Development of a Headrig Process Information System

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Abstract

A computer-based process information system was developed to gather operational information about the headrig bandsaw at the Timber Technology Centre (TiTC) sawmill in the Waiariki Institute of Technology, store the data in a database, and display the information in various forms to the user.

The project was the first part of an encompassing programme to instrument an entire commercial sawmill. This research programme aims to determine which variables are crucial to quantifying the sawing processes and to investigate the best techniques for measuring the variables.

The system developed was extremely modular. Both analysis modules and sensor hardware can be added or removed without any need for restarting the system. A client-server architecture using networking communications was used to facilitate this. A central server gathers and stores the data, and individual clients analyse the data and display the information to the user. This enables analysis modules to be added and removed without even restarting the system.

An experiment to determine the effect of wood density on the variables measured was used to test the viability of the completed system. The system successfully gathered all of the information required for the experiment and performed 70% of the data collation and analysis automatically. The remainder was performed using spreadsheets as this was deemed to be the most suitable method.

The loosely coupled design of the system allows it to be up-scaled to a mill-wide program easily. Experiments performed to gather information about pivotal process variables are currently being planned, and should be underway as the expansion into other machine stations is being designed.

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1. Introduction

1.1 Application of Technology to Sawmilling

The popular opinion among many in the forestry sector is that solid wood processing is a low technology industry. It is thought that it is simply a matter of cutting logs into pieces of suitable dimension, and then selling them. The focus is mainly on how many cubic metres of product can be produced in a given day, and what the raw material cost is, in order to increase the margins. This has lead to a commodity market for timber, where it is sold largely by volume.

The result is a low margin industry with a belief that investment in new technology, which claims to improve the quality of their process, is not feasible. This belief has been perpetuated through the use of machinery that is decades old in many of New Zealand's sawmills, some of which have shown sustained successful operation. Many prefer the older machines and techniques because they can understand them, and know what to do when they fail in any way. An example of this is the overseas research into thinner sawblades, which can reduce the amount of fibre lost to sawdust. Commercial trials of this technology in New Zealand have had mixed results because of the level of control of the process required to use it. Thinner blades need more precise maintenance and have a tighter envelope of operation to be successful (Beauregard, 1995). Figures on the sensitivity of the technology to varying New Zealand practices would help sawmillers to make the decision whether to use it.

Higgs (Higgs, 1989) stated in a keynote address "*There are three basic barriers to the adoption of today's saw technology: fear of the* <u>*cost*</u>, *fear of the* <u>*cost*</u>, *and fear of the* <u>*cost*</u>. *Horror stories abound regarding:*

1. *Initial costs in adopting new technology*
2. *Costs in operating and maintaining a 'sensitive' technology*
3. *The cost to egos and careers, 'bruised' by saw program failures*

What often goes unheralded, however, are the profits a successful sawmill can garner through technological adaptation. Competition tends to hush success."

The fact that there is any investment at all in modern technology shows that at least some of the industry would like to make higher value products, but many have expressed views that upgrading is too hard. Edlin (Edlin, 1994) stated that

"The big constraint is the old problem of capital investment, and shifting production towards more refined products with less product volatility". Some of the complaints directed at new technology are that the new machines and techniques are too fussy and include a range of hidden costs. This seems to be due to the high level of refinement of these technologies in order to produce high quality products overseas, but which have to be altered to perform in New Zealand. An example of this is the typical North American log handling apparatus installed in New Zealand. The typical New Zealand Pinus Radiata log is both bigger in diameter and denser than the typical North American hardwood log that most of these systems are designed for. When installed in New Zealand without modification they have been known to either break within weeks of installation due to the excess loading or are unable to hold the logs in the correct position throughout processing (Labeda, 1993). The high cost of altering an off-the-shelf product so that it still performs as well in NZ as in the country of origin can be prohibitive, and unexpected. This is also reflected in the comments that new machines take too long to commission and do not gain as much as promised when complete.

