Improving Bandsaw Performance: 
Effect of Side Grinding Swaged 
Bandsaws on Cutting Accuracy and 
Surface Finish

by

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Abstract

The primary objective of the study is to measure the effect on cutting accuracy of side grinding swaged tooth bandsaws on cutting accuracy. The effect of side grinding on surface finish is included for comparison with previous work.

Swaged tooth bandsaws tend to leave quite a rough sawn surface. Cutting with large bites or uneven teeth aggravates this problem. Previous studies have shown that side grinding could improve surface finish but it was not shown to have any effect on cutting accuracy, however, sawmills and saw manufacturers have indicated that side grinding can improve cutting accuracy. Therefore, this contradiction needs to be resolved in order to quantify any benefits from side grinding.

The results indicate significant improvements in cutting accuracy and surface finish are possible. Side grinding 17-gauge and 16-gauge bandsaws respectively improved sawing accuracy up to 22% and 44%, reduced sawblade lateral displacement up to 36% and 68% and improved the sawn surface finish up to 24% and 11%.

Extremely careful bandsaw fitting and tooth alignment was necessary in the preparation of side ground saws. This cost-time-effectiveness has to be considered when adding side grinding to swaged saw preparation.
Acknowledgements

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1 Objectives

The primary objective of the study is to measure the effect on cutting accuracy of side grinding swaged tooth bandsaws on cutting accuracy. The effect of side grinding on surface finish is included for comparison with previous work.

2 Introduction

Swaged tooth bandsaws are still popular with sawmills due to their faster preparation in bandsaw fitting, however, they tend to leave quite a rough sawn surface compared to that produced by a circular saw. In particular, cutting with large bites or uneven teeth worsens this problem. If sawing accuracy and surface roughness can be improved through side grinding the opportunity exists to reduce lumber target sizes and improve sawmill profitability.

The previous studies [10] concluded that side grinding swaged tooth bandsaws improved surface finish, but did not have any affect on cutting accuracy. More recently, observations and discussions with sawmill personnel have indicated that side grinding can improve cutting accuracy. Moreover, some North American sawmills are using side ground swaged bandsaws, stating potential gains from side grinding. This contradiction needs to be resolved.

The uneven geometric form of the saw teeth can produce unbalanced lateral force and influence sawing performance [1, 2]. Earlier studies [3] mention that unsymmetrical swaged-tooth damage could cause lumber thickness variations. Therefore, it is important that the tooth edges be ground precisely. Bonac [4] shows that tooth side geometry influences the temperature of the tooth behind the tip and dullness of teeth increases the critical side clearance. Johnson and St Laurent [5] indicate that the amount of side clearance required due to wood’s tendency to spring back was 0.015-in. Kirbach [6] concluded that the minimum (critical) side clearance for bandsaws could be determined to improve wood fibre savings. An investigation [7] was conducted on the effect of side clearance angles and their precision on circular saw cutting accuracy. Too small and uneven side clearance angles caused significant increases in saw deflection and therefore losses in cutting accuracy. A sawmill test [8] shows that bandsaws with alternate top bevelled teeth became dull faster and caused rougher surface. Lehmann [9] presented the results on tooth grinding tolerances of side clearance for circular saws. For an 0.080-in thick saw, every 0.001-in difference in side clearance caused a saw deflection of 0.002-in. Thinner circular blades were even more sensitive to side clearance differences.

In this study, laboratory cutting tests were conducted using two swaged tooth saws and measuring the effect of progressively side grinding them. The means and deviations of blade deflections were recorded and sawn surface roughness was measured to evaluate cutting accuracy and surface finish respectively.

Side grinding the swaged saws was found to significantly improve cutting accuracy and surface finish, and reduce the sawblade displacements.
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4 Materials and Methods

Two swaged tooth sawblades, one 17-gauge and one 16-gauge were selected to do the cutting tests. Following saw tensioning and levelling, the saw fitting work for the 17-gauge saw (grinding, swaging, shaping and side grinding) was conducted at Forintek by the authors. The 16-gauge saw was new and the saw manufacturer completed the swaging and shaping. The profile of teeth and gullets was prepared following the pattern shown in Figure 1. The side clearance angles used in saw preparation were as recommended by Armstrong [11]. The main specifications of the test saws are listed in Table 1.

