



**Forintek
Canada
Corp.**

Forintek Canada Corp.
Western Division
2665 East Mall
Vancouver, British Columbia V6T 1W5

**Improved Processing Efficiency of Post Mountain Pine Beetle
Wood, Part II**

by

John Taylor
Research Scientists
Lumber Manufacturing

Stan Hutton
Research Scientist
Lumber Manufacturing

John White
Electronic Engineer
Lumber Manufacturing

Prepared for



Forestry Innovation Investment

Recipient Agreement No.: FII MDF-07-0017
Contract No.: 2007 - 5154

March 2007

John Taylor
Project Leader

Peter Lister
Department Manager

Summary

This report presents the results of laboratory and mill tests that were designed to assist saw mills to process Mountain Pine Beetle (MPB) affected wood in an efficient manner. Experimental testing was conducted at Forintek's Laboratory in Vancouver and at various mill sites. Laboratory tests were conducted using circular saws to cut MPB wood utilizing saws with different numbers of teeth and with different side clearances. Cutting was conducted at different feed and blade speeds under conditions designed to simulate the cutting of 4" and 6" lumber. Laboratory tests were also conducted to determine the effect of saw alignment on cutting accuracy and to determine the difference in power requirements for the MPB killed wood. Mill tests were used to measure circular saw tooth tip wear rates for four different tip materials and the cutting accuracy of swaged tooth and Stellite™ tipped bandsaws.

Based upon the results of this study, saws with the lower number of teeth cut more accurately, use less power and can run with very low side clearances, even when saw speeds and feed speeds are increased well above typical sawmill processing rates. Saw misalignment had little affect on lumber deviation but wedging was significant. Stainless steel circular saws cut more accurately than regular steel saws but differences in wear were not measurable. Cermet tips performed best in circular saw wear tests, followed very closely by carbide. Stellite™ wore much more than the other two materials. For given operating periods, no difference was seen in cutting accuracy between Stellite™ tipped and swaged bandsaws.

Acknowledgements

Forintek Canada Corp. would like to thank its industry members, Natural Resources Canada (Canadian Forest Service), British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, Nova Scotia, New Brunswick, Newfoundland and Labrador, and the Yukon Territory, for their guidance and financial support for this research.

Forintek Canada Corp. acknowledge the assistance provided by the Province of British Columbia through the Forestry Innovation Investment Market Development Program.

The authors would like to thank the following companies:

- Tolko Industries Ltd., Lakeview and Soda Creek Divisions, for their support with the mill tests, sawblade preparation and data collection.
- Canadian Forest Products Ltd. (Canfor), Quesnel Division, for their support with the mill tests, sawblade preparation and data collection.
- Cal Saw Canada Ltd., for there help with tipping the saws and quick delivery.
- Carbide Processors Inc., for the supply of Cermet tips.

Table of Contents

Summary.....	iii
Acknowledgements.....	iv
List of Photos.....	vi
List of Figures.....	vi
List of Tables.....	vii
1 Background.....	1
2 Objectives.....	1
3 Evaluation of Different Circular Saw Designs.....	2
3.1 Introduction.....	2
3.2 Materials and Methods.....	2
3.3 Discussion of Results.....	4
3.4 Conclusions.....	10
4 Affect of Misalignment Upon Cutting Accuracy.....	10
4.1 Introduction.....	10
4.2 Materials and Methods.....	10
4.3 Discussion of Results.....	11
4.4 Conclusions.....	13
5 Comparison of Stainless and Standard Circular Saws.....	13
5.1 Introduction.....	13
5.2 Materials and Methods.....	13
5.2.1 Sawing accuracy measurements.....	13
5.3 Discussion of Results.....	14
5.3.1 Cutting Accuracy.....	14
5.3.2 Plate Wear.....	14
5.4 Conclusions.....	17
6 Power Required for Cutting Green and Dry MPB Wood.....	17
6.1 Introduction.....	17
6.2 Materials and Methods.....	18
6.3 Discussion of Results.....	19
6.4 Conclusions.....	20
7 Measurement of Wear Rates for Stellite™, Tungsten Carbide and Cermet Tipped Circular Saws.....	21
7.1 Introduction.....	21
7.2 Materials and Methods.....	21
7.3 Discussion of Results.....	22
7.4 Conclusion.....	22
8 Cutting Accuracy for Swaged vs Stellite™ Tipped Band Saws.....	22
8.1 Introduction.....	22
8.2 Materials and Methods.....	23
8.3 Experimental Procedures.....	23
8.4 Results.....	23
8.5 Conclusions.....	27
9 Saw Design Recommendations.....	28
10 References.....	28

List of Photos

<i>Photo 3.1</i>	<i>Details of guided saw and height of cant with respect to the saw.....</i>	<i>3</i>
<i>Photo 3.2</i>	<i>Laser probes used to measure surface deviation on cut board.....</i>	<i>3</i>

List of Figures

<i>Figure 3.1</i>	<i>Tooth profiles for the saws.....</i>	<i>2</i>
<i>Figure 3.2</i>	<i>Laser plots of cut profiles at top and bottom of cant.....</i>	<i>4</i>
<i>Figure 3.3</i>	<i>Effect of feed speed and number of teeth on cutting accuracy (blade Set #1).....</i>	<i>5</i>
<i>Figure 3.4</i>	<i>Effect of feed speed and number of teeth on cutting accuracy (blade Set #2).....</i>	<i>5</i>
<i>Figure 3.5</i>	<i>Effect of feed speed on cutting accuracy of 60 tooth saw.....</i>	<i>6</i>
<i>Figure 3.6</i>	<i>Saw set #1 with slide clearance of 0.016".....</i>	<i>7</i>
<i>Figure 3.7</i>	<i>Saw set #1 with side clearance of 0.005".....</i>	<i>7</i>
<i>Figure 3.8</i>	<i>Saw set #2 with side clearance of 0.016".....</i>	<i>8</i>
<i>Figure 3.9</i>	<i>Saw set #2 with side clearance of 0.005".....</i>	<i>8</i>
<i>Figure 3.10</i>	<i>Effect of blade speed on cutting accuracy blade 301.....</i>	<i>9</i>
<i>Figure 3.11</i>	<i>Effect of blade speed on cutting accuracy blade 302.....</i>	<i>9</i>
<i>Figure 4.1</i>	<i>Plan view of saw misalignment.....</i>	<i>11</i>
<i>Figure 4.2</i>	<i>Effect of saw lead on wedging.....</i>	<i>12</i>
<i>Figure 4.3</i>	<i>Effect of misalignment on wedging and sawing deviation.....</i>	<i>12</i>
<i>Figure 5.1</i>	<i>Location of board measurements.....</i>	<i>14</i>
<i>Figure 5.2</i>	<i>Plate wear measurement locations.....</i>	<i>15</i>
<i>Figure 6.1</i>	<i>Cutting power and gullet feed index for the four test saws.....</i>	<i>20</i>
<i>Figure 7.1</i>	<i>Tip radii before and after 7 hr. cutting test.....</i>	<i>22</i>
<i>Figure 8.1</i>	<i>Typical saw cut data.....</i>	<i>24</i>
<i>Figure 8.2</i>	<i>Cutting performance of Stellite™ tipped saw no. 333.....</i>	<i>25</i>
<i>Figure 8.3</i>	<i>Cutting performance of swaged saw no. 14.....</i>	<i>25</i>
<i>Figure 8.4</i>	<i>Cutting performance of swaged saw no. 55.....</i>	<i>26</i>
<i>Figure 8.5</i>	<i>Cutting performance of Stellite™ tipped saw no. 444.....</i>	<i>26</i>
<i>Figure 8.6</i>	<i>Cutting performance of Stellite™ tipped saw no. 222.....</i>	<i>27</i>

List of Tables

<i>Table 5.1</i>	<i>Cutting accuracy of stainless and regular saws.....</i>	<i>14</i>
<i>Table 5.2</i>	<i>Saw plate wear before re-tipping.....</i>	<i>15</i>
<i>Table 5.3</i>	<i>Gullet wear measurements for regular and stainless steel saws.....</i>	<i>16</i>
<i>Table 6.1</i>	<i>Cant moisture contents.....</i>	<i>19</i>
<i>Table 6.2</i>	<i>Test saws and operating conditions.....</i>	<i>19</i>
<i>Table 6.3</i>	<i>Cutting power measurements.....</i>	<i>20</i>
<i>Table 8.1</i>	<i>Stellite™ tipped test saws.....</i>	<i>23</i>

1 Background

Due to the Mountain Pine Beetle (MPB) epidemic in central BC, vast amounts of timber are drying and degrading. Because of this, the lumber industry is faced with harvesting large volumes of affected trees and funnelling products made from these trees into existing or new markets. Over 90% of the post-MPB logs that are processed currently go to sawmills and will continue to do so for the foreseeable future, thus the majority of the product is exported to the US as dimension lumber. The provincial government wants to obtain fair returns on the timber before it degrades to the point at which sawmills can no longer process the resource profitably. Consequently, the trees need to be processed as quickly as possible to recover the most value from the resource. To this end, the harvesting quotas have been significantly increased and the sawmill companies are expanding existing plants, or building new ones, to process the increasing amounts of the affected resource.

To handle the increased timber quotas that the Province has made available, the industry would like to increase processing speeds to reduce the production costs of this decreasing quality resource. It is almost as if the industry has been forced to shift to a new tree species with different properties. Due to the change in wood characteristics, such as reduced moisture content (MC), brittle fibre, harder resin and increased grit content, post MPB timber is more difficult to process efficiently. As a result, many mills are experiencing problems trying to maintain existing processing speeds let alone increase them.

2 Objectives

The objectives of this project are to study the various characteristics that are believed to be relevant to the issue of sawing MPB affected wood, with the intent to provide new information that will enable more efficient processing of this resource.

This project compares the performance of different saw designs, examine the performance and durability of different saw and saw tip materials, examine the affect of equipment misalignment and determine the power requirements for a range of blade and feed speeds. In addition, to assist the industry to increase the production rates, the effect of increasing circular saw speeds on saw performance will also be determined. Recommendations will be made to assist the mills to improve production rates and reduce manufacturing costs.

In order to achieve the objectives of this study the work conducted was divided into six separate investigations:

- evaluation of different circular saw designs
- affect of misalignment upon cutting accuracy
- comparison of stainless and standard circular saws
- power required for cutting green and dry MPB wood
- measurements of wear rates for Stellite[™], tungsten carbide and cermet tipped circular saws
- cutting accuracy for swaged vs Stellite[™] tipped band saws

In this report each of these components is addressed in a separate section.

3 Evaluation of Different Circular Saw Designs

3.1 Introduction

The aim of this portion of the study was to investigate different circular saw designs with respect to their ability to cut MPB wood. To obtain information on existing saw designs and practices a mill study was conducted by Forintek [White & Taylor, 2006 Part 1A]. From our interaction with the sawmills the ability to process the wood at high feed speeds was of particular interest. With this in view the following saw parameters were investigated: saw plate and feed speed; number of teeth; side clearance; blade speed.

3.2 Materials and Methods

The experimental work was conducted at Forintek's wood cutting laboratory in Vancouver. The wood used in the testing was MPB attacked Lodgepole pine

It was decided to test four different basic saw designs to determine the one most suitable for processing the MPB resource. Saws with 30, 40, 50 and 60 teeth were chosen to span the range of saw pitches currently in use. The four saw designs are shown in Figure 3.1. Three saws of each design were used in the tests to average out the differences between individual saw performance.