In order to evaluate the suitability of technology to the operating environment of the New Zealand solid wood processing industry, and to determine the relative costs and benefits of implementing of the technology, it is necessary to consider internationally standard techniques or procedures by which the effectiveness of the technology may be determined. Technology is defined here as techniques or machinery applied directly to a given process with a view to improving the effectiveness or efficiency of the process.

1.2 Traditional evaluation techniques

The traditional method of evaluating a manufacturing plant is to break down the plant into discrete elements that each perform a conceptually simple task. The value added to the product as it moves through the plant is summed to produce the total value added in the plant. This concept is known as the "Value Chain" (Tzafestas, 1997). Therefore, to evaluate the manufacturing process's performance the process is similarly broken up into discrete elements and evaluated piece by piece.

Tzafestas later states that these elements need to be examined from different points of view, so that the total impact can be realised. Three views are suggested:

1. User View. The impact that the technology has on the operator or user. Such things as ease-of-use, speed, and effectiveness of the operator due to the technology are taken into account.
2. Technology View. The impact of the interconnections of the elements in the plant. Things such as throughput that affects bottlenecks, compatibility with neighbours, and plant logistics are considered.
3. Enterprise View. The cost of the machinery and maintenance and the changeover cost, as well as the overall value to the company as a business is part of this view.

Often it seems that one or two of these points are considered and well catered for when budgeting for a change in a plant, but very rarely are all three.

Currie (Currie, 1994) offers some techniques for measuring some of these factors, such as Payback Period and ABC[1], but points out that in order to embrace advanced manufacturing technologies organisational changes are required. Regular performance measures are stressed and some trusted management techniques are suggested, such as JIT[2], TQM[3], and TPM[4]. Currie points out that if this is to be successful, then it needs to be part of a long-term (longer than 3 years) plan. However, in some large New Zealand forestry companies it is indicated that a payback period of less than 9 months is required on any new technology investments.

Regular measurement of processes and taking action on the information gathered seems to be the cornerstone of improving manufacturing processes. This seems

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[1] Activity Based Costing

[2] Just in Time

[3] Total Quality Management

[4] Total Productivity Management

to be something that is taken for granted by manufacturing industries but is found lacking in the solid-wood processing industry. In the development of the syllabus of a Joint European Project education programme for computer integrated manufacturing the topic of process control was considered too basic for inclusion.

"*Comparatively low attention is given to such problems as control theory and automation, although these subjects form an indispensable part of the education process. This is due to the fact that these topics are covered by separate publications and are traditional from a certain point of view.*" (Adelsberger et al, 1995)

The New Zealand solid-wood processing industry needs to identify the factors that are crucial to its industry and the build a comprehensive process control programme around them before it can consider becoming a world-class manufacturing and processing industry.

1.3 Factors determining performance

Many factors contribute to the successful performance of a sawmill. In New Zealand the log resource has a large impact on a sawmill's performance. In every situation, each log is different from the next, and requires different processing in order to produce the optimum yield of lumber. However, "*Optimising the value of products from logs and lumber requires accurate information about the types and locations of defects...*" (Tian et al, 1997). This has lead to a booming industry producing log scanners utilising more and more innovative techniques. For instance the Lasar™ log imaging system developed by Perceptron, Vancouver, Canada, which uses a modified conventional laser log scanner and records time-of-flight data rather than triangulating the reflection with a CCD camera. This gives a unique three-dimensional map of the log from a single point of view in one single 'snapshot'. Many of these products have been produced for northern hemisphere hardwood species, and are therefore not always suitable for New Zealand radiata pine due to differing feature characteristics.

There is also a factor of uncontrolled use of the machines, even when they are suitable for the job. Libeda (Labeda, 1993) states "... *sawmills invest huge amounts of money ... and then they do not control the effect of their function*". Once scanned and a solution generated, the process must be monitored in order to determine the level of deviation from the ideal solution.