Figure 1  Profile of Teeth and Gullets
Table 1  Specification of Test Saws

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Bandsaw 1 (17-gauge)</th>
<th>Bandsaw 2 (16-gauge)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plate thickness</td>
<td>0.058-in.</td>
<td>0.065-in.</td>
</tr>
<tr>
<td>Number of teeth</td>
<td>231</td>
<td>231</td>
</tr>
<tr>
<td>Length of blade</td>
<td>33.7 ft</td>
<td>33.7 ft</td>
</tr>
<tr>
<td>Tooth pitch</td>
<td>1.75-in.</td>
<td>1.75-in.</td>
</tr>
<tr>
<td>Gullet depth</td>
<td>5/8-in.</td>
<td>11/16-in.</td>
</tr>
<tr>
<td>Back clearance angle</td>
<td>12°</td>
<td>12°</td>
</tr>
<tr>
<td>Hook angle</td>
<td>30°</td>
<td>30°</td>
</tr>
<tr>
<td>Width of blade</td>
<td>7.4-in.</td>
<td>8.0-in.</td>
</tr>
<tr>
<td>Tooth tangential angle</td>
<td>6°</td>
<td>6°</td>
</tr>
<tr>
<td>Tooth radial angle</td>
<td>3°</td>
<td>3°</td>
</tr>
</tbody>
</table>

The bandsaw fitting equipment located in Forintek’s saw laboratory includes: an Armstrong swage; Armstrong 6900 B shaper; Iseli profile grinder and a Vollmer bandsaw side grinder.

In the process of bandsaw fitting, the measurement devices included a side clearance gauge; a micrometer; callipers; a side clearance measuring microscope; several dial gauges and a purpose-made multi-position measurement device. They were used to measure side clearance, kerf, tangential side clearance angle; and tooth misalignment.

The sequential saw kerf settings for the cutting tests are shown in Table 2. It was decided not to reswage and side grind the saw to the original swaged tooth kerf in case the process might change the saw characteristics and influence the cutting performance.

Table 2  Cutting Sequence and Kerf Settings for Cutting Tests

<table>
<thead>
<tr>
<th>Cutting sequence</th>
<th>Kerf of 17-gauge saw</th>
<th>Kerf of 16-gauge saw</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.128-in. (swaged teeth)</td>
<td>0.135-in. (swaged teeth)</td>
</tr>
<tr>
<td>2</td>
<td>0.124-in. (side ground teeth)</td>
<td>0.129-in. (side ground teeth)</td>
</tr>
<tr>
<td>3</td>
<td>0.116-in. (side ground teeth)</td>
<td>0.123-in. (side ground teeth)</td>
</tr>
<tr>
<td>4</td>
<td>0.108-in. (side ground teeth)</td>
<td>0.117-in. (side ground teeth)</td>
</tr>
<tr>
<td>5</td>
<td>Discontinued</td>
<td>0.111-in. (side ground teeth)</td>
</tr>
</tbody>
</table>

The cutting tests were carried out on Forintek’s 5 ft bandmill at a strain of 11,000 lb. The cutting span was 20-in. and the guides were lubricated by oil sprayed on the sawblade. An auto tracking system controlled “front-to-back” movement of the sawblade. Cants were made up from six 2-in.x 10-in.x 8 ft, green hem/fir boards of two and better grade. To improve cutting uniformity between the cants, all the test boards were weighed and grouped in stacks of six such that each stack of boards (or each cant) had approximately the same weight. For each of the saw kerf settings shown in Tables 2, each saw made one cut in each of the twelve cants. This arrangement helped randomize the variations in cutting performance due to natural differences in the boards. Each cut removed approximately ¾-in. thick pieces (including kerf) from each cant. Table 3 lists the parameters used in the cutting tests.
Table 3  Cutting Test Parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>17-gauge saw</th>
<th>16-gauge saw</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gullet area</td>
<td>0.62-in.(^2)</td>
<td>0.64-in.(^2)</td>
</tr>
<tr>
<td>Gullet feed indexes</td>
<td>0.70</td>
<td>0.70</td>
</tr>
<tr>
<td>Blade speed</td>
<td>10,000 fpm</td>
<td>10,000 fpm</td>
</tr>
<tr>
<td>Feed speed</td>
<td>274 fpm</td>
<td>286 fpm</td>
</tr>
<tr>
<td>Tooth bite</td>
<td>0.048-in.</td>
<td>0.050-in.</td>
</tr>
<tr>
<td>Cutting depth</td>
<td>9.000-in.</td>
<td>9.000-in.</td>
</tr>
<tr>
<td>Blade strain</td>
<td>11,000 lb.</td>
<td>11,000 lb.</td>
</tr>
</tbody>
</table>