The testing procedure involved making cuts in 10ft long cants, made up from two rough green 2"x 8" boards, and then measuring the cut surface of the wood. Sixteen cuts were used to determine the cutting accuracy for each sawing condition. The overall depth of cut was 3.4", this was considered a good approximation of a single arbor machine cutting 4" lumber and a double arbor machine cutting 6" lumber. These two dimensions are by far the predominant products produced in the BC interior. The cant height was such that the saw remained completely buried during the cut. In this way, the conditions of the lead saw in a double arbor machine were duplicated. Photo 3.1 show details of the saw and the positional relationship between the 2 board cants and the saw. Photo 3.2 shows the two laser probes used to measure the cut surface.

The codes used in the report, 301, 402,....302, 402,refer to the number of teeth and the set of saws. For example 402 refers to the 40 toothed saw from set #2.

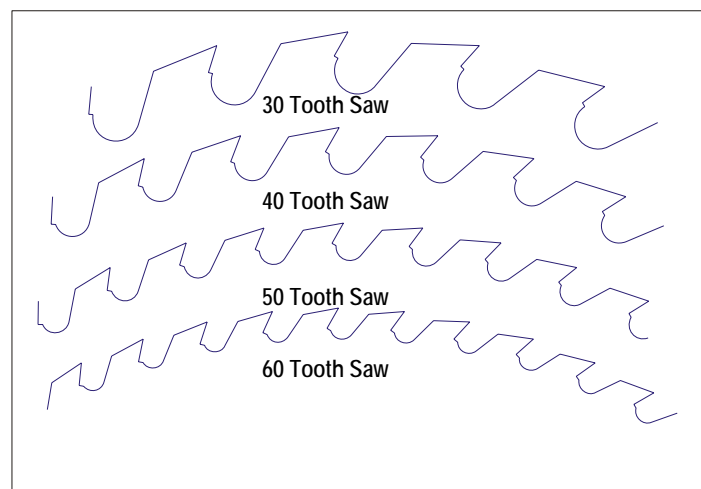


Figure 3.1 *Tooth profiles for the saws*



Photo 3.1 Details of guided saw and height of cant with respect to the saw



Photo 3.2 Laser probes used to measure surface deviation on cut board

Figure 3.2 shows a typical plot of the output from the laser probes from which the sawing accuracy was determined. A negative deflection indicates the blade is leaning away from the cant. The standard deviations of the profiles, measured at the top and bottom of each board, were calculated and recorded. The mean value of the difference between the top and bottom probes was also recorded; this gives an indication of the wedging (the amount the saw leans over) that is occurring.

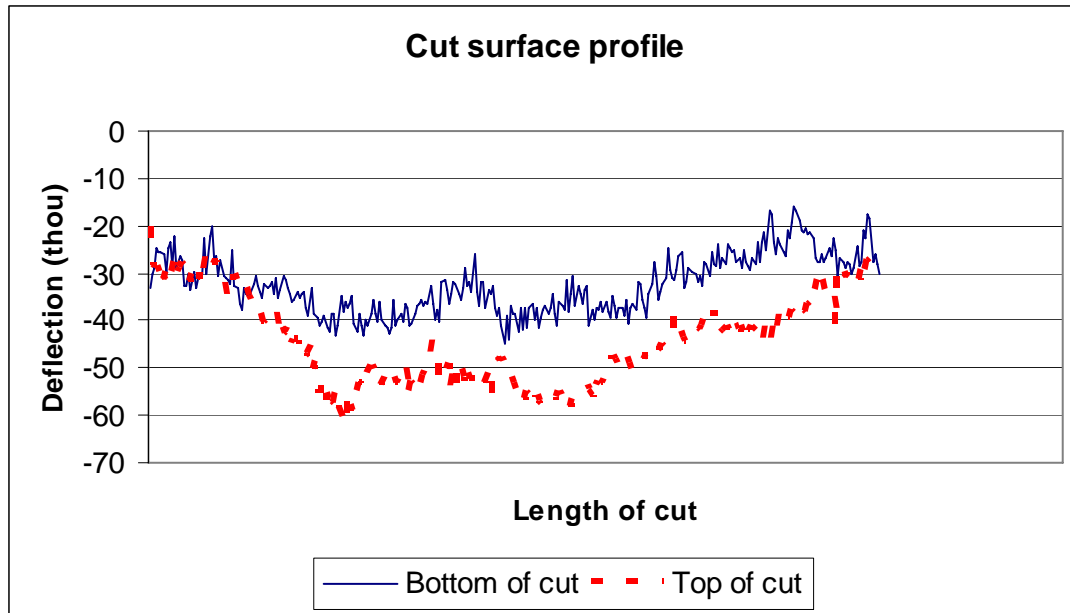


Figure 3.2 Laser plots of cut profiles at top and bottom of cant

The following tests were carried out:

- A. A comparison of the effect of 4 tooth pitches and 2 different Gullet Feed Index's (0.5 and 0.7). For this test the side clearance for all saws was 0.016". The blade speed was held constant at 3000 RPM.
- B. A comparison of the effect of running the 60 tooth saw at a much higher GFI than is traditionally recommended (500 fpm).
- C. A comparison of the effect of side clearance on saws with different numbers of teeth at high feed speed. Side clearances of 0.016" and 0.005" were investigated. The tests were carried out at a constant feed speed of 650 fpm.
- D. A comparison of the effect of blade speed for the 30 tooth saws, with a side clearance of 0.005". Using a constant feed speed of 650fpm, blade speeds of 3000, 3200, 3400, and 3600 RPM were investigated.

3.3 Discussion of Results

Test A

Figure 3.3 presents a comparison of the standard deviation (SD) of the top and bottom traces, as well as the mean value of the difference between the top and bottom records, for the four different pitched blades in set #1. In this figure the listed feed speeds correspond to gullet feed indexes (GFI) of 0.5 and 0.7. Figure 3.4 presents the same data for blade Set #2. As may be seen the data trends are similar in both plots.

These results indicate that increasing the GFI generally increases the saw deviation. The exception was the deviation measured at the bottom of the cant, nearest to the guides, which remained relatively constant.

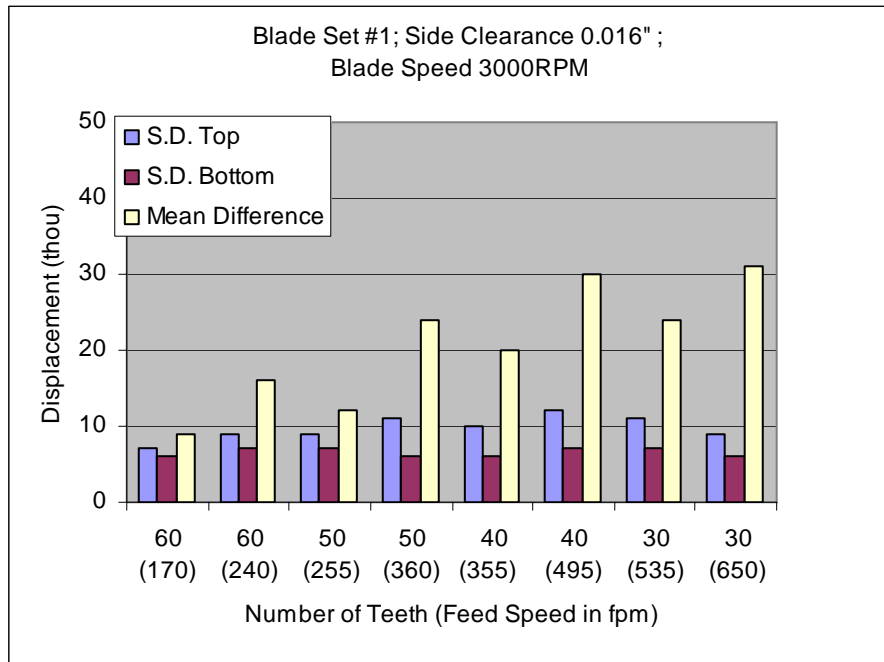


Figure 3.3 Effect of feed speed and number of teeth on cutting accuracy (blade Set #1)

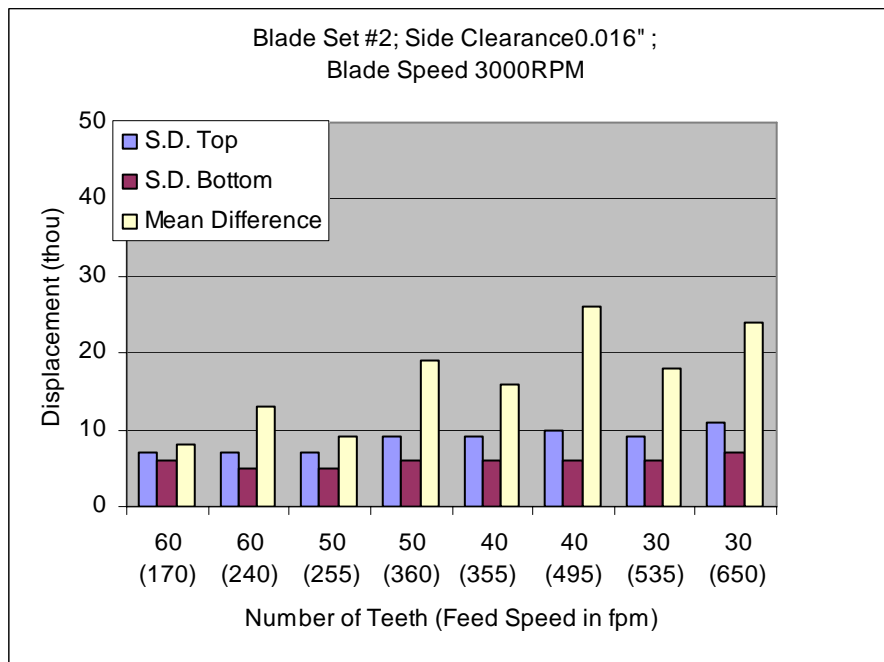


Figure 3.4 Effect of feed speed and number of teeth on cutting accuracy (blade Set #2)

Test B

Figure 3.5 presents the results of running a 60 tooth saw at different feed speeds, up to a maximum of 500 fpm. In these tests only four board samples were used. The tests were designed to see how the 60 tooth saw responded to over feeding of the gullet. The results indicated that it was reasonable to conduct further testing of the 60 tooth saw at such high feed speeds. The GFI's were 0.42, 1.25, 1.67 and 2.08 for the four increasing feed speeds shown. As would be expected the wedging and the standard deviation, measured at the top of the cant, increase with feed speed.

