Frequency- and variation analysis on online measurements from a paper machine

-at StoraEnso Paper Mill in Nymölla

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Sweden, January 2007

Abstract

To maintain market shares in the paper industry you always have to develop the process of papermaking and raise efficiency in the production. In line with the main target to do so Nymölla has purchased a surveillance system called Sensodec 6S, which is a vibration surveillance system that also surveys the quality of the paper. Today the software is used by the maintenance engineers to reduce unplanned stops by doing maintenance work well ahead of time so that the machine doesn't break down before scheduled stops. The quality aspect of the software is not fully implemented and the main purpose of this thesis was to find a way that Sensodec can be used for analysis and control. This thesis focus on the basis weight parameter but the same method that is used can be applied for the other two, moisture and calliper. There's also the possibility to do analysis by sampling signals with the tools from the instrument department. These analyses were performed in MATLAB, with toolboxes for FFT transformation and correlation analysis.

Introduction

Nymölla paper plant is a part of Stora Enso and has about 800 employees and produces 400 ton per year with a turn around of approximately 2.5 billion SEK. The main focus in paper industry is to raise efficiency and make paper with competitive quality. In order to do so a paper plant has to have a sufficient surveillance system. This keeps track of all the important parameters that affect the ability to keep high speed in the paper machine and the parameters that have impact on the quality of the paper. One of the major issues is vibrations that develop in different parts of the process and gives the paper poor quality as well as it's slowing down the machine. By monitoring the vibrations Nymölla are able to schedule their stops for maintenance work and well ahead in time see if something is starting to fail. Nymöllas vibration surveillance system is called Sensodec 6S and this system also contains a quality feature that survey basic weight, calliper and moisture.

Objective

The objective with this thesis is to analyse vibrations and variations in the process to see if and how it affects the quality of the paper and what can be improved. The tools used for this is both Sensodec and the existing control system. There are tools in Sensodec that aren't used and Nymölla

haven't got education in how to use them. Therefore, part of the thesis will be to learn how it works and then create a manual for Nymölla to follow and how Nymölla can implement it. There are pre-selected sources connected to the quality parameters which are the most likely to affect the quality. This thesis examines if those parameters actually contribute the most to variations in quality and if there might be other sources. The focus is on basis weight variations but the same procedures apply to other variations such as calliper and colour. The thesis also covers suggestions for improvement of the quality.

Methodology

First a literature study was made to gather information in the subject and see what kind of research had been done prior to this. Then empirical examinations were made with thorough documentation. Most of the analysis is preformed in Matlab and big part of the work was to write the code. Another key aspect of the thesis was the communication between different divisions at Nymölla and the understanding of the problem.

Analysis

This chapter will be divided into two parts. The first part will present the slow variations with low frequencies and the other part fast variations with high frequencies.

Slow variations

Slow variations mean frequencies from 0.25 Hz down to 0.001 Hz. In table 1 is an illustration of what might be the cause for variations in different frequencies.

Frequency (Hz)	Random Variations	Periodic Variations
0.001	Slurry variations	
0.01	↓	↑
0.1	↓	
1	↑	Pressure pulsations
10	Instability in head box	↓
>100	↓	

This thesis is focusing on periodic variations. The most likely parameters affecting basis weight is those furthest back in the process where slurry is mixed with water[1]. This is due to big containers of water where large volumes create long recirculation times. The time series was collected with sensors and exported to Matlab where they where transformed into frequency spectrum. After that it's possible to pinpoint peaks at the same frequency. See Figure 1 where basis weight is compared to pressure in the head box (where the slurry is sprayed to the wire).

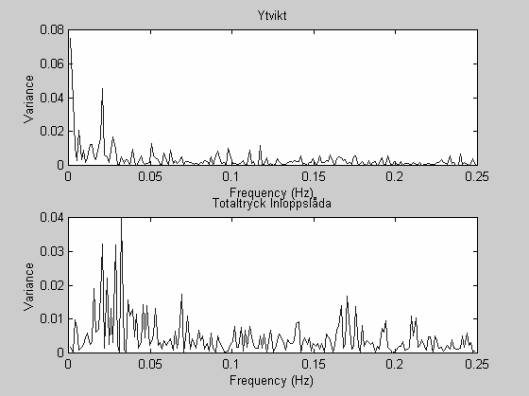

Figure 1. Window to compare frequencies.

With the data collected it was also possible to study the correlations between different parts of the process. That was done in Matlab as well. Figure 2 shows the correlation between differential pressure and the level in the mixing chest.

