Vibration Monitoring
on
Paper Machine Calender

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1 Introduction

This case study describes how to measure and monitor the condition of calender rolls in a paper mill.

This case study from Stora Enso Kvarnsveden AB, Sweden describes a super calender with twelve rollers on one stack. Some of these rollers are soft (elastic) and frequently become worn and corrugated; thus they need to be grinded regularly. With the measurement setup described here, the system generates one vibration trend per roller, which helps the operators determine when and which roll to replace.

Stora Enso Kvarnsveden AB is one of the largest paper mills in Sweden. The plant has three paper machines: PM8, PM10 and PM12. These machines all have different kinds of calenders. The one in this case study is a super calender on PM8.

2 Conclusion and summary

Vibrations in calenders are difficult to analyze with traditional vibration measurement. With the system setup described in this case study, the condition of individual rolls in the calender can be monitored. The operators decide when and which roll needs to be changed and sent to grinding. To enable operators to view measuring results, the readings are exported, via OPC, from Condmaster to another system (Mill Information System, MIS) installed in the calender control room.

Calender rolls running for too long will become worn, resulting in vibrations throughout the stack. Excessive vibration levels in the calender will require speed reduction, in turn leading to potential quality and production losses. High vibration levels in the stack overall will also increase wear on the other rolls in the stack.

The condition measurements help operators decide in a more optimal way when and which rolls need to be replaced and sent for grinding, thus enabling more stable operation of the calender and maximized equipment lifetime.
3 Application description

A calender is a series of high pressure rollers, used to create a smooth and glossy surface of the paper by applying pressure, heat and steam. Calendering is part of the finishing process and its purpose is to improve the printability of the paper. Calenders integrated with the paper machine are called online calenders. Calenders run as separate units (offline) are also called supercalenders, see Figure 1. The series of rollers are also named a stack. A calender may contain one or more stacks.

Fig. 1 Principle drawing of a super calender.

Calenders are composed of different kinds of rollers. The blue rollers in Figure 1 are softer rolls which quickly get worn and corrugated; some of the soft rolls only run in the machine for a few days. The black and green rolls are steel rolls with considerably longer working life.

The big roll of paper produced in the paper machine is called a tambour. It is moved from the paper machine to the supercalender by a trolley on rails. The paper is manually fed between the twelve pressure rolls. When the paper from a tambour has run through the calender, with steam, heat and pressure, it is wound up onto a new tambour and sent away, on the same trolley, to a winder. The approximate time for one tambour in the calender is 1.5 hours.

A corrugated roll will cause vibrations throughout the machine and it is crucial for the lifetime of the other rolls that the corrugated roll is replaced and sent to grinding at the earliest possible time.
4 Background

The background for these condition measurements is a period of very high vibrations in the calender, resulting in reduced machine speed. Vibration analysis is one of the measures taken in order to increase the availability of the calender.

5 System setup

5.1 Measuring equipment

Since corrugation occurs mainly on the soft rolls, the decision was to monitor these only and exclude the steel rolls.

An Intellinova online system and a VCM20 online system are used to monitor the six soft rolls. The reason for using two online monitoring units is because measurements are time critical. The goal was to perform four measurements on each of the rollers while the paper from one tambour goes through the calender. Since an unused VCM20 system was available on site, this was incorporated in the technical solution for the calender.

A single vibration transducer mounted on one of the rolls (see Image 1) is used per online monitoring unit to cover the entire calender.

*Img. 1* A single vibration transducer per online system monitors the whole stack.
A single vibration transducer per online monitoring unit was mounted on the same roll. In addition, one RPM transducer was installed on each of the soft rolls, see Figure 2. The reason for using only one vibration transducer per online monitoring unit is that vibration levels are similar throughout the stack.

**Fig. 2 Sensor placements in the calender.**

The RPM sensor is a photo sensor and a piece of reflective tape is mounted on the roll; see Image 2. The photo sensor is used due to the difficulties of mounting an inductive sensor and the fact that the rolls are changed regularly. The photo sensor works well, but the reflective tape is less optimal since it is difficult to keep it clean.
The vibration level in a stack is quite similar no matter where the measurement is taken. Vibrations from the rollers is spread through the entire stack; signals of the same frequencies therefore are found both on the top and bottom rolls. To enable separation of the vibrations in the stack and create one vibration trend per roll, a “Time Synchronous Averaging” measurement (TSA) is used. The TSA measurement generates one vibration trend per roller.

In an ongoing project, magnets are now mounted onto the rolls, see Image 4, and Hall effect sensors will be used instead of the photo sensors, see Image 3.
5.2 Condmaster setup

The rolls exhibit various kinds of corrugation, see Figure 3:

**Fig. 3 Different kinds of corrugation.**

To cover all different cases, the highest factor of corrugation was about 120X. The rolls were run at 300–400 RPM and the F-max was therefore set to 1000 Hz, \( \frac{400 \times 120}{60} = 800 \) Hz. A recommendation for the next setup of this kind of measurement is to use Orders instead of Hz.

In Condmaster, a single measuring point per online monitoring unit was created for the entire stack, with one measuring assignment per roll set up, see Image 5. The resolution is fairly high for a TSA measurement, but the trial period showed that fault symptoms were best calculated at this resolution.

**Img. 5 Setup in Condmaster.**
Symptom calculation is done because the operators doing the grinding of the rolls are interested to know the nature of the corrugation. In the control room, the operators can monitor three trends per roll:

- Roll vibration LF (Calculating 1-6X), see Image 6 below
- Roll vibration MF (Calculating 7-17X)
- Roll vibration HF (Calculating 18-120X)

**Img. 6 An example of how to set up the 1-6X symptom.**

To enable operators to view the measuring results, they are exported via OPC to another system where all process data can be accessed. In the control room, two screens show the roll vibrations, see Image 4.
**Img. 4** Measuring results are displayed in the control room. Roll 3 has become corrugated and replaced. The trends show that rolls number 6 and 2 have small corrugation increases.

The number of averages was tested over a period of time. The goal was to perform four measurements on each of the rollers while the paper from one tambour goes through the calender. An averaging of 75 proved optimal.
6 Case descriptions

6.1 Case #1

The vibrations in the calender are mainly attributed to bad rolls and speed. In Image 5, both factors can be seen. The roll is becoming corrugated and the speed has been varying.

*Img. 5* It is evident from this trend graph that vibrations have a clear correlation to rotational speed. In this case, the roll has become corrugated over a period of time and replaced at the blue marker. The black trend is vibration (mm/s RMS) and the red trend is the rotational speed of the roll.
6.2 Case #2

In this example, two different rolls have become corrugated and replaced on different occasions.

**Img. 6** Roll no. 4 replaced at the blue marker and roll 3 replaced at red marker.