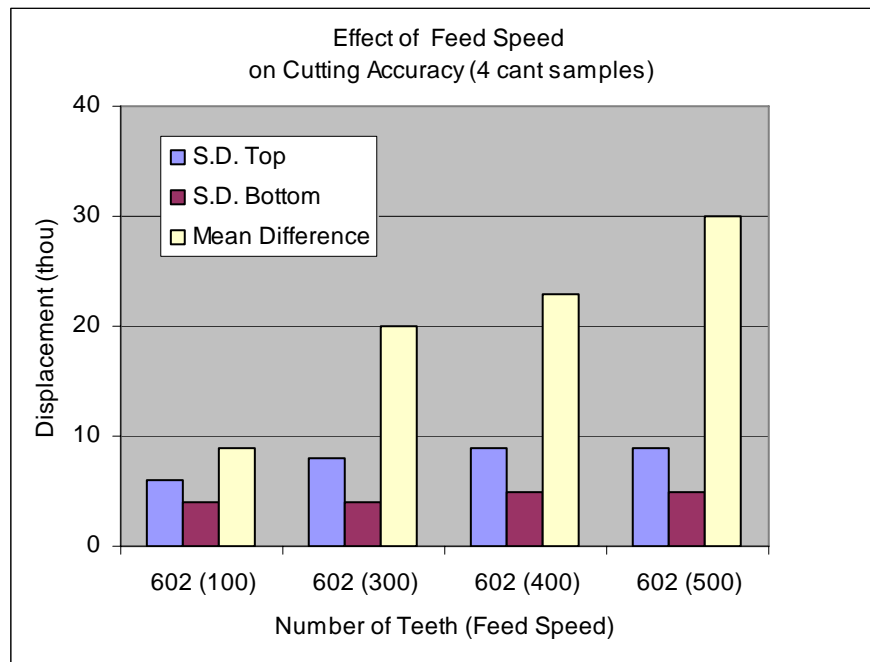


Figure 3.5 *Effect of feed speed on cutting accuracy of 60 tooth saw*

Test C

Figures 3.6 and 3.7 present a comparison of the results for the four saws in Set #1, for side clearance values of 0.016" and 0.005". Figures 3.8 and 3.9 present the same comparison of results for the four saws in Set #2. The blade speed was held constant at 3000 RPM and the feed speed was 650 FPM. The GFI's for this condition were 0.88, 1.36, 1.86 and 2.71 for the 30, 40, 50 and 60 tooth saws respectively.

These results indicate significant differences between the performances of saws with different numbers of teeth. In particular, the saws with 60 teeth perform significantly worse when the side clearance is reduced from 0.016" to 0.005" (when measuring the SD at the top of the cant). There is not a significant difference between the cutting accuracy of the 30 tooth saws when the side clearance is reduced.

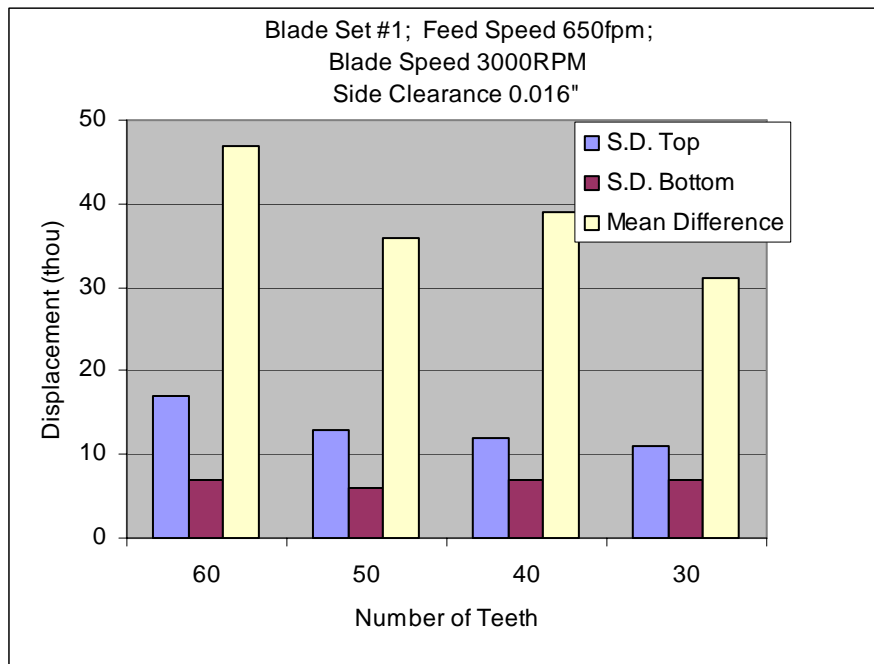


Figure 3.6 Saw set #1 with slide clearance of 0.016"

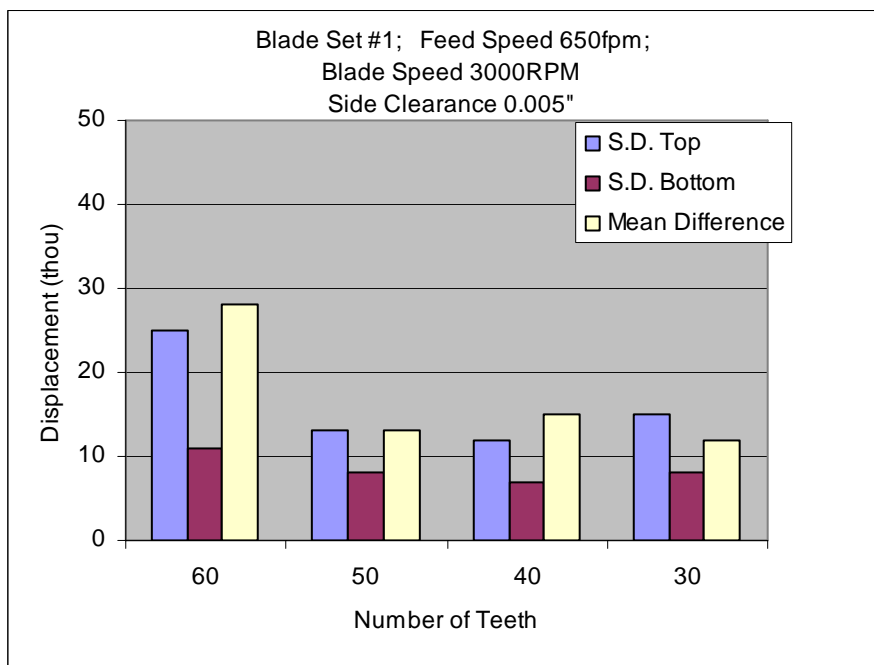


Figure 3.7 Saw set #1 with side clearance of 0.005"

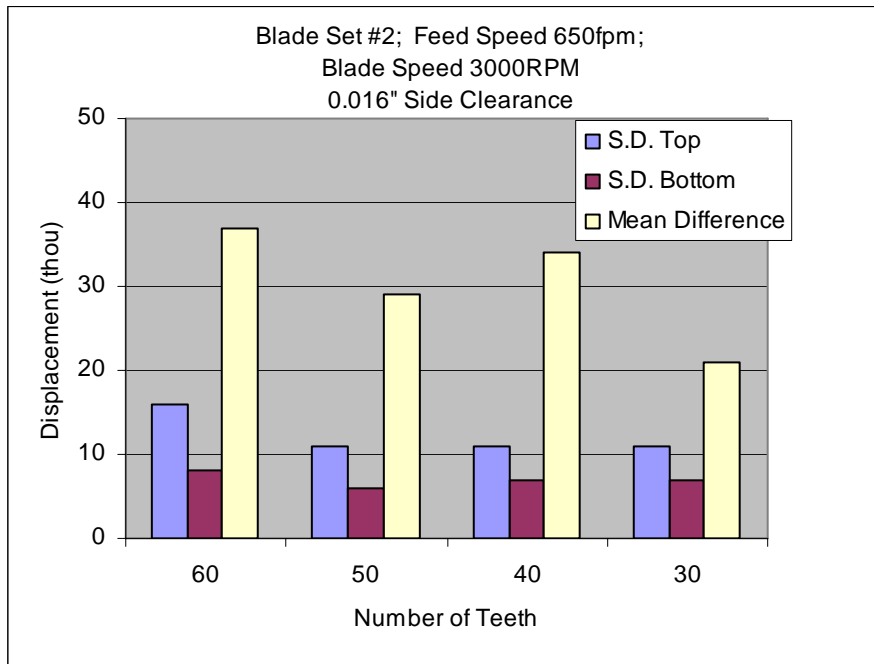


Figure 3.8 Saw set #2 with side clearance of 0.016"

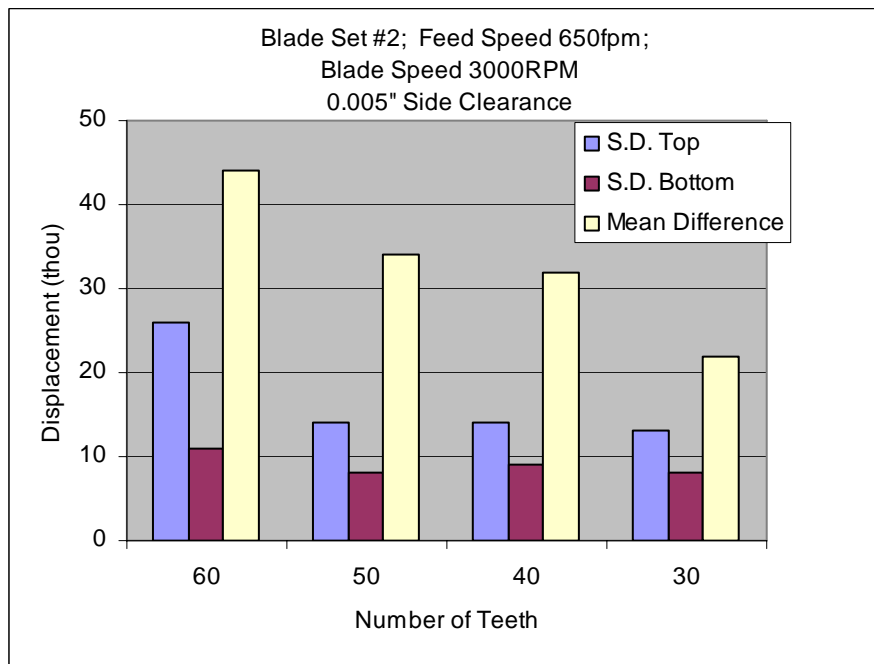


Figure 3.9 Saw set #2 with side clearance of 0.005"

Test D

Figures 3.10 and 3.11 show the results of changing the blade speed while keeping the other parameters constant. As may be noted, blade 301 has better cutting accuracy at all blade speeds but, in the case of both saws, the cutting accuracy is essentially constant, with some slight tendency to improve as the speed increases. It may be noted that the first critical speed of this saw in the region of 3200 RPM.