[1] Fellers, Norman (1998) *"Pappersteknik"*

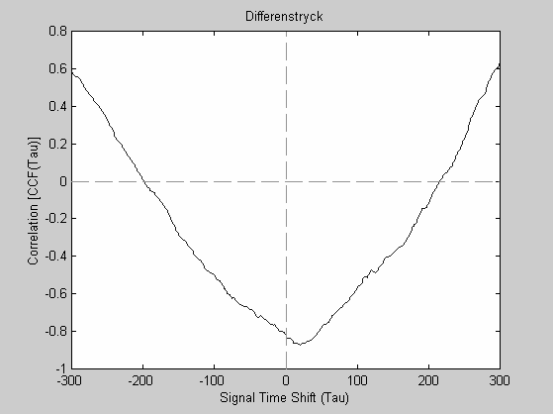

Figure 2. Correlation graph.

One of the most important aspects of reducing random variations is to maximize the mixture between white water and the slurry. The best mixture is obtained at a ratio of 8 between the speed of the water and the speed of the slurry. The difficulties at Nymölla were to calculate the energy losses in the process since the geometry was quit complex in pipes, silos, and other passages. Although, using values that were known, it was possible to calculate a ratio with the equation:

$$\frac{v_{tjockmassa}}{v_{bakvatten}} = \frac{\frac{Q_{tjockmassa}}{A_{tjockmassa}}}{\frac{Q_{bakvatten}}{A_{bakvatten}}} = \frac{Q_{tjockmassa}A_{bakvatten}}{Q_{bakvatten}A_{tjockmassa}} = \frac{Q_{tjockmassa}d^2_{bakvatten}}{Q_{bakvatten}d^2_{tjockmassa}}$$

The result showed that the value might be too low and something should be done about it.

Fast variations

The fast variations was studied with Sensodec 6S. This is new software with sensors connected to almost everything moving in the paper machine. The sensors that measure the vibrations are called accelometres. Magnetic and optic triggers make it possible to measure how a single component is contributing to the total vibration in a section with several components.

The feature SMCA tool (Simultaneous Multi Channel Analysis) makes it possible to simultaneous measure several different parameters and then like the slow variations try to find common frequencies that indicates a connection. In this feature it's also an advantage to use the STA tool (Synchronous Time Average). This tool uses the triggers mentioned above to make it easier to see what causes the vibrations, i.e. the root to the problem. Figure 3. shows what a window in this tool can look like. The lines show how much this particular parameter is contributing to the total signal at every frequency that is a multiple of the objects natural frequency. The natural frequency is the lowest frequency in a harmonic series.

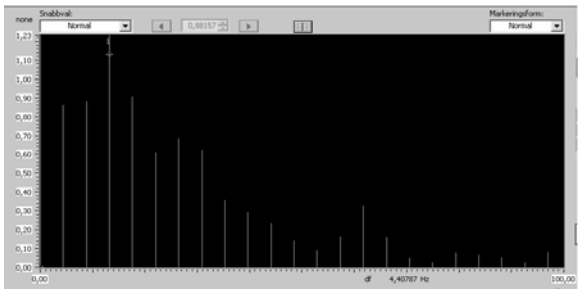
Figure 3. STA window.

The great thing about this is that it covers a very broad frequency band (2–10000 Hz) with good resolution (the distance between frequencies on the x-axis). Since the quality aspects of the program haven't been used at Nymölla a manual was established on how to use the tool and a summary of what kind of analysis that can be done with this tool.

Conclusions and recommendations

The slow variations showed that there could be variations in basis weight at very low frequencies which could be of essence when it coincides with variations of higher frequencies. The most likely parts of the process to affect basis weight are those in the "wet end", i.e. the parts prior to the press section; head box, white water pit, mixing pump, wire section etc. Another interesting aspect of the sampled signals is the cross correlation between different parts of the process. In some cases there is

clear correlation between the mixing chest and machine chest. When that occurs, there is also high or moderate correlation between mixing chest and several parts in the paper machine, such as dewatering, clear filtrate for chemical dilution and suction boxes.

The fast variations shows that there is some connections to the machine screen and the nose roller 230 but most of all it's proven to be an efficient tool in doing analysis that definitely should be taken more seriously in every day work. One of the most interesting tools of Sensodec is the SMCA (Simultaneous Multi Channel Analysis) where one can choose to do several analysis simultaneously as well as STA analysis (Synchronous Time Average) which is useful for determine how much a vibration or pressure variation affects another parameter such as basis weight in this case. When investigating the results it's preferable to do so in the tool called "Reference Tool" where it's possible to choose to look at several spectrums or signals in time domain in one window and pinpointing peaks.

References

Fellers Christer, Norman Bo (1998). *"Pappersteknik"*, tredje upplagan. Stockholm, Instutitionen för Pappersteknik, Kungl Tekniska Högskolan,

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