One of the most common factors used in today's mills to evaluate performance on an individual and aggregate machine basis is sawing variation, and ultimately saw stability. A survey of New Zealand mills in 1986 (Doyle, 1986) showed that the average standard deviation in lumber size was 1.318mm and was allowed for by over-cutting the final dimensions by 2.79mm. A general rule of thumb used in the forestry industry is that reducing the over-cut by 1mm will produce another 1% of annual turnover in revenue. Consequently, there is a lot of research in reducing sawing variation.

The Operating Envelope (Beauregard, 1995;Lunstrum, 1985) has been used in New Zealand as a guide to keep saw machines within limits as dictated by allowable sawing variation.

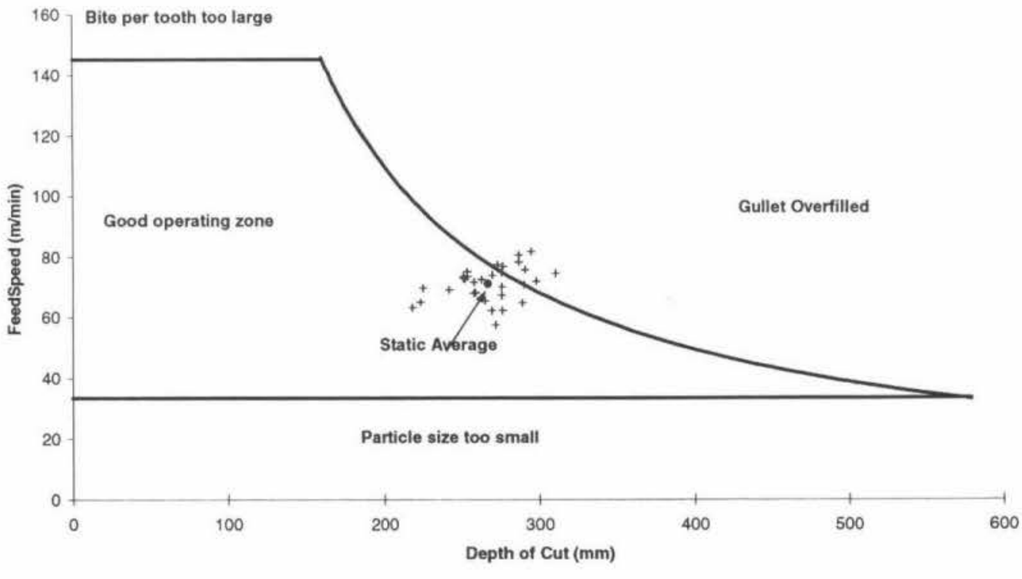

Figure 1-1: Operating Envelope

70% of the tooth gullet filled with sawdust upon exiting the cut has been determined to be the maximum allowable limit before excessive sawing variation occurs, as illustrated by Lunstrum (1985, page 4). The Maximum and minimum feed speeds for a workpiece are calculated from the bite per tooth that the saw design can handle, and the 70% gullet filling line is calculated from the depth of the cut and the feed speed. This produces a closed envelope as shown in Figure 1-1, where the best operating position is next to the curved 70% line and just inside the envelope.

Analysis of vibrations in sawblades have been researched in Canada for some time and have shown that "*... because of a combination of some avoidable and some unavoidable circumstances real bandsaws always vibrate even during idling conditions*" (Hutton, 1997). There has been research to try to understand and perhaps remedy some of these circumstances using theoretical physics, especially on circular saws, such as Sindre Holøyen's work at the Norsk Tretensik Institutt in Norway (Holøyen, 1983), and has had limited success in translating into today's sawmills. Other researchers have attempted to remove vibrations using innovative damping techniques, irrespective of the causes of the vibrations. A fairly successful example is the work performed by Tan, Huang, and Fan at Wayne State University, Michigan. He states "*The on-line control is performed through a DSP (Digital Signal Processor) board and control actuation is provided by non-contact electromagnetic forces*" (Tan et al, 1997). Vibrations in the affected saw are reported to be "*significantly reduced*".