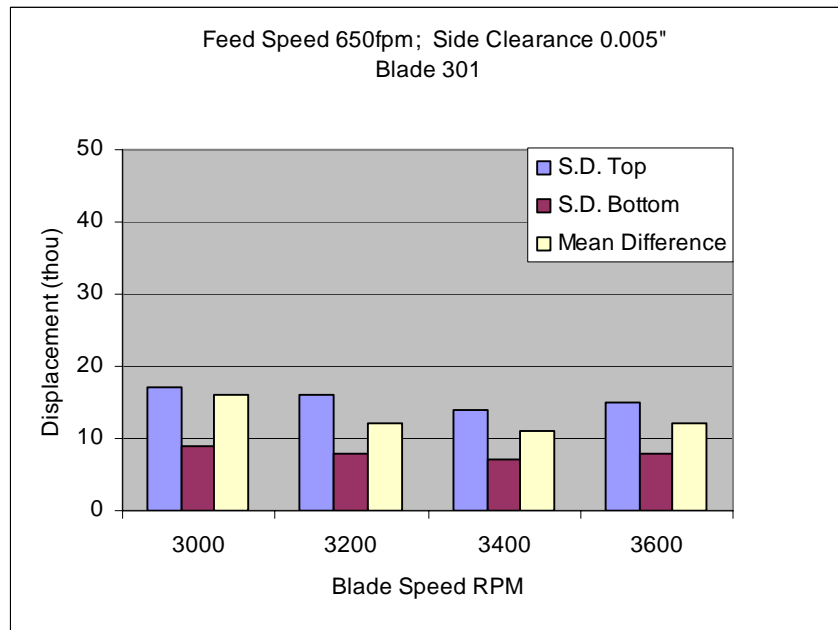


Figure 3.10 Effect of blade speed on cutting accuracy blade 301

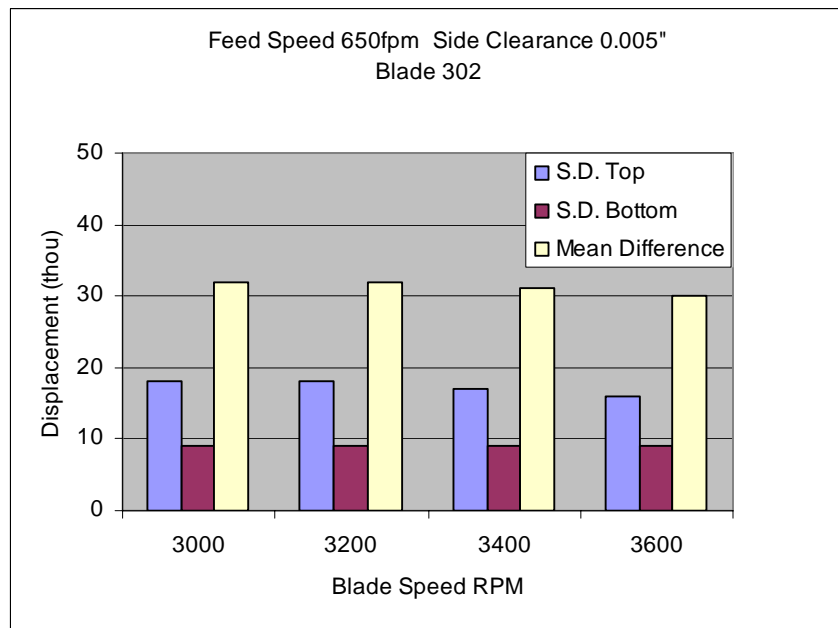


Figure 3.11 Effect of blade speed on cutting accuracy blade 302

3.4 Conclusions

The tests conducted compared the performance of 0.070" thick saws cutting MPB wood with different numbers of teeth and different side clearances, running at different blade speeds and with different feed speeds. Of particular interest was the determination of those parameters that allowed the fastest feed speeds with acceptable cutting accuracy.

The results indicated that the saws with the lowest number of teeth (30) performed the best. These saws had the largest gullet areas and the largest total gullet area. It was found that they could be run satisfactorily at feed speeds of 650 fpm, which corresponded to a gullet feed index of 0.74. Also these saws had essentially the same cutting accuracy with a side clearance of 0.005" as they did with a side clearance of 0.016". It will be noted that kerf width with a 0.005" side clearance is 22% smaller than that with a 0.016" side clearance. Such a difference gives rise to a significant improvement in lumber recovery and a corresponding reduction in sawdust produced.

The tests conducted to determine the effect of blade speed indicated that there was not a significant difference in cutting accuracy as the speed was increased from 3000 RPM to 3600 RPM. The significance of this result is that the higher the blade speed the higher the feed speed that can be handled.

The results pertaining to the fact that higher gullet loadings and smaller side clearances can be tolerated may be a consequence of the fact that the MPB wood is drier than the green lumber traditionally processed.

4 Affect of Misalignment Upon Cutting Accuracy

4.1 Introduction

Alignment is an important issue in sawmills. In many cases, poor cutting accuracy can be attributed to poor alignment. It is estimated that at least 50% of sawing problems are not due to the saws but are due to maintenance and alignment problems. This increase to 75% for complicated lines like a double length infeed with close coupled chipping and sawing.

Some measure of misalignment is a fact of nature in all mills. The question that arises is to the effect of various levels of misalignment upon the cutting performance of the saws. In the tests reported herein deliberate levels of misalignment were introduced into circular saws, and the effect on cutting accuracy documented.

4.2 Materials and Methods

Three saws were used for these tests, designated 07, 08 and 09, and were obtained from a sawmill processing MPB attacked wood. The saws were 19" diameter with 32 teeth, had a plate thickness of 0.075" and an eye for a 3.5 Involute arbor. The mill arbor speed of 2865 rpm and feed speed of 230 fpm were used for all the tests.

Three sets of ten 5" thick by 8" wide by 8-ft long cants were used for the tests. These were made up from three rough green 2" x 8" x 8-ft MPB attacked Lodgepole pine boards. One set of ten cants was used for each saw. Each cut produced a 3/8" board from the cant.

To emulate the effect of alignment errors in a feed system the saw guides were deliberately misaligned with respect to the direction of the feed. The amount of misalignment was measured over a 6" length of the guide pad. A positive value refers to the saw leading into the cant (Figure 4.1).



Figure 4.1 Plan view of saw misalignment

As in Section 3 (Figure 3.2), traces of the surface profile of the cut face at the top and bottom of the cant were used to determine the standard deviation of the cut as well as the mean value of the difference between the two traces. The mean difference of the two traces provides a measure of the “wedging” that occurs due to the blade leaning over in the cut.

4.3 Discussion of Results

The effect of misalignment on the cutting behaviour of all three saws is shown in Figure 4.2. The three saws behave differently with respect to the lateral displacement, however, the shape of the traces are similar. This difference in behaviour between saws is very common and is the reason that three saws were used for these tests. Interestingly, the ‘standard deviation’ (upper traces) are relatively insensitive to saw lead. This is likely due to a stabilizing effect from the interaction between the saw and the wood. The non zero deflection for a perfectly aligned saw (zero lead) is thought due to the influence of the relatively narrow boards being cut from the cant. Previous work has shown that the cutting power reduces as the saw approaches the edge of the cant (Lubkin, 1957).

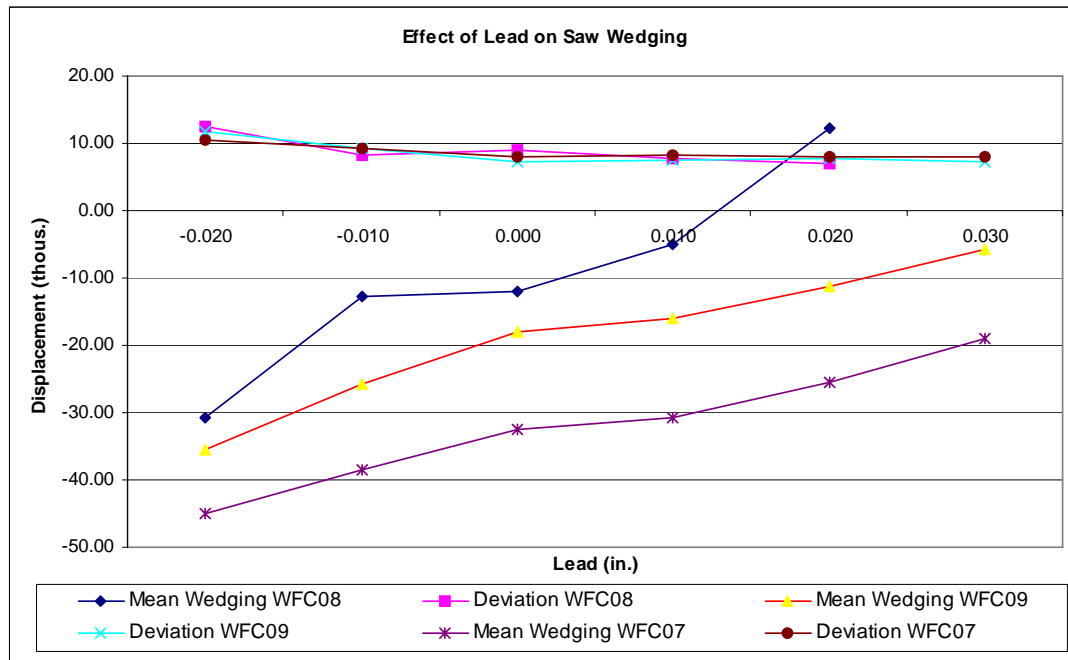


Figure 4.2 *Effect of saw lead on wedging*

The results of the saw misalignment tests are summarized in Figure 4.3. The lower trace is the average wedging for all three saws. The upper trace is the average standard deviation of the bottom and top of the cut. The slope of the wedging with respect to misalignment (lead), is 0.43 in the +/- 0.010" range, increasing to just below 1 outside this range.

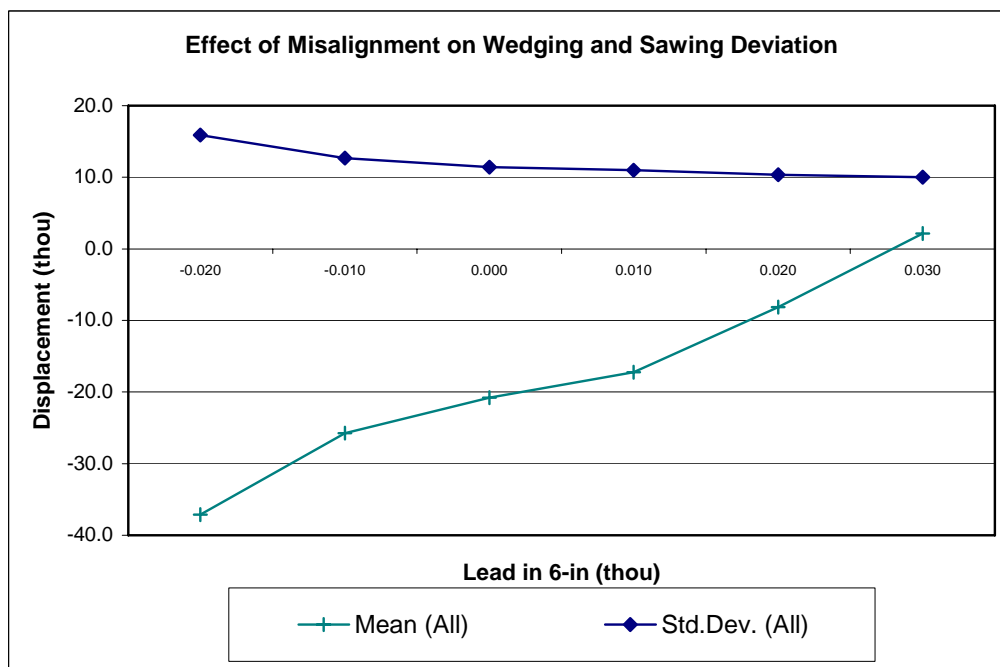


Figure 4.3 *Effect of misalignment on wedging and sawing deviation*

4.4 Conclusions

In most guided saw machines the guides have around 0.003” clearance. Some guide misalignment is likely and will be added to the clearance value and the resulting effect will likely increase deviation and contribute to the wedging of the lumber. If, in a gang saw, the saws are misaligned with respect to one another, the lumber sizes could vary by up to twice the amount of lead.

5 Comparison of Stainless and Standard Circular Saws

5.1 Introduction

Some mills are experiencing an increase in saw wear, saw usage and tip and tooth loss when cutting MPB attacked wood. Stainless steel saws have been available for some time and have a higher tensile strength and material hardness than regular saws and may well reduce the number of saws needed and the number of tooth failures. The purpose of this mill test to determine the wear characteristics and cutting performance of stainless steel saws when cutting drier post MPB attacked wood and compare this to standard steel saws.

5.2 Materials and Methods

The tests were carried out over an extensive period in Tolko’s Lakeview sawmill on the small log, vertical double arbour (VDA) 8” line.

