery condition by maintenance staff promotes a cooperative effort which improves machinery uptime and leads to cost-effective maintenance planning.

INTRODUCTION

Starting in the late 1980s, first quality measurements and controls, then machinery controls, drive controls and their user interface and information management functions have been integrated and consolidated step-by-step in distributed control systems. Monitoring and diagnosis of field devices has also been added to the DCS capability. Today, modern DCS systems offer truly integrated operation and information analysis for all quality, machine and process control functions.

Machinery vibration and condition monitoring and analysis was the next logical step in this embedding process, and today that integration is a reality. Once the realm of maintenance specialists, the analyses of machinery condition, roll cover condition, process pulsations and many other diagnostic tools are now available to process operators as well as maintenance staff in an integrated DCS platform. The unified system uses common I/O hardware, signal processing hardware and software, engineering configuration tools, information trending and alarming, and user interfaces. A machine operator can now evaluate machinery condition alongside the usual process control and quality control functions in a single system. Maintenance staff can follow up the same information and utilize integrated diagnostic tools from the production floor or from the maintenance shop.

This integration comes at a time when maintenance and production departments in pulp and paper mills are developing programs to coordinate their efforts in maintenance planning and predictive maintenance activities in order to ensure production goals are met and maintenance is focused on well-defined needs. The embedded condition analysis function in a DCS will therefore promote these cooperative maintenance and production planning programs and help mill staff to target maximum process availability and cost-effective operations.

In an article entitled "Operators in Maintenance"¹ Mr. Christer Idhammar of Idcon Inc. emphasized the importance of involving operator in an effective preventive maintenance program. He says "To include operators in essential care of equipment including preventive maintenance inspections is one of the reliability and maintenance improvement initiatives that can yield the best return on investment. The investment is low and results in increased reliability and lower maintenance costs can be substantial. Still, very few pulp and paper mills can claim that their operators are involved to a significant extent in these activities."

Why include operators in maintenance? The main reasons why operators should be included in essential equipment care include:

- The urgent need to increase competitiveness and productivity.
- Preventive maintenance programs will be much more cost effective.

- The partnership between operations and maintenance will improve.
- The operators are there always when production is up and running, 24 hours per and 7 days a week.

Mr. Idhammar continues, “Many basic equipment inspections require a frequency of less than eight hours. It cannot be justified to have maintenance crafts people to do these inspections twice a day. If it makes sense, these inspections will be done by operators who combine them with process inspections they do anyway.”

A similar important effect on operator activities was noted when machine interlock logic and its diagnostic “help pages” was included in DCS systems several years ago. With this diagnostic capability operators are able to find and correct the causes of machine halts and alert maintenance staff to the needed repairs.

THE GOALS OF EMBEDDED CONDITION MONITORING

The benefits of on-line condition monitoring are well known and documented². By analyzing immediate and historical trends of machine vibrations, unexpected and costly failures and production outages are avoided. Thus, the mechanical assets of a mill are protected and workers’ safety is ensured. Condition-based maintenance planning is very effective at maintaining uptime at a lower cost since only the required maintenance is done at the most appropriate times.

However, until recently, these condition monitoring systems were not integrated into the DCS. They used separate and unique I/O hardware, signal processing and computing hardware, diagnostic software, user interfaces, time trending and data management software. In many cases, the user interface terminals were in the corner of the main control room, separated from the operators’ primary activity area, or in the maintenance shop only. Because of this separation of information and activities, process operations and maintenance were not connected to a large extent.

Thus, the process of integration of condition monitoring in the DCS had several interrelated objectives. These included:

- Common diagnostic tools for process operators and mechanical analysis specialists, thus promoting maintenance staff collaboration with production staff.
- Incorporation of all diagnostic features of the previous condition monitoring system including, the analysis of mechanical system vibrations, process pulsation, roll cover condition, and fabric-induced vibrations.
- A single user interface for operation, trending and alarm handling and also for detailed mechanical condition and process pulsation diagnostics. This would permit continuous monitoring 24 hours per day and 7 days per week, the same as the process control function of a DCS.
- A common history database for all data for reports and analysis. The integration with process data would make the analysis of machine condition data very effective and would facilitate the correlation of process and mechanical condition data.
- Common I/O and process station hardware for process controls and machine monitoring. This would allow a common and cost-effective system structure. The system would use the same configuration tools as for process controls, thus making engineering and systems service more efficient.
- The ability to cost-effectively configure a small monitoring application with just a few measurement points.
- The same operator and engineering training for cost savings.
- Common spare parts for cost savings.