One of the most common methods that is used to keep a saw stable is a guide. Usually, a guide is a lubricated, composite rubber block placed on either side of the non-cutting surface of the saw. Gary Schajer stated that in 1985 "*About half of the rotary gang-saw machines currently in use have guided sawblades*" (Schajer, 1986). However, it has been noted that guides in bandsaws are not designed to eliminate some non-vibrational instability. Taylor (Taylor et al, 1997a) states "*Laboratory and sawmill cutting experiments have shown that bandsaws tend to cut off-line, i.e., the mean sawblade displacement during the cut is biased toward one side.*" Taylor is currently investigating methods of reducing this effect.

The preparation in the sawshop is just as crucial as setting the guides up correctly. Chabrier (Chabrier et al, 1999) gives a good overview of the different aspects of saw doctoring listing some of the attributes that should be measured and benchmarked before a saw is released into service. Some of the factors mentioned include critical speeds, blade tension, and temperature effects, and the interaction of the three. The differences between static measurements on the saw bench and dynamic measurements when the blade is spinning are also highlighted as important.

The surface finish and the visual grading of the product are areas that have been largely subjective. Features such as roughness and knottiness have only recently been able to be measured in an objective way. At the Institut für Werkzeugmaschinen und Fertigungstechnik in Braunschweig, Germany, "... *a new method is being designed and tested which can separately evaluate topographic characteristics originating in the wood anatomy and in the machining process by means of image processing*" (Westkamper et al, 1995). They suggest that the quality measure in this respect is a signal to noise ratio of the visual and tactile effect of the natural wood characteristics versus the machining marks.

With the advent of the Resource Management Act, the noise produced as a side effect of the process can be considered a performance criterion. Rhemrev (Rhemev et al, 1997) shows how noise levels can be monitored objectively and how saws may be redesigned to reduce the noise level without reducing throughput. Conjecture within the industry is that low noise saws also produce less sawing variation due to the reduction of single frequency vibration in the saw, but this has yet to be tested.

Productivity and the economic bottom line seem to be the major driving factors in determining performance. However, Holøyen (Holøyen et al, 1991) states that sawmill productivity, as opposed to production, is not measured effectively if only described in subjective terms. He suggests an objective scheme of on-line productivity measurement to remedy this. Ultimately, a sawmill is part of a business; in order to evaluate any advance in sawmilling practices, the monetary effect on the business of any change must always be taken into account.

1.4 Outline of Thesis

There are several techniques in advanced manufacturing and processing industries that could be applied in the New Zealand solid-wood processing industry to better evaluate new technology. While these techniques are standard in other industries, they are not being regularly applied within sawmills. Part of the problem here is that many of these techniques require regular measurement of pivotal process variables in the form of data, and this data is not readily available in most mills. Many process variables and the techniques required to measure them are available, but it is unclear which variables are pivotal to the sawmilling process and exactly what their interactions are. The research programme that encompasses this thesis is focussed on identifying and ranking these factors and their interactions as a first step towards world-class status. To achieve this, we need to have available a fully instrumented sawmill that is capable of providing the required data.

Chapter 2 describes the requirements of such a facility. While fully instrumenting a sawmill is beyond the scope of this project, this chapter goes on to describe the requirements in instrumenting a single machine station, the headrig bandsaw. The instrumentation set up as part of this thesis is described in chapter 3. The design of the software that captures the information, and makes it available to both the user and the technologist is described in chapter 4.

One of the significant problems identified in current sawmills is sawing variation. Chapter 5 describes an experiment whereby the initial system is tested by gathering and analysing data relating the effect of log density on saw variation. Two key variables measured are blade deviation and bandwheel displacement.

In order to evaluate the success of the project key performance criteria of the information system are measured. Chapter 6 details the results of these measurements, in particular the responsiveness of the system, and discusses the implications.

The final conclusions are made in Chapter 7, which are then set back into the context of the greater research programme. The scalability of the single machine model to a mill-wide system through the use of a local network is discussed.