Equipment:

- Small Log Line – 8”VDA gang
- Number of saws per arbor: 4
- Arbor Speed: 3400 rpm
- Arbor type: #3 Retec (6” O.D.)
- Cutting Mode: Climb
- Feed speed: 570 fpm

Saws:

- Diameter: 17”
- Number of Teeth: 50
- Gullet Area: 0.69 sq. in.
- Thickness: 0.075”
- Kerf: 0.090”

The following procedures were used in these tests:

1. The initial plate thickness and gullet corner sharpness was measured.
2. The saws were run on the machine in rotating sets of 8 saws, four of each type on each arbor, four sets in total.
3. The lumber sizes were measured at six places either side of the match line (Figure 5.1). The results were obtained from the sawmill lumber size control software as Within Board, Between Board and Total sawing deviation.
4. When the saws were ready for re-tipping, the plate and gullet wear were measured again.
5. The saws were re-tipped and testing continued.
6. Finally, the wear was measured before the 2nd re-tipping.

5.2.1 Sawing accuracy measurements

Within Board - refers to the sawing accuracy on a board by board basis with little emphasis on any changes in the average size. Mean of the Variances. Between Board indicates the change in average size of the boards and is more a reflection of the networks and feed system than the saws. Variance of the Means. Total Sawing Deviation is a combination of the two. Total Variation.

5.3 Discussion of Results

5.3.1 Cutting Accuracy

To determine the cutting accuracy of both saw types board measurements were taken either side of the match line (Figure 5.1). This gives a closer representation of the actual saw performance because the edge of the board nearest to the saw guides has very little sawing deviation and including this edge in the measurements gives an artificially low value. During the one month test period the sawmill Quality Control department took 1,692 measurements on the side sawn by the regular saws (282 boards) and 1,720 measurements for the side sawn by the stainless steel saws (285 boards). The results show that the Stainless saws had 6.3% lower total sawing deviation than the regular saws (see Table 5.1).

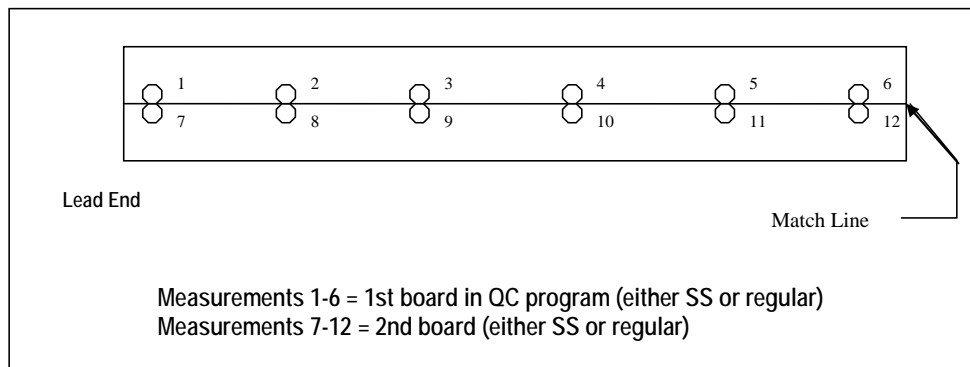


Figure 5.1 Location of board measurements

Table 5.1 Cutting accuracy of stainless and regular saws

Blade Type	Avg. Size			Within Board Deviation	Between Board Deviation	Total Deviation	Number of	
	Target	Avg.	Diff.				Msmts	Boards
Regular	1.660	1.680	0.020	0.015	0.029	0.032	1692	282
Stainless	1.660	1.675	0.015	0.014	0.026	0.030	1710	285
Difference		0.3%		6.7%	10.3%	6.3%		

5.3.2 Plate Wear

To determine the wear rates of the blades the plate thickness was measured in two places (Figure 5.2) and the gullet corners were just measured. Measurements were made when the saws were new and again before the first re-tipping. Table 5.2 shows the thickness measurements for the test saws from new to just before the first re-tipping and before the second re-tipping. All but one of the wear measurements is less than a thousandth of an inch and can be considered due to measurement variation rather than wear. Plate wear before the first re-tipping was less than the measurement error for both the regular and stainless. Unfortunately, the saw history was not traceable prior to the second re-tipping, hence the missing data in Table 5.2. Stainless saw plate wear before the second re-tipping was still less than the measurement error.

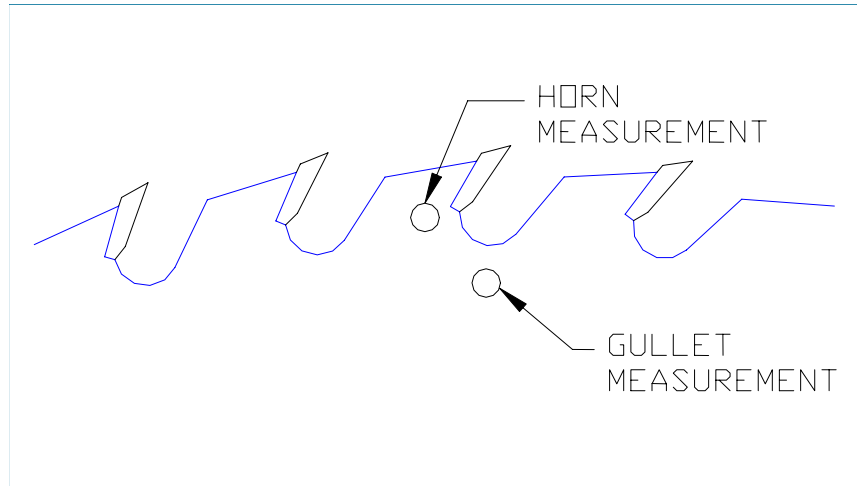


Figure 5.2 Plate wear measurement locations

Table 5.2 Saw plate wear before re-tipping

Saw ID	Gullet of New Saw (in.)	Gullet Before 1st Retip (in.)	Gullet Wear (New- 1st) (in.)	Gullet Before 2nd Retip (in.)	Gullet Wear (New- 2nd) (in.)	Horn of New Saw (in.)	Horn Before 1st Retip (in.)	Horn Wear (New- 1st) (in.)	Horn Before 2nd Retip (in.)	Horn Wear (New- 2nd) (in.)
R8-17	0.0742	0.0742	0.0000			0.0741	0.0735	0.0006		
R8-18	0.0742	0.0740	0.0002			0.0742	0.0737	0.0005		
R8-19	0.0742	0.0743	-0.0001			0.0743	0.0739	0.0004		
R8-20	0.0745	0.0741	0.0004			0.0743	0.0736	0.0007		
R8-21	0.0742	0.0741	0.0001			0.0737	0.0730	0.0007		
R8-22	0.0743	0.0747	-0.0003			0.0743	0.0737	0.0006		
R8-23	0.0740	0.0743	-0.0003			0.0740	0.0722	0.0018		
R8-24	0.0748	0.0744	0.0004			0.0749	0.0726	0.0023		
R8-25	0.0747	0.0743	0.0004			0.0748	0.0731	0.0017		
R8-26	0.0744	0.0745	-0.0001	0.07434	0.0001	0.0746	0.0743	0.0003	0.0742	0.0004
R8-27	0.0748	0.0730	0.0018			0.0749	0.0742	0.0007		
Average	0.0744	0.0742	0.0002			0.0744	0.0734	0.0010		
Std. Dev.	0.0003	0.0004	0.0006			0.0004	0.0006	0.0007		
SS-17	0.0743	0.0744	-0.0001	0.0743	-0.0000	0.0743	0.0744	-0.0001	0.0745	-0.0002
SS-18	0.0733	0.0736	-0.0003	0.0733	0.0000	0.0734	0.0740	-0.0006	0.0735	-0.0001
SS-19	0.0739	0.0743	-0.0004	0.0740	-0.0001	0.0740	0.0743	-0.0003	0.0742	-0.0002
SS-20	0.0739	0.0743	-0.0004			0.0740	0.0741	-0.0001		
SS-21	0.0733	0.0734	-0.0001	0.0732	0.0001	0.0736	0.0737	-0.0001	0.0735	0.0001
SS-22	0.0733	0.0737	-0.0004	0.0735	-0.0001	0.0728	0.0737	-0.0009	0.0735	-0.0007

Saw ID	Gullet of New Saw (in.)	Gullet Before 1st Retip (in.)	Gullet Wear (New- 1st) (in.)	Gullet Before 2nd Retip (in.)	Gullet Wear (New- 2nd) (in.)	Horn of New Saw (in.)	Horn Before 1st Retip (in.)	Horn Wear (New- 1st) (in.)	Horn Before 2nd Retip (in.)	Horn Wear (New- 2nd) (in.)
SS-23	0.0730	0.0734	-0.0004	0.0732	-0.0002	0.0730	0.0736	-0.0006	0.0733	-0.0003
SS-24	0.0748	0.0745	0.0003			0.0748	0.0747	0.0001		
SS-25	0.0746	0.0745	0.0001	0.0743	0.0003	0.0749	0.0745	0.0004	0.0744	0.0005
SS-26	0.0746	0.0742	0.0004	0.0745	0.0001	0.0749	0.0746	0.0003	0.0747	0.0002
SS-27	0.0746	0.0746	0.000			0.0748		0.0748		
Average	0.0740	0.0740	-0.0001	0.0738	-0.0000	0.0740	0.0742	-0.0002	0.0739	-0.0001
Std. Dev.	0.0007	0.0004	0.0003	0.0006	0.0002	0.0008	0.0004	0.0004	0.0006	0.0004

In addition to plate wear, the sharp corners of the gullets become rounded from sawdust abrasive wear. This can lead to an increase in sawdust spilling from the gullet and can result in saw heating, reduced cutting accuracy and accelerated plate wear. As a result, most regular saw steel saws have the gullets reground in a process called “gumming out” whenever the saws are re-tipped. This is a high wear region on a sawblade and was used to measure the wear rates of the two types of saw.

Table 5.3 lists the initial and worn gullet wear measurements for the test saws. Note that saws R8-16, SS-16 and SS-27 were damaged and discarded before gullet wear measurements could be made. No appreciable difference in gullet corner wear could be measured, the corner recessions being almost identical. The regular steel saws had a recession of 0.021” with a standard deviation of 0.007” and the stainless steel saws had a recession of 0.020”

Table 5.3 *Gullet wear measurements for regular and stainless steel saws*

Saw ID	Initial Radius (mm)	Worn Radius (mm)	Difference (mm)	Recession mm
R8-17	0.064	0.110	0.047	0.02
R8-18	0.004	0.072	0.069	0.03
R8-19	0.012	0.045	0.034	0.01
R8-20	0.002	0.081	0.078	0.03
R8-21	0.010	0.048	0.037	0.02
R8-22	0.011	0.047	0.035	0.01
R8-23	0.016	0.055	0.039	0.02
R8-24	0.007	0.071	0.064	0.03
R8-25	0.005	0.066	0.061	0.03
R8-26	0.008	0.038	0.030	0.01
R8-27	0.002	0.055	0.053	0.02
Average	0.013	0.063	0.050	0.021
Std. Dev.	0.017	0.020	0.015	0.007

Saw ID	Initial Radius (mm)	Worn Radius (mm)	Difference (mm)	Recession mm
SS-17	0.040	0.082	0.042	0.02
SS-18	0.033	0.049	0.016	0.01
SS-19	0.023	0.034	0.012	0.00
SS-20	0.035	0.113	0.077	0.03
SS-21	0.029	0.105	0.076	0.03
SS-22	0.026	0.078	0.053	0.02
SS-23	0.035	0.066	0.031	0.01
SS-24	0.040	0.098	0.058	0.02
SS-25	0.023	0.089	0.067	0.03
SS-26	0.012	0.058	0.045	0.02
Average	0.030	0.077	0.047	0.020
Std. Dev.	0.009	0.025	0.023	0.010

5.4 Conclusions

Over a fairly extensive test, the stainless steel saws cut slightly more accurately than the regular saws, giving a 6.7% and a 10.3% improvement in within board and between board standard deviations, respectively, and a 6.3% improvement in total sawing deviation. With respect to the plate and gullet wear measurements, the results were inconclusive. There was no measurable plate wear in either type of saw over the test period, nor was there a significant difference in the gullet corner wear.