The integration of the condition monitoring function in the DCS was done in several steps starting in 2008. First, the existing standalone condition monitoring system used common DCS I/O and analysis station hardware. New high frequency I/O was added to the DCS I/O family with the capability to handle vibration signals up to 20 kHz. The existing condition monitoring database server was networked to the DCS which then displayed the existing condition monitoring user interface screens on the DCS operator stations.

In its present form, available today, the condition monitoring function is fully embedded into the DCS with common hardware, integrated user interface, common trending, alarming, reporting and engineering configuration tools.

UNIFIED USER INTERFACE

With an embedded system, both machine operators and maintenance specialists are involved in the problem recognition and solution process so the displays are designed for both users to be easy to use and meaningful. Combined process and vibration analysis displays can be used quickly and effectively to diagnose mechanical problems. Operators can react much faster to critical, fast-developing problems like calendar barring, polymer roll “hot spots” and other severe vibration conditions that might indicate premature failure. More detailed component-specific analyses and trouble-shooting tools are provided for maintenance staff. Figure 1 shows how a machinery condition alarm generates a visible alert on a process element, in this case a pump. When this alarming point is activated by mouse click a detailed vibration analysis window opens. See Figure 2. The detailed analysis reveals the source of the problem, a bearing or other mechanical component.

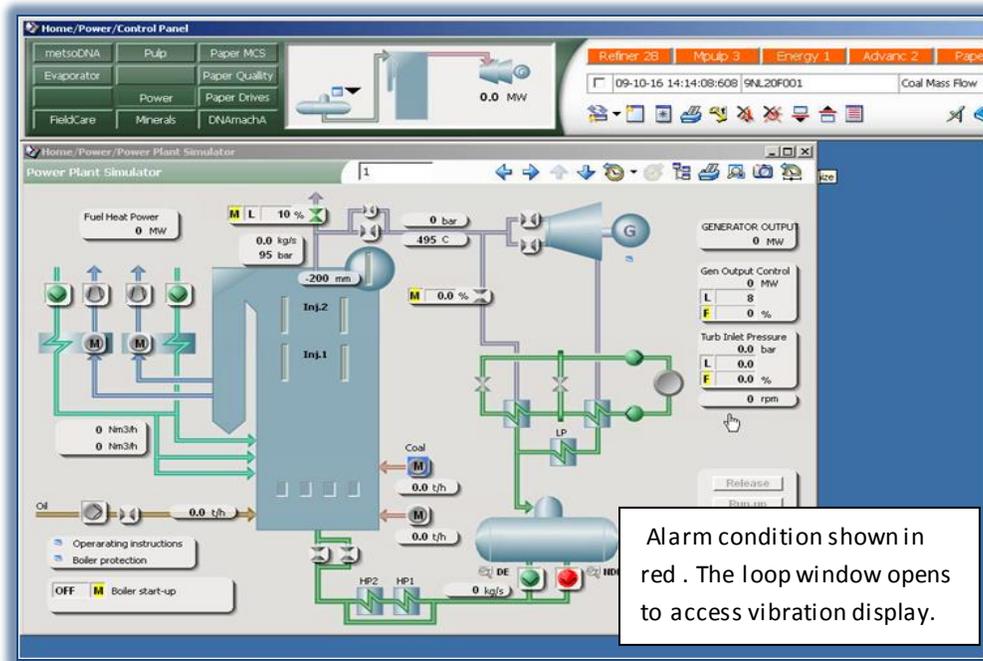


Figure 1: A machinery condition alarms generates a visible alert on the DCS process display. When this alarm is activated by a mouse click a detailed vibration analysis window opens as shown in Figure 2.

