Bandsaw Performance Monitoring

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Introduction

Saw deviation sensing equipment is no longer an exotic or unusual technology in sawmills. Systems are available ranging from a basic warning light display for the sawyer to full control of the feed system. The benefits of monitoring saw deviation include:

- reduced sawing deviation
- increased throughput
- less damage to saws
- warning of guide wear or guide damage.

For the most part, the monitoring systems are used by the sawyers: if the warning light comes on, reduce the feed speed; if the warning lights come on even at low speeds: change the saw. On the other hand, if no lights come on, then the sawyer can feed faster. Some saw filers are using an oscilloscope or chart recorder to track saw performance and to identify sawing problems. However, the major benefits of saw deviation monitoring on production are gained from the sawyer responding to the warning lights.

This paper discusses how to get the most information from the deviation signals. Some of these techniques are already used by universities, research laboratories, and at least one sawmill. Some have yet to be developed. The availability of inexpensive computing power and new programming methods makes these techniques possible. These products will provide information for sawmills to further improve sawing accuracy, throughput, and machine reliability.

Uses of Saw Deviation Data

The signal produced by the deviation probe is a voltage proportional to the blade displacement. To be useful, this voltage must be converted to a number by calibrating the probe to produce, for example, 1 volt for every 0.100 inches of blade deflection.

Another aspect to account for is time. Common questions that arise during trouble-shooting are:

- when did the problem start?

- how quickly did the accuracy deteriorate?
- does the problem only occur at the beginning of the cut?
- did the press roll come in late?
- is the problem in every cut, or is it intermittent?

The mean deflection, or the number of times that a warning limit is exceeded for a shift provides no information about when the blade deflected. When time is part of the deviation data it becomes possible to trace a problem to it's cause and to make informed decisions about the consequences of possible solution.

This is the key point: information is needed for making decisions. When the sawyer sees a warning light flash, the decision is simple: slow down. Saw monitoring systems that aspire to be more than flashing lights must organize and present the deviation data in ways that will guide decisions about saw changes, feed speeds, saw preparation, operator habits, and the handling of different species.

In high production mills a lot of numbers can be collected, even if all that is recorded is the average and standard deviation of the blade deflection for each log. The simplest method for presenting that data is in two numbers: overall average and standard deviation for one shift. Another number is the number of times that a warning limit was exceeded during a shift. These numbers are valid, but much information is lost that would be useful when looking for the cause of a problem, or more importantly, when looking for opportunities for improvement. The information that was lost is related to time.

Different time scales must be used for different analysis goals. If the goal is to prevent gradual deterioration of sawing performance (or to prove improved performance) then the a graph showing saw deviation once an hour, once a shift, or even once a week, will provide the needed information. This process is called trending. If the goal is problem solving, then it is necessary to have detailed traces of blade deflection from within a cut, where the interval between measurements is a fraction of a second.

Trending

The purpose of trending is to determine whether a problem is developing, nothing has changed, or there is an improvement. Well developed statistical methods are available for determining whether the process is in control, getting worse or getting better with time. Graphs of change over time are called 'control charts' by statisticians because if some points go outside the upper or lower 'control limits' then there is 95% certainty that a significant change has occurred and action is required. Control charts are not new to sawmills: they are produced by all the lumber size control programs. Figure 1 is an example of a control chart.