One of the objectives in this section was obtain information on the durability of the stainless saws when compared to the regular saws. Due to their increased hardness stainless saws will sometimes shatter when a jam up or crash occurs. Because of this, one other factor we wished to determine was the number of stainless saws that were used compared to the regular saws. The instances of saw failure for the standard saws were not recorded and no comparisons could be made.

This portion of the work emphasized the challenges with any research carried out in the field. It is often quite difficult to maintain control over the tests and make sure that all the necessary data are collected. The tests would be under much better control in the laboratory, however, with items like wear and durability, the mill is the only place that truly represents the conditions. This is one of the ongoing challenges with sawing research.

6 Power Required for Cutting Green and Dry MPB Wood

6.1 Introduction

Due to the change in wood characteristics, such as reduced moisture content (MC), brittle fibre, harder resin and increased grit content, post MPB timber is more difficult to process efficiently. As a result, many mills are experiencing problems trying to maintain existing processing speeds let alone increase

them. The purpose of this mill test was to measure the differences in cutting power required to process the dry MPB affected Lodgepole pine logs when compared to green logs. Initial tests were carried out at Tolko's Lakeview Division, however, the results were inconclusive and the tests were transferred to Forintek's laboratory where it was easier to control the variables.

6.2 Materials and Methods

Equipment

- Forintek Laboratory Circular Saw
- Load Controls Inc. PH3A-350 Power Transducer.
- Delmhorst RDM-2S pin-type moisture meter
- Arbor type: #3 Retec (6" O.D.)

Operating Conditions:

- Cutting Mode: Climb
- Arbor Speed: 2550 rpm
- Feed speed: 300 fpm
- Depth of Cut: 5.125"
- Length of cut: 9 ft
- Wood: MPB attacked Lodgepole Pine

Saws:

- Diameter: 17" (Regular saw steel)
- Number of Teeth: 30, 40, 50 & 60
- Nominal Plate Thickness: 0.070"
- Nominal Kerf: 0.100"

Wood:

- 12 Cants each made up from three 2" x 8" by 10-ft rough green boards.

The test procedure consisted of cutting the same 12 cants, first in a wet condition and then in a dry condition, with the above four saws. The lumber for the tests was obtained from the Williams Lake region, however, very few boards were found with moisture contents above fiber saturation. To overcome this problem 40 boards were pressure treated with water in Forintek's treated wood pilot plant. Refer to Table 6.1 for the average initial moisture content of each cant, based on a calculated oven dry weight, and the original board moisture measurement.

The MC of wood is defined as the weight of water in the wood divided by the oven dry weight of the wood. The calculated oven dry weight was needed to obtain the MC of the cants after the pressure treatment; this is because measurements of MC significantly above fibre saturation are unreliable. The initial MC and weight of the boards were measured prior to pressure treating and the oven dry weight calculated. This oven dry weight was then used to determine the MC after pressure treatment.

Each saw was then used to cut each of the 12 'wet' cants, with the operating conditions shown in Table 6.2, and the horsepower measured and recorded. After allowing the boards to dry the cutting tests were repeated. It was appreciated that the gullet feed index for the 50 and 60 toothed saws was very high, however, many sawmills are trying saws with more teeth and we were interested in the power consumption when these were used at typical feed speeds.

Table 6.1 *Cant moisture contents*

Cant Number	Initial Measured M.C. (%)	Calculated M.C. After Treating (%)	Air Dry Measured M.C (%)
1	31.5	70.6	13.1
2	30.8	63.7	16.4
3	32.4	74.3	15.3
4	30.9	64.5	15.8
5	28.1	64.1	20.3
6	31.2	55.8	17.4
7	31.8	58.9	18.0
8	32.2	70.3	20.6
9	31.4	62.7	19.2
10	32.1	67.3	19.3
11	31.8	63.0	18.9
12	30.9	57.3	19.0
Total	31.3	64.2	17.8

Table 6.2 *Test saws and operating conditions*

Saw ID	Number of Teeth	Gullet Area (Sq.in.)	Feed Speed (Fpm)	Resulting GFI
3-7-1	30	0.49	300	0.48
4-7-1	40	0.24	300	0.74
5-7-1	50	0.14	300	1.01
6-7-1	60	0.08	300	1.47

6.3 Discussion of Results

Net cutting power for the four saws is shown in Table 6.3. As expected, cutting power is higher for the dry wood, with the exception of the results for the 60 tooth blade. During the cutting of wet wood noticeable packing of sawdust in the gullets was observed with the 60-tooth saw. This packed sawdust did not clear during cutting and the added friction increased the cutting power, accounting for the sudden increase in power for this saw in wet wood (Figure 6.1). Sawdust packing did not appear to be a problem when cutting the dry wood.

Cutting power in rip sawing is proportional to the number of teeth in the cut (Taylor et al, 1999) consequently, saws with the higher number of teeth will use more power. Cutting energy decreases with bite but it does not compensate for the extra teeth in the cut. Additionally, saws with a high number of teeth have a smaller relative gullet area and sawdust friction against the cut surface is also a factor. This is ably demonstrated in the results of the 60 tooth saw in wet wood.

Table 6.3 *Cutting power measurements*

Saw Numbers	Number of Teeth	Cutting Power (Green)		Cutting Power (Dry)		Increase of dry wood (%)
		Mean (Hp)	Deviation (Hp)	Mean (Hp)	Deviation (Hp)	
MPB 3-7-1	30	28.4	5.9	31.1	6.4	8.7%
MPB 4-7-1	40	30.3	7.0	33.4	7.0	9.3%
MPB 5-7-1	50	33.4	7.2	36.9	8.7	9.4%
MPB 6-7-1	60	48.2	11.6	41.1	8.7	-17.3%

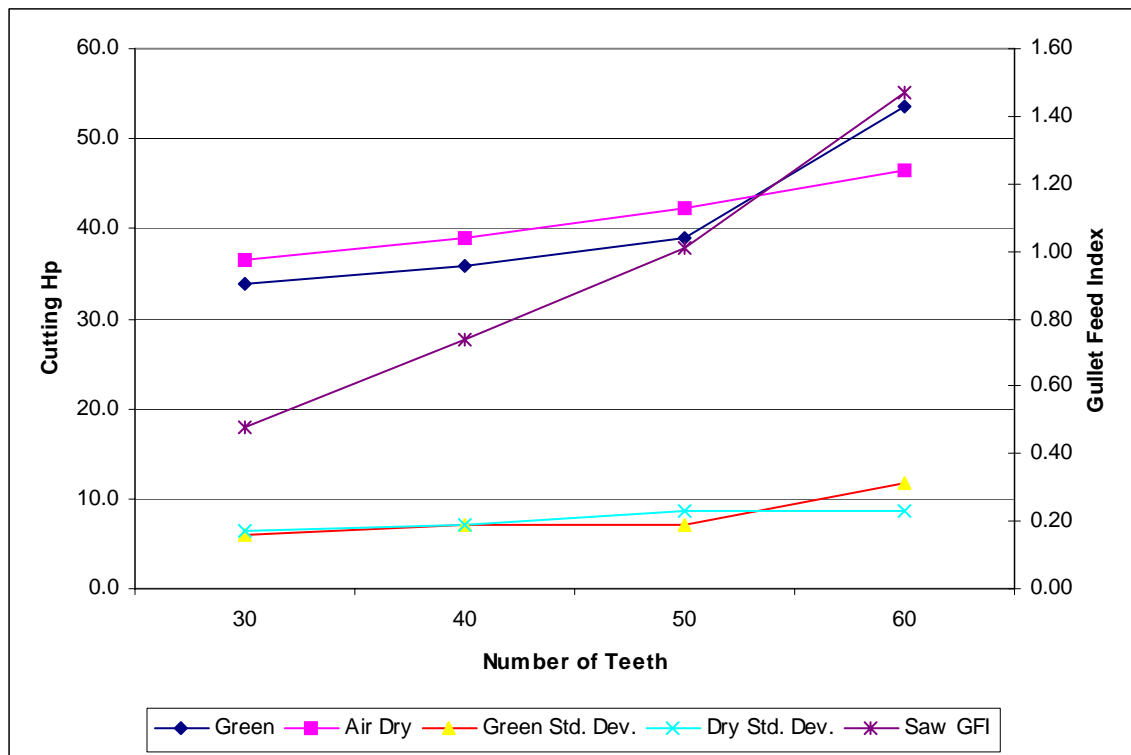


Figure 6.1 *Cutting power and gullet feed index for the four test saws*

6.4 Conclusions

The results of the laboratory cutting tests indicate a 9% increase in power when cutting the dry MPB attacked Lodgepole pine. For the cutting conditions evaluated, the 30 tooth saw would seem to be the most appropriate with respect to power required, followed closely by the 40 and 50 tooth saws. The 60 tooth saw cannot compete against the 30 tooth saw due to the excessive gullet feed index required to maintain similar processing speeds.

Many sawmills in Canada processing softwood lumber are using saws with a high number of teeth. Although this study was directed at MPB attacked wood, it is apparent from the results that saws with fewer teeth are more efficient and can process wood at higher speeds. The only reason this may not apply in a mill environment is if tooth breakage and tip loss become a major problem due to the higher tooth bites.

7 Measurement of Wear Rates for Stellite™, Tungsten Carbide and Cermet Tipped Circular Saws

7.1 Introduction

The wear tests for the carbide and Stellite™ tipped circular saws were carried out at Canfor's Quesnel sawmill. The mill supplied the saws and tipping was arranged by Forintek. Although not included in the original proposal, we were able to obtain two different types of ceramic/metal tips (Cermets) to include in the testing. This is a relatively new material to the wood products industry and provides an interesting addition to the information obtained by the tests.

Due to the unforeseen problems that can occur during sawmill tests, only two saws were used at a time. The first set ran for 3.5 hours until a saw change became necessary (not necessarily due to the test saws). The second set ran for just over 7 hours before a saw change was required. The second set were returned to Forintek's laboratory and used for the wear measurements.

7.2 Materials and Methods

Machine:

Comact DDM 500 vertical single arbor curve sawing machine with 8 saws.
RPM 2800

Tips:

- S = Stellite™ -12
- C = OM-2 Carbide
- A = Cermet Type A
- B = Cermet Type B

Saws:

- Four 19" diameter
- Plate 0.100"
- 46 teeth
- Kerf: 0.136"
- 5" Ultratech arbour
-

Feed Speeds:

- 4" - 600 fpm
- 6" - 375 & 400 fpm

Amount processed:

- 560 logs per hour

Wear:

Impressions of the tip cutting edges were taken before running the saws in the mill and again on completion of the tests. The difference in tip radii were used to compare the wear rates of the different tip materials.

7.3 Discussion of Results

Impressions were taken from three tips of each type. The tip radii from before the test and after 7 hours of cutting are shown in Figure 7.1. Due to the wear mechanism of the different materials, the initial tip radius is not a major factor when considering wear. However, as all the tip radii were similar, the final radii can be taken as a good indicator of wear rate.