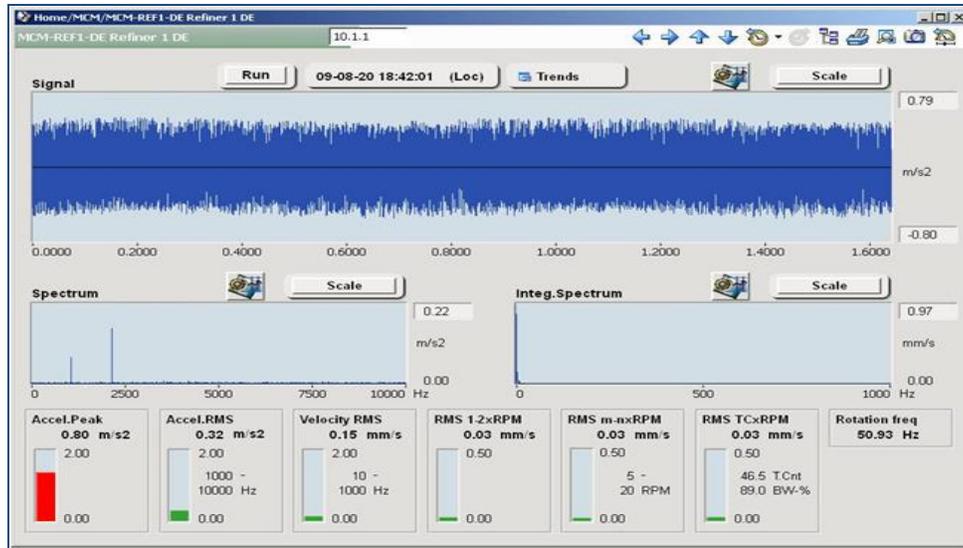


Figure 2: When a vibration alarm is acknowledged and activated by a mouse click on the combined process display, a pop-up window reveals the details of the vibration patterns in the process element.

COMPONENT-SPECIFIC ANALYSIS

The vibration analysis window reveals a wealth of information about the vibration characteristics of the process elements. The configurable and scalable displays can show the raw vibration signals up to 20 kHz, scalable bar graphs indicating both overall vibrations and fault-specific frequency components of these vibrations, and spectral analyses. These analyses viewed by maintenance specialists can reveal more detailed information about the root causes of the vibration problems. The system is also equipped with an extensive machine component database, including a bearing library which associates a fault frequency analysis to a typical problem with a drive train component.

Motor driven process components can be equipped with multiple vibration sensors and triggers to measure rotation speed. Figure 3 shows a typical sensor complement which can be used to deduce misalignment, imbalance, bearing or gearbox faults or other problems with mechanical systems which can be fixed or variable speed. The selection of the number and types of sensors required depends on the machine type, its construction, machine size and motor rating.

