With the pressures on our industry at this time and the need to push the envelopes with respect to feed speeds and lumber recovery, it is useful to revisit this interesting topic and consider making a practical approach to it's application. This paper contains a simple description of critical speed for circular saws, reviews some of the previous work, discusses how we might specify suitable rim speeds for different machines and presents the results of some earlier super critical speed (SCS) cutting tests with very thin saws.
Outline of Presentation

- Explanation of terms
- Animated demonstration
- Videos
- Specifying RPM's
- Lab tests
- ROI
- Previous results
Many of us who are familiar with the dynamics of super-critical speed saws talk glibly about critical speed, natural frequencies, mode shapes, traveling waves, mathematical modeling and boundary conditions. Because many people in the practical side of the industry are not familiar with these terms, or their meaning, I hope you will bear with me while I start with a simple explanation of critical speed and how it affects the saw.
Previous Work

Collared saws
- Investigated by many authors
- Critical speed behaviour well understood

Guided Saws
- More recently investigation into guided saws.
- Extremely complicated behaviour
- Super-critical speed behaviour not well understood.

Critical speed for unguided circular saws has been analysed by many authors over the last two or three decades and the limits of rim speed for this type of saw are well understood.

More recently, some investigation has taken place into the behaviour of guided saws above the critical speed. The behaviour is extremely complicated and has been an area of investigation at the University of British Columbia. (Hutton and Kishimoto 1995 and 1996), Hutton 1991, Yang and Hutton 1991. To my knowledge, successful prediction of this behaviour has yet to be achieved. To try and further our understanding and help develop useful guidelines, Forintek and UBC (Lister, Hutton and Kishimoto 1996) conducted some experimental work on SCSS.
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Demonstration

Travelling wave video

Let us first take a long length of rope supported at both ends, similar to that we might see marking out a temporary car park or some other such situation. If we strike the rope with a stick we can see a wave travel along the rope to the far end and reflect back again (Figure 1), diminishing as the energy of the blow is used up. If we strike the rope in the middle, waves will move away from the impact point, reflect at the ends and pass back through one another and continue on to the other end, reflect back and so on. Thus, we now have a situation where waves are traveling in both directions.
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If we now take this rope (or string) and form it into a circle in the air, as shown, we have the basic circular saw shape with traveling waves in both directions. If we now rotate the string, one wave is traveling with the string direction “forward traveling wave” and one is traveling against the string direction “backward traveling wave” (shown).
If we now increase the rotation speed of the circular string to match that of the wave we have a wave that appears to be stationary in space, this is known as “critical speed” (Figure 2). Now imagine that this is a narrow circular sawblade and you try to cut with it. This is very difficult as the standing wave has no stiffness and the saw will not cut.
We have taken some videos of a guided sawblade and the behaviour at, or close to critical speed to demonstrate their lack of stiffness.
Several mill are using super critical speed either by design or accident.

The problem is how to answer the question “What super critical speed should I run my arbor to get good sawing deviation and stable operation”?

There is no technical way to answer this therefore we resort to the lab.
Locating a suitable RPM

- Use the laboratory arbor and the saws from the mill.
- Copy the guide set up
- Study the behaviour of the saws for a range of speeds
- Select a suitable super critical speed for mill trials.
- Test the results.
Locating a suitable RPM

Cutting Deviation Blade K1 (sharp)
Probe #1 Depth of Cut 3.25"

Mean Value

Blade Speed (3400=.033 bite)
Locating a suitable RPM

Cutting S.D. Blade K1 (sharp) Probe #1
Depth of Cut 3.25"

Cutting S.D. vs. Blade Speed

[Graph showing cutting speed and depth of cut variations]
The driving force behind SCSS is that the mill can gain on two usually counter related factors, not only is the kerf reduced but the feeds speeds may also increase. This can provide very large increases in the bottom line. From a Forintek sawing performance survey (Lister 1995) a considerable amount of information was recorded for some 27 mills across Canada. In a 4-inch machine, one of the mills included in the survey was running very thin saws at supercritical speeds.

From the survey, we note that the average kerf for a 4-inch machine was 0.136-inches with a feed speed of 264 fpm (Table 1).
The mill with the supercritical speed saws had a kerf of 0.090-inches and a feed speed of 380 fpm (Table 2). This is a kerf reduction of 0.046-inch and is worth around $900,000 per year to a 100MMbf/yr mill, plus the gains in production from the increase in feed speeds. Therefore, it is easy to see why we would like to have a technically sound method that would enable us to predict supercritical saw speeds for the range of machines and saws currently in use.

<table>
<thead>
<tr>
<th>Machine Type</th>
<th>Mill ID Number</th>
<th>Kerf Width* (in.)</th>
<th>Total Sawing Variation* (in.)</th>
<th>Feed Speed at Max. Depth-of-Cut* (fpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gang edger, 3-in. cut-per-saw</td>
<td>18</td>
<td>0.110 (-0.028)</td>
<td>n/a</td>
<td>320 (-10)</td>
</tr>
<tr>
<td>Gang edger, 4-in. cut-per-saw</td>
<td>19</td>
<td>0.090 (-0.046)</td>
<td>0.009 (-0.004)</td>
<td>380 (+16)</td>
</tr>
<tr>
<td>Gang edger, 5-in. cut-per-saw</td>
<td>38</td>
<td>0.110 (-0.024)</td>
<td>0.012 (-0.004)</td>
<td>203 (+16)</td>
</tr>
<tr>
<td>Gang edger, 6-in. cut-per-saw</td>
<td>29</td>
<td>0.110 (-0.026)</td>
<td>0.041 (-0.015)</td>
<td>350 (+114)</td>
</tr>
</tbody>
</table>
The problem with transferring SCSS to the industry is that the mills need to know the saw RPM for successful operation. Trial and error is not a practical approach considering the costs of changing machine RPM and the possible downtime it could create, thus we need to be able to predict the RPM such that the saws are stable and cut accurately. Ideally, a variable speed drive on the circular gang would make life easier but we would still need some indication of the speed ranges to try as finding the correct speed can be very difficult.

At Forintek we have two factors that can help us rise to this challenge, a good working relationship with Dr Stan Hutton at UBC (one of the few people who has been working in the area of SCSS with guided saws) and an excellent sawing pilot plant (Figure 7) complete with a single/double arbor circular saw test stand (Figure 8), variable speed drive and good instrumentation. How can we use this to achieve our goal of transferring SCSS technology to the sawmills? Some of the suggestions are as follows:

1. We can copy the saw/guide configuration used in a particular mill
2. Continue with mathematical modelling
3. Survey existing mills.

Not necessarily a straight forward exercise, one mill has had problems transferring the technology.
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