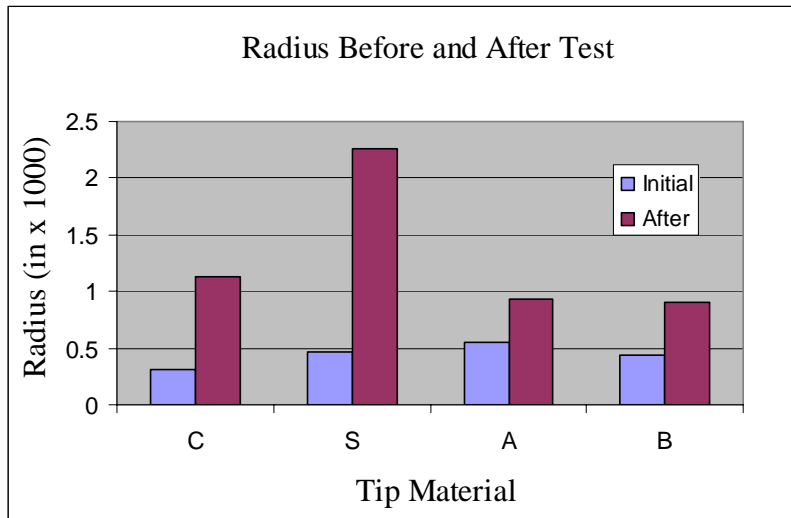


Figure 7.1 Tip radii before and after 7 hr. cutting test

7.4 Conclusion

After 7 hours of cutting, at 560 logs per hour, the two cermet tips performed slightly better than the carbide. The Stellite™ showed the most wear. Use caution when evaluating the different materials based on wear rates. Stellite™, even though it wears faster, has shown improved sawing accuracy and fewer saw changes when compared to carbide (Mill test results, 2005). This is thought due to the wear mechanism of Stellite™ which tends wear to a smooth rounded tip compared to carbide, where the matrix recedes and the carbide granules break out leaving a rough edge.

8 Cutting Accuracy for Swaged vs Stellite™ Tipped Band Saws

8.1 Introduction

Although hard tipping has been shown to extend saw sharpness the majority of bandsaws in the interior of BC have swaged tips. The purpose of this test was to see whether Stellite™ tipped bandsaws maintain their cutting accuracy better than conventional swage tipped saws, when processing MPB attacked wood. The tests were carried out at Tolko's Soda Creek Division.

8.2 Materials and Methods

The tests were carried out on a double length infeed canter line with close coupled chipping and sawing.

Equipment:

- DLI with CC Chipping & Sawing
- 6' Twin bandmills
- 7" average cut depth
- 11,500 sfpm rim Speed:
- 21,000 lbs Strain
- 300 - 450 fpm feed speeds

Saws:

- Length: 36-ft 10-in.
- Plate Thickness: 0.072" (15ga.)
- Width: 10" overall
- Pitch: 2.25"
- Gullet Area ~ 1.12 sq.in.
- Nominal Kerf: 0.150"

8.3 Experimental Procedures

Four saws were supplied by Forintek for the cutting tests, two left-hand and two right-hand. The saws had the same specifications as those used at the mill except they were Stellite™ tipped instead of swaged. The saws were checked by Forintek and the mill prior to use. Saw numbers and handing are shown in Table 8.1.

A portable version of Forintek's Bandsaw Monitoring System was installed on the twin bandmills to record cutting accuracy for the tests. To try and equalize the characteristics of wood cut by the two saw types, a Stellite™ tipped saw was run on one bandmill while a regular swaged saw was run on the other bandmill. When the saws were changed the swaged and Stellite™ saw positions were reversed to account for any difference in the two bandmills and any bias in the sideboard removal.

Table 8.1 *Stellite™ tipped test saws*

Saw Number	Bandmill	Number of Runs
111	Left	1
222	Right	1
333	Left	1
444	Right	2
Note: The bandmill hand is defined by the view from the in-feed end.		

8.4 Results

Data for approximately 25,000 cuts for each bandmill were collected over a four-day period. The monitoring system collects real time saw blade cutting data at 100 Hz and calculates and stores the mean and standard deviation of each cut. Figure 1 shows the results for Saw #222, cutting over 900 cuts within a three-hour span.

As most saws, even when prepared identically, tend to have different cutting behaviors, it was decided that the best way to compare the performance of the swaged and Stellite™ saws was to compare the performance at the beginning of a run, when the saws are sharp, to the end of the run when they are ready for changing. The rather dense data shown in Figure 8.1 is not ideal for comparing performances of different saws, consequently, individual saw performance was broken down into blocks of cuts depending on the amount of data collected. In this manner, the change in saw performance could be readily

observed. Figures 8.2 to 8.6 show typical sawing performance of the saws broken down into blocks. The size of each block is indicated by the number of cuts that are incorporated into the mean and standard deviation bars.

Examining the available data and comparing Figures 8.2 to 8.6, it is apparent that there is no clear difference between the two types of saw blade, even at the end of a 7-hour run, when one would expect the swaged saws to be quite dull. Some blades improved with time, others deteriorated and some switched part way through the period of operation. Changes in log size and quality throughout the shift could account for the variability between consecutive blocks of data. There were also some problems with logs breaking, twisting and moving during the chipping and sawing process. This can easily damage a saw and affect the performance. It should also be noted that these are fairly heavy band saws (15-ga) for the average depth of cut (7") and this could well be one reason for the lack of difference in the two saw types.