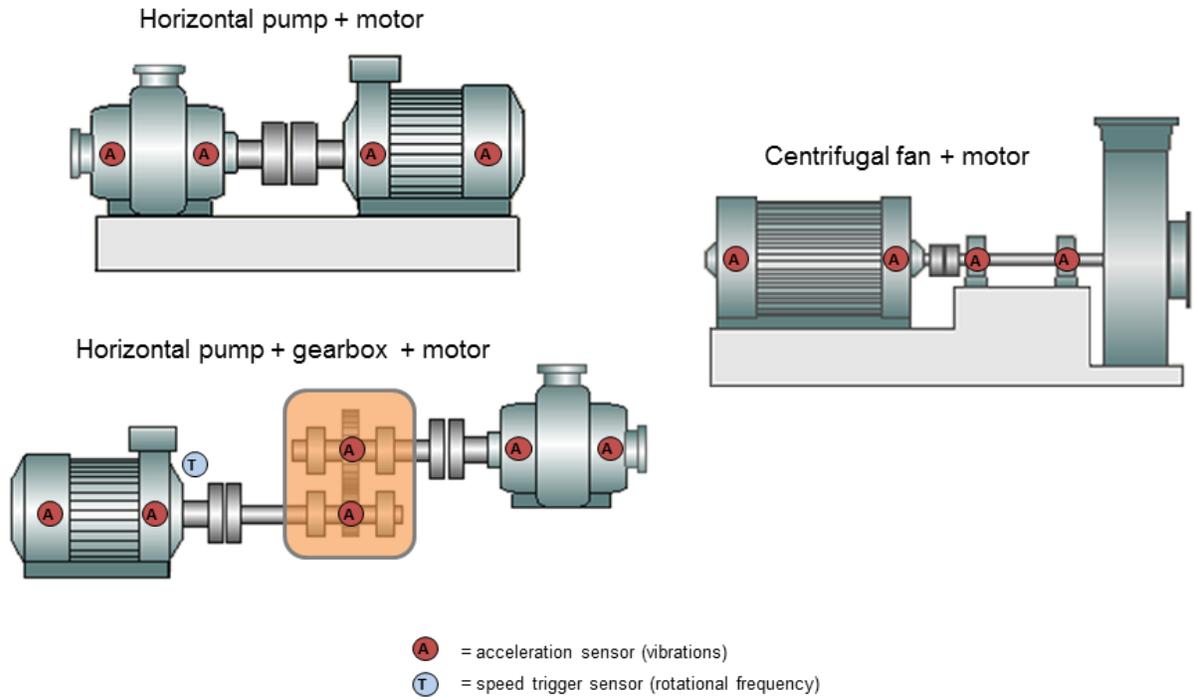


Figure 3 shows a typical sensor complement which can be used to deduce misalignment, imbalance, bearing or gearbox faults or other problems with mechanical systems. The drives can be fixed or variable speed.

Vibration measurements can also be time trended and alarmed along with process data to show the development of vibration levels during extended machine running periods. Operators and maintenance staff can therefore see developing trends and plan maintenance activities. Trends of vibration data can also indicate if the machine can be run safely until the next planned maintenance stop or even for a longer period without encountering any production problems.

GROUP CONFIGURATION IN DCS

Many driven machine mechanical systems have common drive and power transmission components, therefore the analysis set-up and alarm limits can be set as a group. See Figure 4. To make the project execution simple and efficient, similar machine types are configured using “templates” with pre-defined calculation scales and alarm limits. The template also includes common displays for the user interface. In this respect, the condition analysis function of the DCS is configured just like normal DCS process input groups. However, there is always a possibility to modify or tune parameters in a group or custom handle an individual monitoring target by disabling the grouping for the target and adjusting the parameters individually.