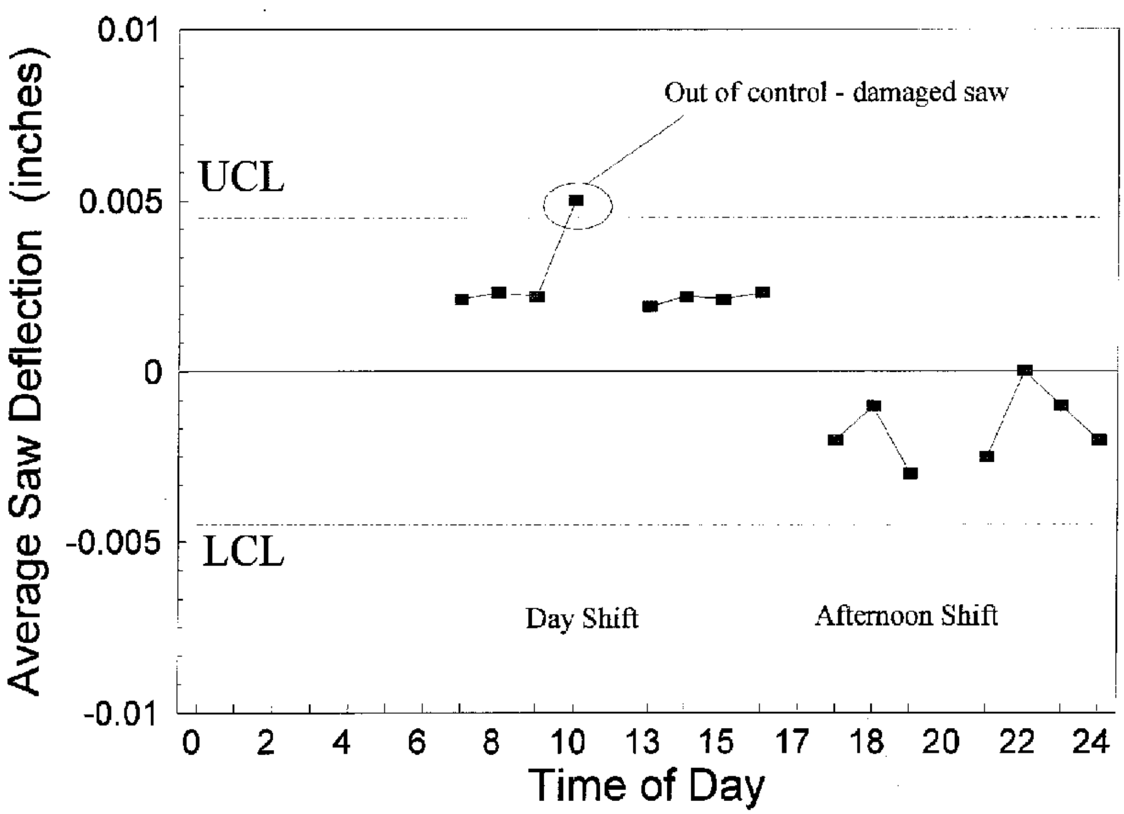

Figure 1. Control chart for average saw deflection over one day.

When every cut is monitored, it is possible to produce hourly statistics showing, for instance, how long the saws are staying sharp. If the time scale is in days instead of hours, then the chart would show the effectiveness of training, new filing room equipment, machine realignment or any other change or combination of changes.

Control charts for a saw should be instantly available to the sawyer, filers and the production supervisor so that timely decisions can be made that maximize production and recovery. Yesterdays quality control data is too late. Given today's computer power and networking capability, this is an achievable goal.

Problem Solving

Statistics, including trending, can warn that something has changed, and may give some clues about the cause of a problem. More evidence is needed track down and confirm the causes. The best procedure is to look at detailed pictures of how the blade deflected. An example of a deflection trace is shown in Figure 2.