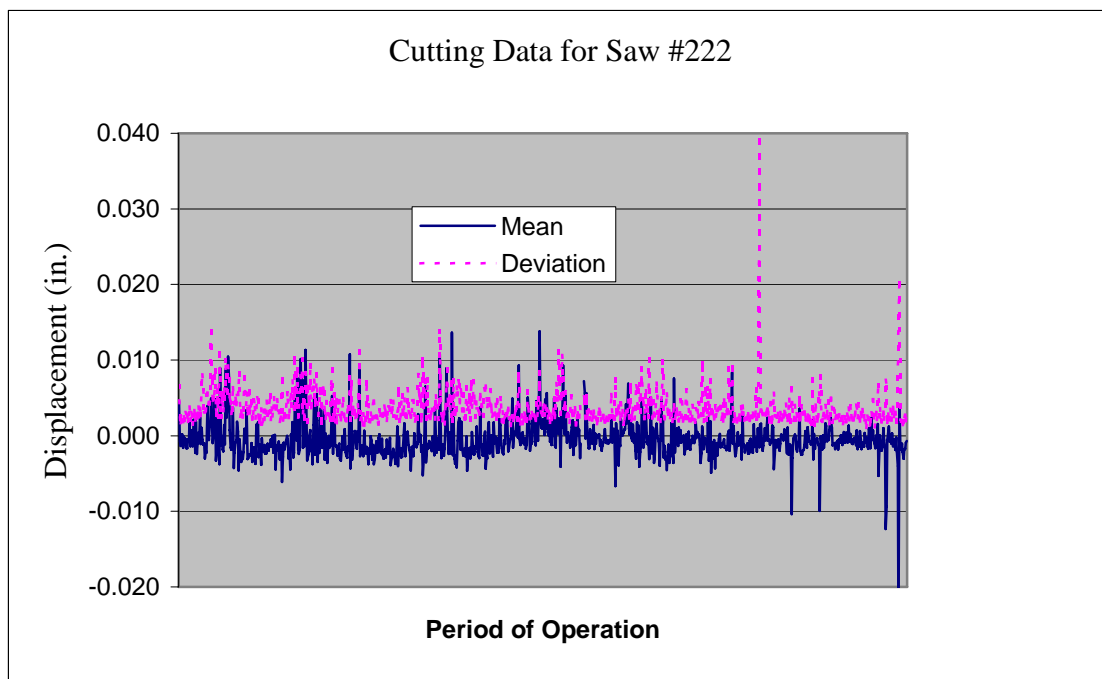


Figure 8.1 *Typical saw cut data*

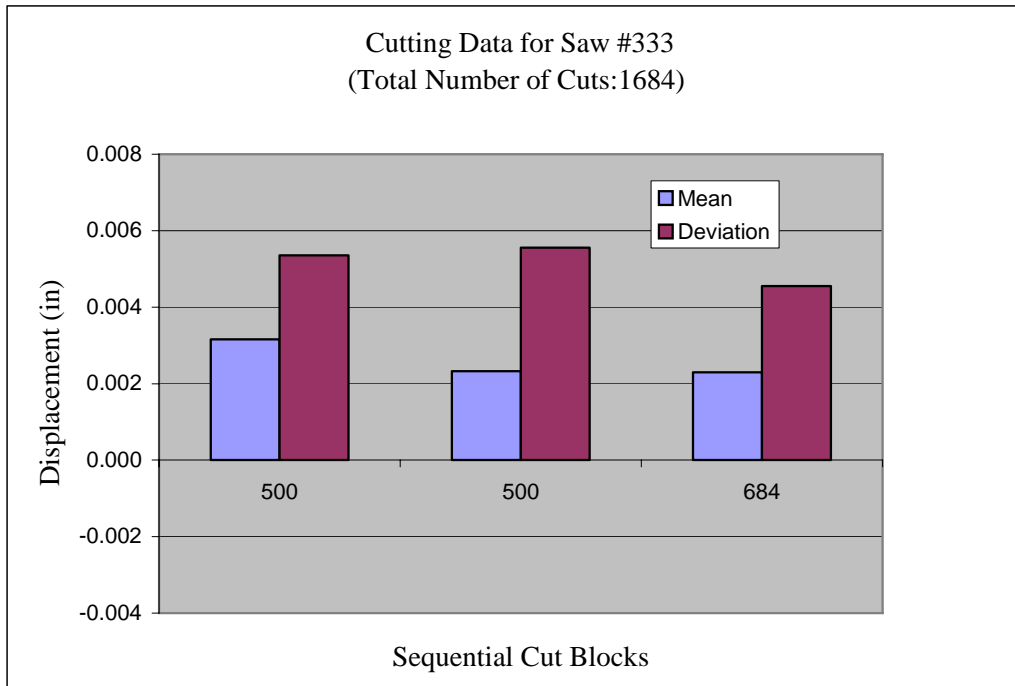


Figure 8.2 Cutting performance of Stellite™ tipped saw no. 333

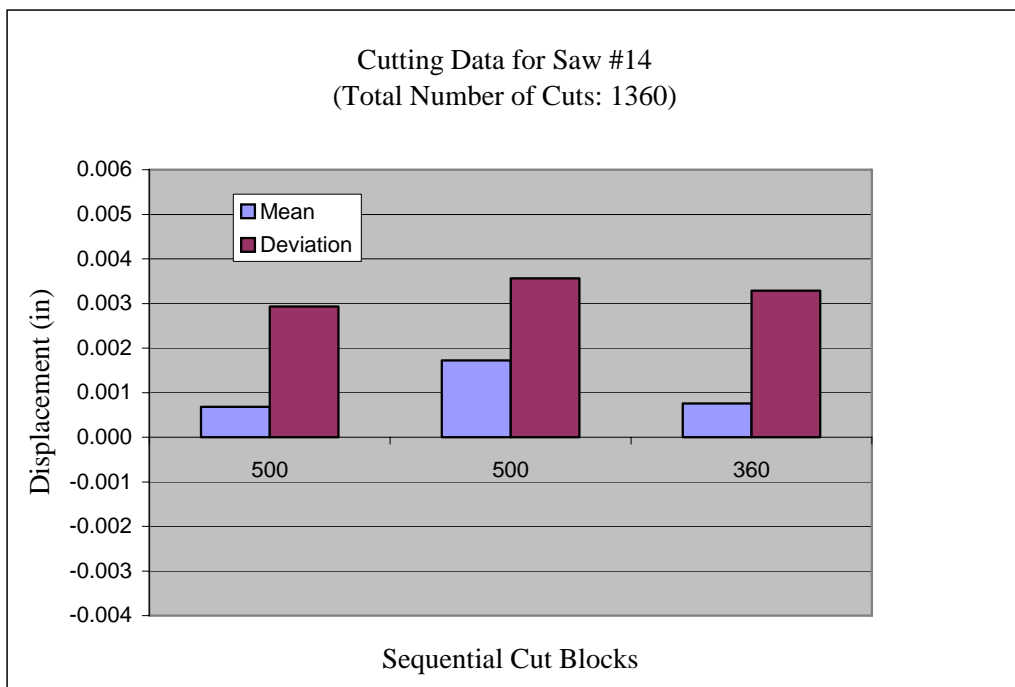


Figure 8.3 Cutting performance of swaged saw no. 14

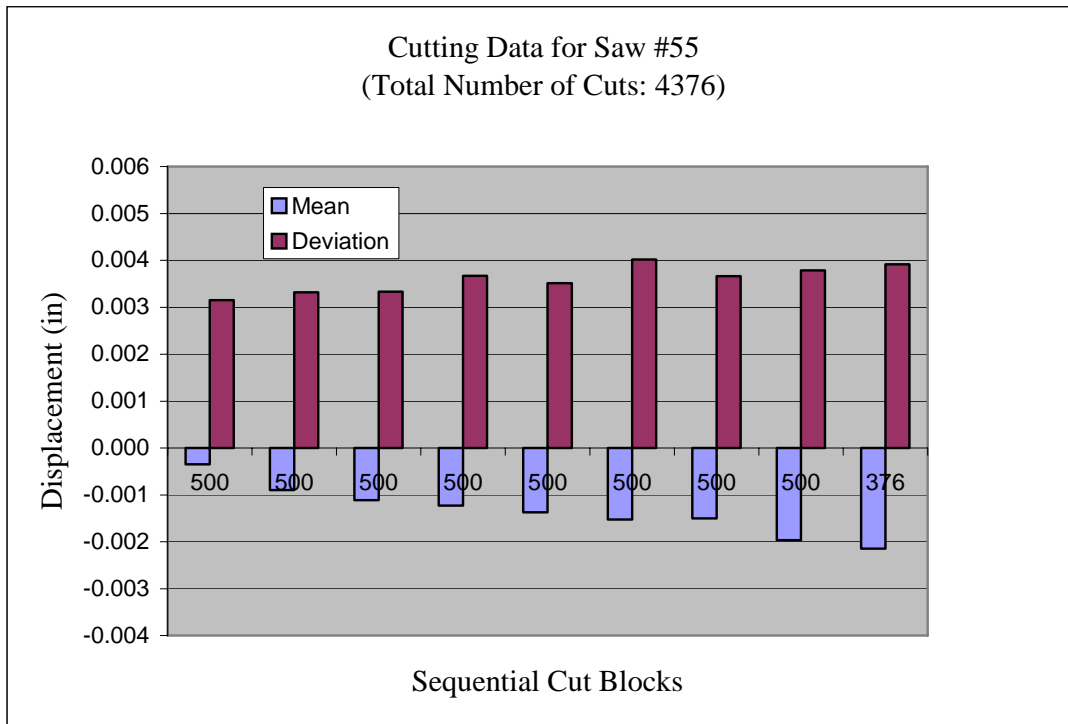


Figure 8.4 Cutting performance of swaged saw no. 55

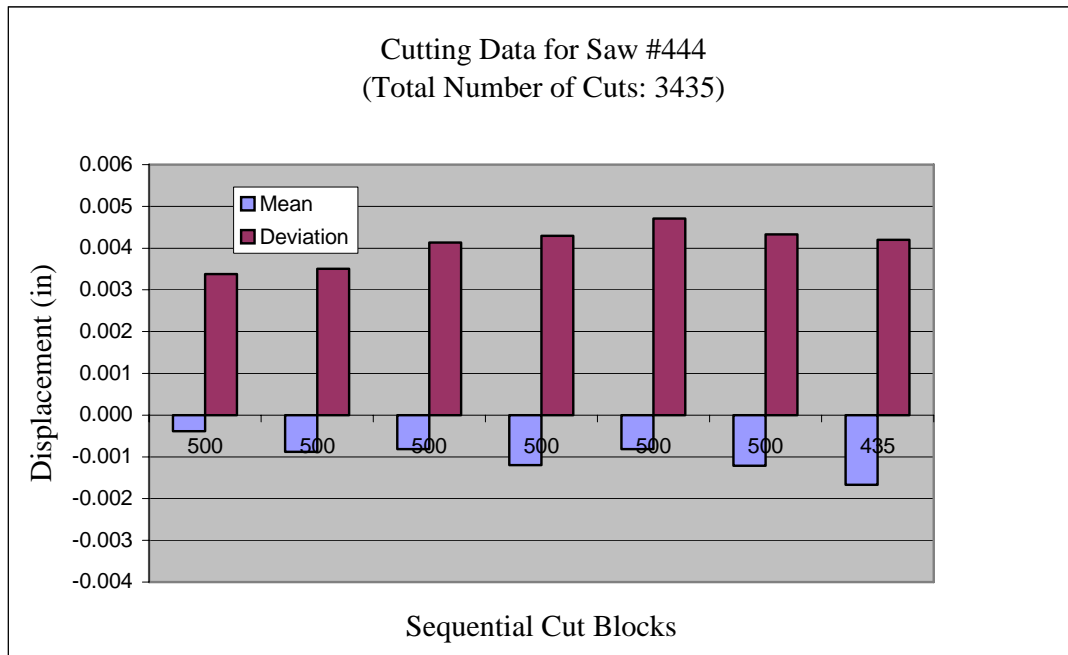


Figure 8.5 Cutting performance of Stellite™ tipped saw no. 444

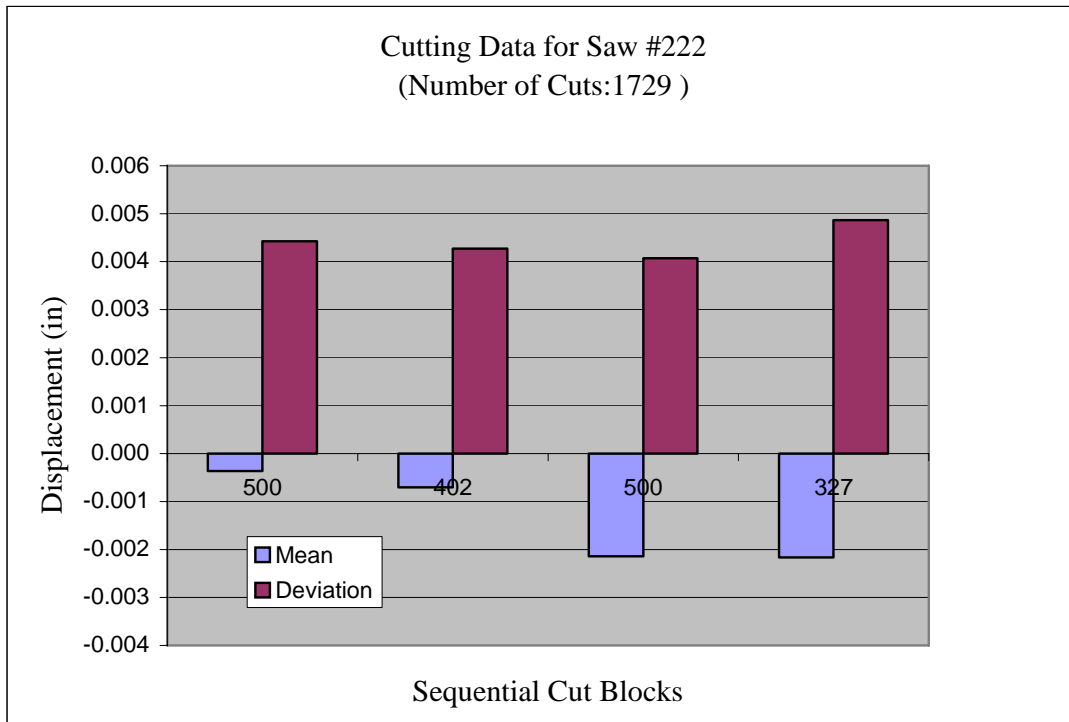


Figure 8.6 Cutting performance of *Stellite™* tipped saw no. 222

8.5 Conclusions

Extensive cutting data from *Stellite™* tipped and swaged bandsaws did not indicate any difference in cutting accuracy between the two saw types. This was somewhat surprising as *Stellite™* tipping should maintain a sharper cutting edge, especially in the MPB attacked wood. There are, however, some qualifications to the test results. Due to the dry and brittle nature of the MPB resource, log breakage in the chipping section was a problem at the mill. The log breakage caused frequent saw damage and unscheduled saw changes, and reduced the collection of cutting data. For the cutting tests where saw accuracy data was collected, there was no significant difference between the *Stellite™* tipped saws to that of swaged saws. An additional contributing factor to this result may be the relatively heavy saw with respect to the 7" average cut depth, masking the difference in wear and sharpness of the two saws.

9 Saw Design Recommendations

The major motivation behind the present study was the investigation of saw design modifications that would assist in the efficient processing of Mountain Pine Beetle attacked wood. This section presents such recommendations and many of these are based upon the results of laboratory testing. It will be recognized that conditions in a mill cannot be fully replicated in the laboratory. Thus these recommendations should be viewed in this light.

- Saw Design
 - a) Saws with the minimum number of teeth should be used. Saws were tested with 60, 50, 40 and 30 teeth and the 30 tooth saws performed best; they used least horsepower, they were able to run at the highest feed speeds and they gave the best cutting accuracy.
 - b) Saws should be run with minimum side clearance. Minimum side clearance increases lumber recovery and it was found that a side clearance of .005" produced good cutting accuracy at a feed speed of 650 feet/minute.
 - c) Saws should be run at a higher Gullet Feed Index than is traditionally used. This means that higher feed speeds can be utilized.
 - d) Saws that are thinner than commonly used should be explored. The laboratory testing successfully used saws with a plate thickness of .070." The use of thinner saws leads to higher recovery.
 - e) Higher blade speeds than are commonly used may be possible. The laboratory tests showed no decrease in cutting accuracy in blade speed tests up to 3600RPM. At this speed the blades were running at supercritical speeds.
- Saw misalignment is likely to cause more problems with wedging than sawing deviation.
- Allow an extra 10% in the power requirements when cutting dry MPB wood.
- The use of Cermet tips should be considered for MPB wood.
- Switching from swaged to Stellite™ tipped bandsaws will not necessarily improve cutting accuracy.

10 References

- Lubkin, J.L. 1957. "Status report on research in the circular sawing of wood." American Machine & Foundry Co.
- Mill test results. December 2004. Si-Cam data sheets for Quesnel sawmill.
- Taylor, J., White, J., Gingras, A., Niessen, R., Gagne, D. 1999. Power Requirements for Sawing and Chipping. Forintek Canada Corp. Vancouver, BC.
- White, John and John Taylor, 2006. "Improving processing efficiency of post-mpb wood, Part 1A: Mill Survey". Forintek Canada Corp. report for Forestry Innovation Investment Ltd.
- White, John and John Taylor, 2006. "Improving processing efficiency of post-mpb wood, Part 1B: Benchmarking cutting tests". Forintek Canada Corp. report for Forestry Innovation Investment Ltd. 10p.