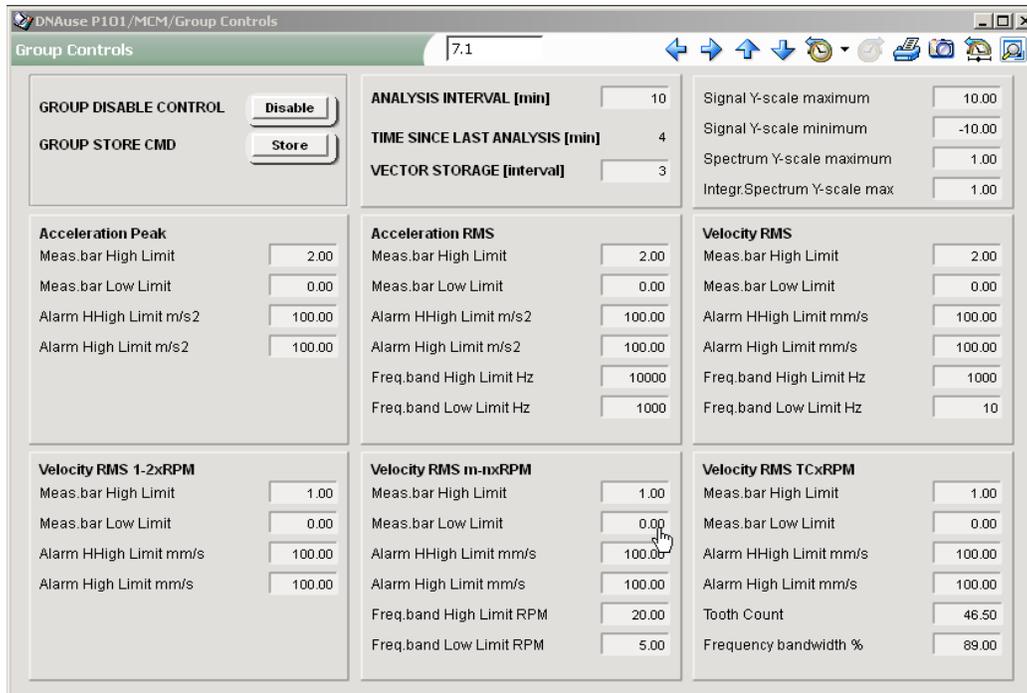


Figure 4: Many driven machine mechanical systems have common drive and power transmission components, therefore the analysis set-up and alarm limits can be set as a group. Individual set-ups are also possible

CASE STUDY – LIME KILN ROLLER MISALIGNMENT

A typical case of embedded condition monitoring is illustrated by the diagnosis and correction of a lime kiln support roller misalignment problem. A faulty roller bearing had just been replaced along with the complete kiln support roller assembly. After the kiln had warmed up to normal operating conditions production personnel noticed that the same support roller area was showing an alarm situation, as shown in Figure 5, and maintenance people were notified.

When the alarmed point was clicked a pop-window of the vibration pattern of that support roller showed a cluster of pulses occurring in regular intervals in the vibration time trended signal. See Figure 6. The impulse frequency was close to the characteristic impulses from a failed inner race roller bearing. But the pattern was not exactly the same as a failed bearing and the impulses were not continuous. The impulse series during a 19-second sample period appeared about once per support roller rotation period of 11.1 seconds, corresponding to a rotation frequency of 0.09 Hz.

After some thought and a site inspection it was noticed that the rotation of the kiln was not smooth and there was a “rumbling” noise. This is a typical indication of an alignment error in the kiln. With a further inspection it was noticed that the new support roller was slightly larger than the older one, so it was carrying more load than the others. A realignment of the support rollers was completed and the kiln mechanical operation returned to normal.

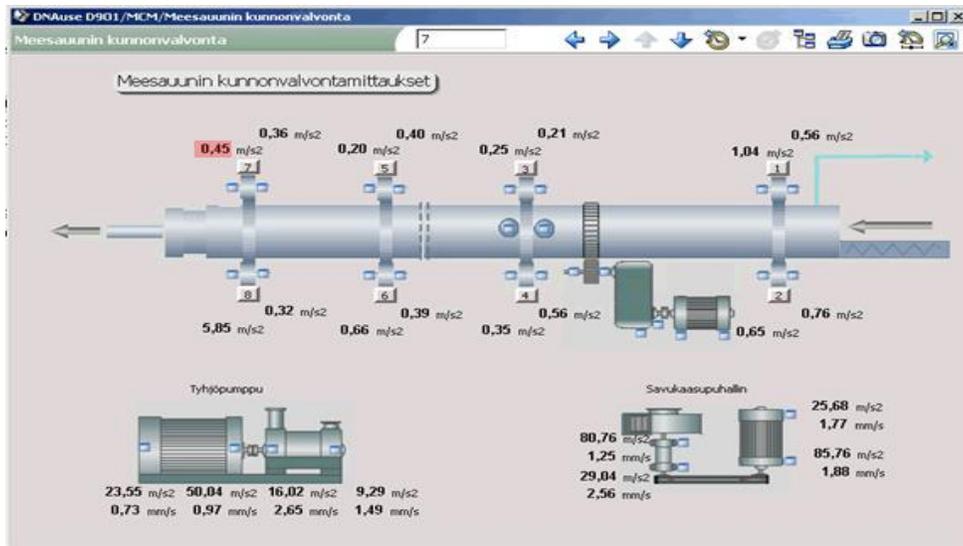


Figure 5: Alarmed point in red indicates a vibration problem in a kiln support roller. Clicking on that point opens up a vibration analysis tool as shown in Figure 6.