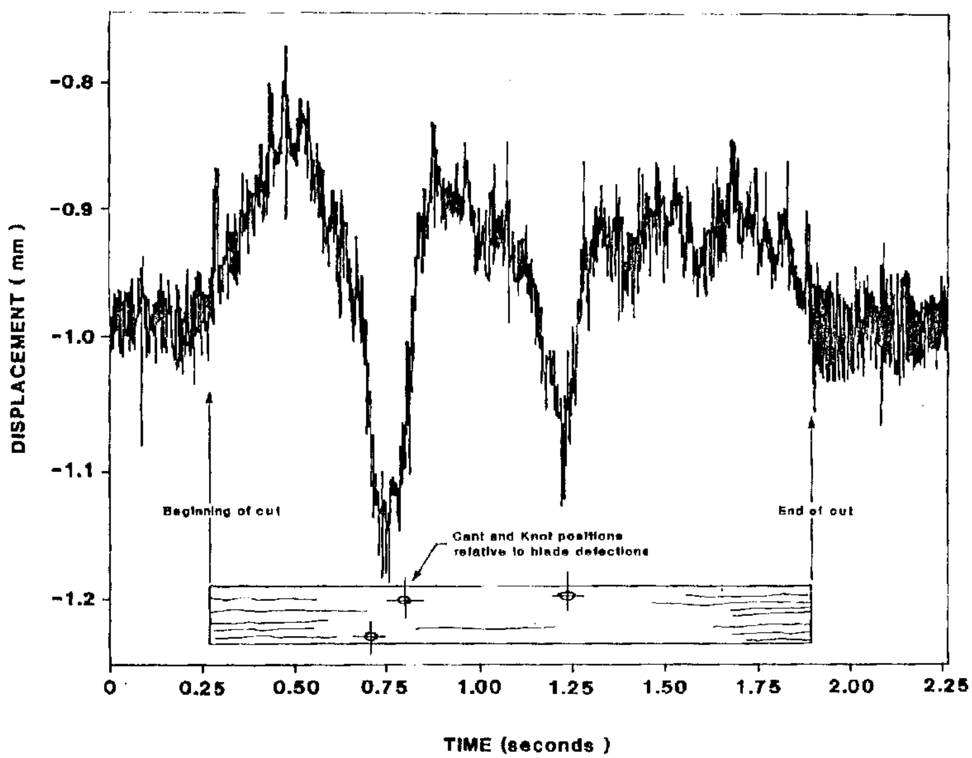

Figure 2. Displacement of blade showing cant and knot locations (Source: John Taylor, Forintek Canada Corp.)

When the deflection trace is shown at this scale, it is possible to assess how the blade behaved. Some expertise is needed to make a detailed interpretation of theses traces, but one can see immediately whether the blade is cutting off target or is not recovering from knots. The biggest challenge is to spot patterns of behavior because each log will present a different loading on the saw. There is also the complication of intermittent problems such as slivers in the guides, and sticking press roll cylinders.

The physics of sawing is discussed below, but some examples of commonly seen behaviors are:

- the blade leans to one side for every cut.
- recovery from knots is slow
- blade 'jumps' at the same point along the cut, for every cant.
- snaking, even in clear wood
- snipe
- press roll and timing problems
- over feeding or dull saws (when to change saws)
- incorrect guide lead or problems with shifter rails
- sawdust packing guides
- unequal tooth angles
- worn or damaged guides

Searching for patterns in saw behavior is a task well suited to an expert system program for three reasons:

1) a computer can store and manipulate the large volume of data that will be collected;
2) a computer can analyze every cut, whereas a person would quickly become bored; and
3) 3) a computer can isolate several patterns that occur together. This detailed analysis is not only useful for trouble-shooting, but also for identifying opportunities for improvement.

Data Bases

So far the only data that has been discussed is saw deviation. Other information would also be useful to have, especially if it can be matched to changes in sawing deviation. If saw and machine maintenance were coupled with saw deviation data, then one could document cause and effect. More importantly, one could plan maintenance based on ongoing performance.

A key element for predictive maintenance is to develop a catalog of machine problems and their solutions. An example is of this is the characteristic trace seen on the oscilloscope that indicates a failure of one of the wheel bearings. Some warning signals will be predicable from machine design considerations, but most will come from experience and insightful observations. In this manner the development of saw monitoring is comparable to machine vibration monitoring for bearings, and rotating machinery.

Monitoring for Sawing Research

Displacement probes have been used in the sawing research laboratories at Forintek Canada Corp. and the University of British Columbia for about twenty years. The goals of sawing research usually require that as much data as possible be collected. Often two or more probes are used to get a better picture of how the blade deflects (see Figure 3). The large quantity of data is stored, analyzed and graphed by a computer, usually by specialized programs. These instrumentation and computer programs are the foundation for future commercial monitoring systems. They are especially suited to the problem-solving tasks because they can present detailed information about every cut.