In the cutting tests, one non-contact eddy current probe was positioned to measure the lateral displacements of the sawblade just above the cutting area (Figures 2 and 3). Forintek’s PC based data acquisition system recorded displacement signals from the probe as well as lumber feed speed and bandmill rim speed. After each cut, the system recorded the mean and standard deviation of the blade displacements measured by the probe (Figure 4). The sampling rate was 26 samples per second. The sawing accuracy (total sawing standard deviation) was calculated by combining within-cut and between-cut sawing variation.

![Figure 2: Schematic Arrangement of Experiment Set-up](image-url)
Each cut produced six strips as shown in Figure 3. The surface roughness of each strip was measured two feet from each end with a pneumatic roughness-measuring device (Figure 5) developed by Bonac [12]. The surface roughness of each cut was the average of all twelve measured roughness values.

Figure 4  Blade Deflection and Deviation
5 Results and Discussions

5.1 Effect of Side Grinding on Cutting Accuracy

In this section, the effect of side grinding on the total sawing deviation, and on the blade means (average bias to one side of a perfectly straight cut), are presented for both of the sawblades. (See Table 4 and Figures 6 to 9).

Table 4 Effect of side grinding on cutting accuracy (in)

<table>
<thead>
<tr>
<th>Saw</th>
<th>Variable</th>
<th>Swaged tip</th>
<th>Side ground step</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>First</td>
</tr>
<tr>
<td>17 ga.</td>
<td>Mean</td>
<td>-0.0039</td>
<td>-0.0025</td>
</tr>
<tr>
<td>17 ga.</td>
<td>Dev’n</td>
<td>0.0023</td>
<td>0.0019</td>
</tr>
<tr>
<td>16 ga.</td>
<td>Mean</td>
<td>0.0039</td>
<td>0.0019</td>
</tr>
<tr>
<td>16 ga.</td>
<td>Dev’n</td>
<td>0.0043</td>
<td>0.0024</td>
</tr>
</tbody>
</table>

Sawing Accuracy

Cutting tests were conducted until the mean or deviation started to increase, indicating that the lack of side clearance was beginning to adversely affect the results. Table 4 presents the cutting accuracy results for all of the cutting tests. Figures 6 to 9 were included to give a better visual picture of the saw performances. The first data point is the deviation with the swaged tip followed by the deviations for each side ground condition.
Improving Bandsaw Performance: Effect of Side Grinding Swaged Bandsaws on Cutting Accuracy and Surface Finish

Figure 6  Total Sawing Standard Deviation vs. Kerf for the 17-gauge Saw

Figure 7  Average Blade Displacement vs. Kerf for the 17-gauge Saw
Figure 8 Total Sawing Standard Deviation vs. Kerf for the 16-gauge Saw

Figure 9 Average Blade Displacement vs. Kerf for the 16-gauge Saw
Because the sawblade deflection we measured above the top of the cant and behind the teeth, the mean and deviation values tend to be smaller than normal lumber measurements. Examination of the percentage changes due to the side grinding (Table 5) gives a better indication of the magnitude of the change that occurred.

For the 17-gauge saw, side grinding improved the cutting accuracy until the third side grinding. At this kerf width (0.108-in.), the total sawing standard deviation increased by 54% (Figure 6) and the sawblade mean deflection by 56% (Figure 7). For this saw, with a side clearance of 0.025-in., the interaction between the saw and workpiece was likely the reason for the increase in sawing deviation. The side clearance of 0.0288-in. obtained from the second side grinding was close to the critical or minimum side clearance that could provide stable sawing and good cutting accuracy [6].

For the 16-gauge saw, both deviation and mean deflections improved with side grinding until the kerf reached 0.117-in. (side clearance of 0.026-in). With the fourth side grinding, the side clearance was down to 0.023-in., the sawing deviation increased significantly and the mean deflection became slightly worse.

Saw kerf measurements indicated that the improvement of the sawing accuracy was mainly derived from improving the kerf accuracy by side grinding these saws. The second side grinding significantly improved kerf accuracy for both saws. Side grinding continued to improve kerf accuracy, however, around the critical side clearance of 0.025-in.[6, 10] the interaction between the saw and lumber overrode the gain from the more accurate kerf and increased the sawing deviation.