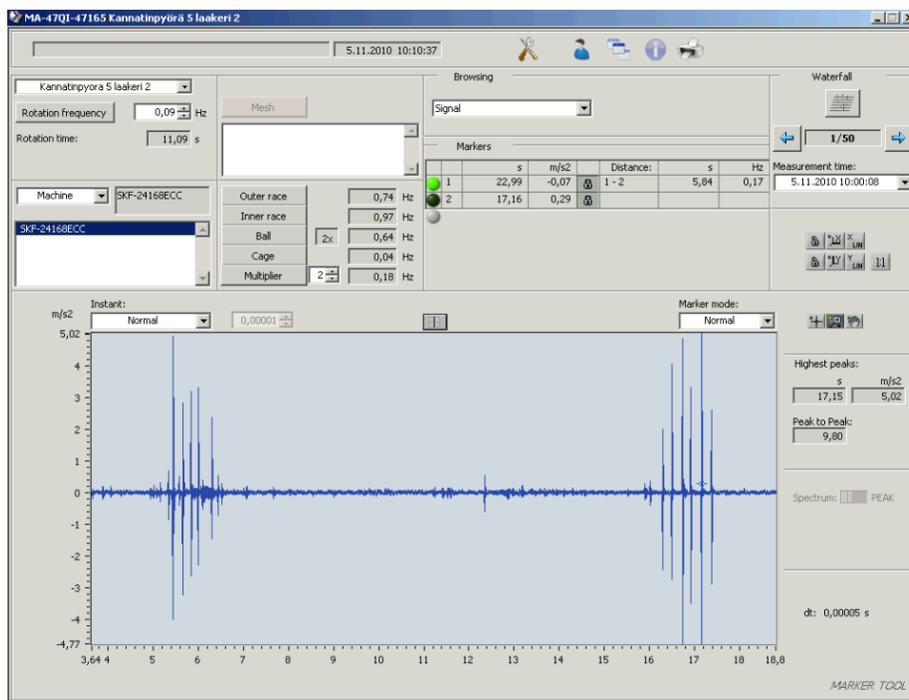


Figure 6: A signal sample from a troublesome support roller bearing housing vibration.

BENEFITS OF EMBEDDED CONDITION ANALYSIS

By measuring, analyzing, trending and alarming vibration levels in mechanical systems immediate mechanical faults can be detected and definitive corrective action can be taken at the right time for the right reasons. In many cases this positive action, reinforced by precise and meaningful data, can avoid unplanned failures and extensive and expensive machine downtime. Also, safety problems can be foreseen and prevented. Machine runnability and product quality can be optimized by diagnosing machine pulsation and vibrations and solving them at their source.

By archiving vibration data over extended periods, a maintenance history of a mechanical system can be developed and maintenance can therefore be scheduled to ensure maximum machine uptime for the right service actions and the lowest service costs. Only the most effective and targeted maintenance need be done.

Condition monitoring embedded in a DCS also allows the analysis of pulsations and vibrations in various paper machine sections from the wet end to paper finishing. The solution to these vibration or pulsation problems often results in better paper quality or machine runnability. Figures 7 and 8 illustrate how this analysis capability can be used to diagnose wet end pressure pulsations and calendar barring problems. By STA analysis of vibrations in paper machine press and calender nips, the running condition of press fabrics and the condition of roll covers can be assessed. Fabrics and rolls can be removed at the optimum time so paper quality or runnability are not compromised. In practice, roll grinding intervals can be extended as long as the covers are certified to be in good condition. The use of condition monitoring in multi-nip soft calendering is particularly critical as early warning of calendar “hot spots” can avoid premature, costly and dangerous roll cover failures.²