The deflection traces in Figure 4 are an example of what is collected and how it is presented. Two probes, located on the blade as shown in Figure 3, were used to measure blade deflection near the front and back edges of the blade. With this information, it is possible to see how the blade twisted through the cut, which is shown in the lower section of Figure 4. These traces clearly show the vibration of the blade before and after the cut, and the beginning and end of the cut. The interesting observation from these traces is that at twice during the cut the back of the blade deflected further than the front. The interpretation is that the teeth on the front edge created a bump on the sawn surface that pushes out the back edge.

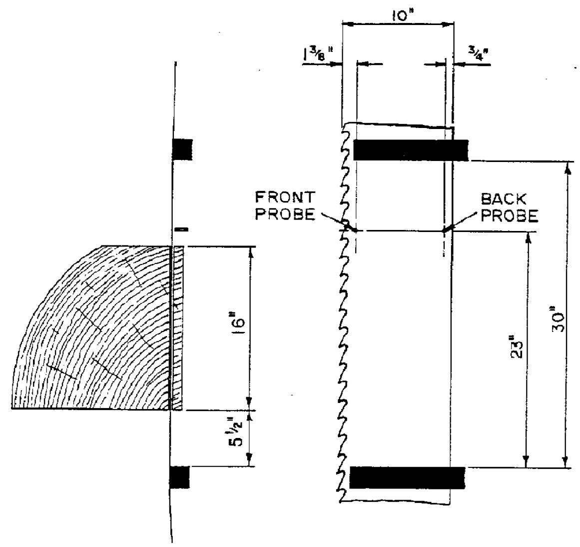

Figure 3. Arrangement of saw and displacement probes for research experiment.

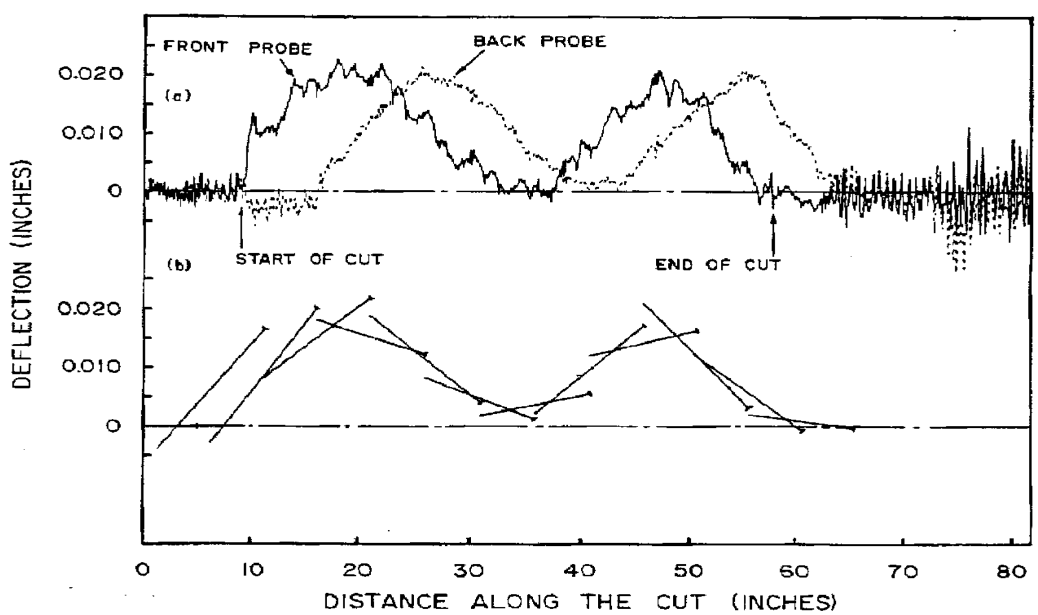

Figure 4. Blade deflection during cutting. a) Displacement at the front and back probes. b) Interpolated position of the blade.

Besides deflection traces and statistics, it is common to determine the frequency content of the blade motion. A typical graph of the how much the blade deflected for frequencies below 100 hz is shown in Figure 5. These spectra, as they are called, are the basic analysis tool for bearing vibration monitoring systems.