### Effect of Side Grinding on Surface Finish

The results of sawn surface roughness measurements are shown in Figures 10 and 11 for the 17-gauge and 16-gauge saws respectively. For the 17-gauge saw, the sawn surface roughness was reduced by 10%, 24% and 11% for the three side grinding operations. For the 16-gauge saw, the sawn surface roughness was not affected by the first side grinding and reduced by 3.5%, 11% and 11% for the following three side grinding operations. We do not have a good explanation for the lack of change in roughness with the first side-grinding step.
Figure 10 Surface Roughness vs. Kerf for the 17-gauge Saw

Figure 11 Surface Roughness vs. Kerf for the 16-gauge Saw
5.3 Some Comments on the Results

The experimental results indicated that side grinding 17-gauge and 16-gauge swaged saws improved cutting accuracy, sawblade deflection and surface finish. This could be related to kerf accuracy of the teeth.

In a preliminary study, an extensively used 16-gauge saw was tested. The blade material had been heavily worked and the level of the blade was less than ideal. The quality of the blade gave inconsistent tooth positions when clamped and tooth and side grinding accuracy suffered. In this case, the sawing accuracy got worse with side grinding. This led us to the conclusion that poorly prepared or old saws, saws with excessive tension or saws with inaccurate tooth alignment, may not respond favourably to side grinding. It should also be recognized that swaging and shaping a non-symmetric side ground tooth can give imperfect results.

In order to find the effect of side grinding on cutting accuracy, significant efforts were made to ensure accurately prepared test saws. To ensure a good quality side ground saw, a series of steps was carefully conducted. Saws were swaged three times and shaped twice prior to side grinding. Some special measurement tools were fabricated. Tooth position in the side grinder was continually monitored and accurately aligned. As this was in a research environment we were able to spend a considerable amount of time on each blade, both in preparation and in measuring and checking each tooth. We are pleased to say that this degree of care provided an improvement in cutting performance. In a production environment, the necessary accuracy would be achieved more efficiently, however, the extra effort to achieve the improvement should not be ignored.

In the process of saw fitting, it was found that shaping twice significantly improved kerf accuracy and side grinding each side separately produced more symmetric side clearances. However, these operations needed more time and care to complete. The swaged kerf needs to be reasonably full so that several side ground kerf settings can be obtained before reaching the critical side clearance and before re-swaging. Re-swaging the side ground saws was not easy to conduct.

Side grinding the 17-gauge saw down to kerfs of 0.124-in. and 0.116-in. saved 0.005-in. and 0.010-in. in a combination of sawing accuracy, blade bias from cutting centre, surface roughness and reduction of kerf. For the 16-gauge saw, the side ground kerfs of 0.129-in., 0.123-in. and 0.117-in. gave combined reductions of 0.007-in., 0.010-in. and 0.014-in. If, by careful side grinding, every swaged saw in a mill got this improvement and all the lumber was cut by these saws, the increase in lumber recovery could be significant. For example, a calculation was conducted on 2-in. x 4-in. boards with the target size reduction of 0.010-in. and 0.014-in. for the 17-gauge and 16-gauge saw respectively. This gave increases of up to 0.8% and 1.2% in lumber yield. For a mill with lumber production of 100 MMBF per year, this would provide a return of $240,000 and $340,000 per year.

In a practical production environment it may not be possible to achieve the same improvements in sawing accuracy and surface finish. This factor has to be considered when determining possible gains from side grinding swaged bandsaws.
6 Conclusions

1 Side grinding improves sawing deviation and mean blade deflection. The reduction in deviation was up to 22% for the 17-gauge saw and 44% for the 16-gauge saw. The reduction in the mean deflection was up to 36% for the 17-gauge saw and 68% for the 16-gauge saw.

2 Side grinding reduces the sawn surface roughness. This reduction was up to 24% for the 17-gauge saw and 11% for the 16-gauge saw.

3 Side grinding requires well-prepared blades and additional care and time in fitting.

4 Shaping twice significantly improved kerf accuracy.

5 With careful alignment of the teeth, each side-grinding step improves kerf accuracy. It is believed that this improvement is responsible for the gains from side grinding.

6 Swaged teeth are more forgiving of saw preparation and tooth alignment than side ground teeth.

7 References