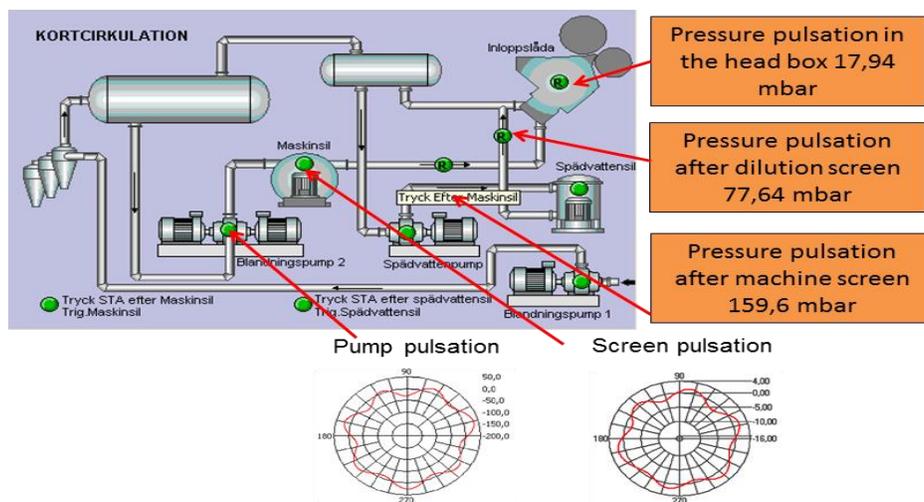


Figure 7: The origins of wet end pulsations are determined by the integrated monitoring of the DCS system

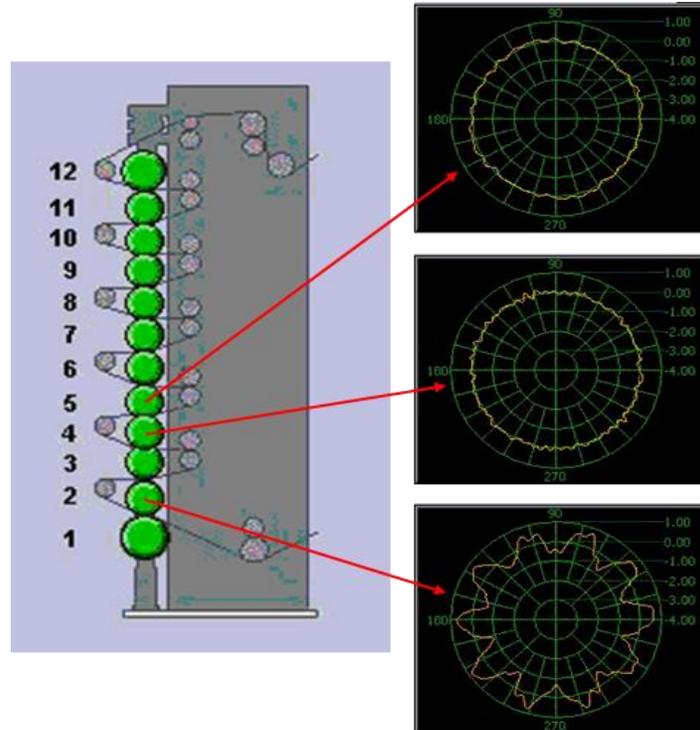


Figure 8: Synchronous time averaging (STA) analysis determines which roll in a supercalender is causing a barring problem.

With a single system the linking of maintenance requirements to Computerized Maintenance Management Systems (CMMS) is greatly simplified since there is only one link. Through the DCS operator diary function, notes and comments by process operators can be transferred and made visible to all. These communications include maintenance problems and their solutions during all shifts. Also, work orders may be activated if seen necessary. Once maintenance is completed a task-completed note can be added to the diary entry and communicated back to the operators.

CONCLUSIONS

With the embedding of condition monitoring in a DCS, the process operators' role in maintenance has become more active and important, since critical vibration or pulsation problems are now showed quickly and clearly on the DCS user interface. Condition monitoring shares equal importance with process monitoring and is now available in the operators' main activity area. The consolidation of the condition monitoring function allows production and maintenance staff to collaborate in determining the maintenance issues at hand and for scheduling maintenance activities to ensure production goals are met and expensive production outages are prevented.

REFERENCES

1. Idhammar, C., "Operators in Maintenance", an article published on the website of Idcon, Inc., www.idcon.com
2. Jaatinen, E. and Rautiainen, H., "Paper Machine MD Variability Reduction with On-line Monitoring", a paper presented at the Tappi PaperCon Conference, 2009, St Louis, MO.