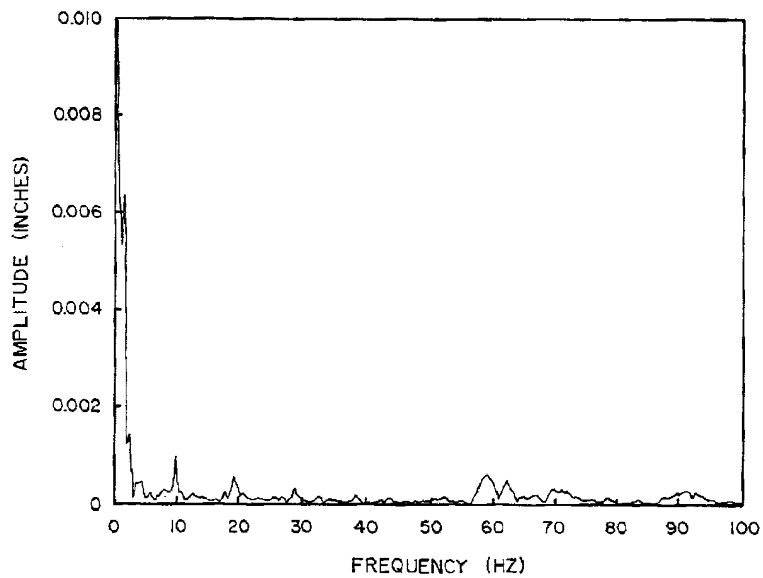

Figure 5. Spectrum of the blade deflection.

The small peak in Figure 5 at 60 hz is the resonant frequency of the blade, which appeared as the blade vibration before and after the cut in Figure 4. Note that this high frequency vibration is damped out as soon as the cut starts. The peaks at 10, 20 and 30 hz are from the weld passing the probe ten times per second. Most of the deflection that is generally called snaking occurs at frequencies below 10 hz. This shows that snaking is a very slow oscillation of the blade.

All these analysis and graphical tools are already available. The task for future saw monitoring systems is to present this information in forms that are quick and easy to understand.

Interpretation of Data

Sawing is a complex process with interactions between the blade, the wood, the sawdust and the feed system. Learning to interpret the data and the deflection traces requires a solid understanding of the factors that govern saw behavior. Computer programs will do all of the routine calculations and, as more knowledge becomes available on the physics of sawing, expert system programs will suggest solutions for simple, common problems. However, people will still have to make the decision to accept the computer's suggestion or to create their own interpretation and conclusions.

Some of the factors that determine how a saw deflects are:

- the cutting forces acting on saw (tangential, feed, and lateral)
- the forces from the blade contacting the sawn surfaces
- the forces of the spilled sawdust wedging between the blade and wood
- the effect of saw stiffness in resisting the forces acting on the blade
- the effect of heat on saw stiffness
- the effect of guide span and guide pressure on stiffness
- the effect of the large variation in wood properties
- the mechanics of how a blade recovers from a knot
- the effects of grinding problems, dulling or tooth damage
- the effects of misaligment of the blade and the feed system
- the effect of not controlling the wood

Every bandmill has its own characteristics that may or may not produce sawing defects. The important task is to find the causes of problems as quickly as possible and to keep searching for changes that will increase recovery and production.

Final Comments

An important benefit of having hard data is fewer arguments between the supervisors, millwrights, operators, electricians and filers because they can see exactly how the saw behaves. When the finger-pointing stops, cooperation is more likely to occur.

Saw monitoring systems will develop to have the same features as vibration monitoring of bearings, including trending, acceptable operating levels, predictive maintenance, and problem diagnosis. There is much work required to make these advanced saw monitoring systems into a form that is friendly to the users, but the sensor technology and programming methods already exist.

When these systems become available, most of the guesswork of saw operation will be gone. Real gains in recovery and production will come if the monitoring system provides information that leads to improvements in the design, operation and maintenance of the sawing centers. To emphasize the importance of saw monitoring, the consistent operation of very thin kerf saws may be impossible without a monitoring system to prevent problems before they become critical.