Thin Kerf Sawing Technologies

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Introduction

The definition of thin kerf sawing is not fixed. In the 1980's, a circular gang saw with a plate thickness less than 0.125" (3 mm) was considered thin. Now (2005), 0.080" (2 mm) is common, 0.060" (1.5 mm) is being tried in several mills, and 0.040" (1 mm) is "thin", but being used in successfully in a few mills

Although there are new developments in thin kerf sawing each year, the major lesson learned by sawmills that successfully run thin saws is the necessity to look after the basics of saw preparation and machine setup. Precision and consistency of all aspects of the sawing system are absolute requirements. Thin saws are so much more fragile and flexible that small errors will result in poor cutting accuracy, more unscheduled saw changes, and more damage to the saws. In some cases, saws must be changed after only two hours because the increased cutting forces from slightly dull teeth will damage the saws.

This paper discusses the basic issues involved in running thin kerf saws. While the definition of "thin" is still changing, the formula for making thin saws run well has converged.

Potential Savings

Conceptually, the savings from thin kerf saws are obvious: more solid wood and less sawdust. But where does the solid wood appear? In secondary wood processing, where a board is being ripped into strips, the saving is visible as an extra strip from the board. The savings, in this case, can very large. For example, if seven pieces are obtained rather than six, the output volume is increased by 14% with no increase in wood costs.

When cutting logs, the potential savings are not so obvious, especially for small logs. Occasionally, reducing the kerf will result in another board from a log, but this will only happen for logs of the diameter that the sawing pattern changes. Most of the benefits of reducing kerf come from the extra lengths or widths of the side boards. Due to the taper in the tree, the closer a saw line is to the centre of the tree, the wider and longer will be the side boards. For every 0.010" (0.24 mm) saved in kerf, there will be a 1% to 2% increase in lumber recovery. This is a significant amount if the cost of logs, delivered to the mill site, is 75% of the cost of the finished lumber, as it is for many mills.

Technology of Thin Kerf Sawing

With the exception of the development of guided, splined arbour technology for the primary industry, the advances in sawing technology have been incremental. However, none of these small improvements can be ignored.

Most of the progress has been with circular saws, but many of the factors listed below also apply to bandsaws.

Saws

Saws need to be though of as tooling, not just as a circular plate with a serrated edge. Precision manufacture and preparation of the saws are required at all stages. Many sawmills have an inspection checklist for new saws. Table I is a typical checklist, including the tolerances.

Table I. Typical Saw Specifications

Measurement	Value	Tolerance
Thickness	0.070" (1.78 mm)	+0.000"/ -0.002" +0.00/-0.05 mm
Hook Angle	30°	±0.5°
Back Clearance Angle	8°	±0.5°
Side Clearance	0.022"	±0.002" No more than 0.002" difference from side to side.
Radial Side Clearance Angle	2°	±0.25°
Tangential Side Clearance Angle	3°	±0.25°
Eye Specification	6" Lobe (Retec) Spline	clearance 0.005" ±0.002" 0.13 ±0.05 mm
Runout at rim		0.005" TIR 0.13 mm
Hardness	44 Rc	43 - 45 Rc

For thin circular saws, levelling is much more important than tensioning. Because of their low bending stiffness, thin saws buckle much more easily. This means that they cannot hold as much tension, and easily develop lumps. Once the saw loses its flatness, the effect of tensioning is lost, and the saw will be bent even more by the large in-plane (radial and tangential) cutting forces. On the other hand, thin saws can be levelled by bending them by hand or with a wrench-like tool.

Another consequence of the reduced bending stiffness is a change in the tooth design. Gullets for thin kerf saws are much shallower and the backs of the teeth are longer. See Figure 1. The resulting gullets are much smaller, but as discussed later, this is not a problem because the feed speeds are correspondingly lower as well.

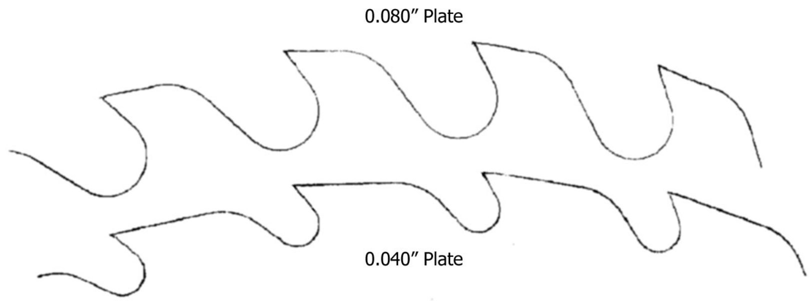

Figure 1. Change in tooth design for thin saws.

The bending stiffness of the blade, including the teeth, is proportional to the cube of the thickness (h^3). This means that for a 10% reduction in plate thickness, the stiffness decreases by about 30%. Or, halving the thickness reduces stiffness to only $1/8^{th}$ of the original amount. This large drop in plate stiffness is the main reason thin saws can be so difficult to run well.

Grinding

With such low blade stiffness, any defect or asymmetry in the tooth geometry will bias the deflection of the saw during cutting:

1. Sharpness. The initial sharpness is important because the cutting forces from dull teeth can permanently distort the plate. More important, thin blades have very little rigidity to resist even small increases in the lateral component of the cutting force.
2. Dubbing. Dubbing is a rounding of the tooth corner occurs when either the tooth or the grinding wheel deflect from too much grinding pressure. This is especially a problem during side grinding, where even the spring force from the dial gauge used to measure the side clearance can deflect the tooth 0.005" (0.1mm).
3. Side clearance angles and side clearances. The geometry and sharpness of the tooth must be symmetric, or the cutting will be biassed to one side.

Precision alignment and calibration of the grinders are required for thin kerf saws. Also, a quality control program for ensuring tooth and plate preparation is recommended.

Saw Guides and Arbours

Guided, splined arbour saws have three advantages over collared saws:

1. The guides support the saw close to the cutting region.
2. The spline allows the centre and back of the saw to move, thus reducing the contact forces between the sawn surfaces and the saw. This reduces blade heating and damage to the saws.
3. The lubrication system provides cooling that keeps the blade a uniform temperature.

These features, and the accuracy of the guide preparation, have made thin kerf sawing possible in the primary wood industry.

Feed Systems
The design and construction of the feed system are critical to thin kerf sawing, although it is rarely discussed. In fact, much of the success of thin kerf sawing is due to the accuracy and rigidity of modern feed systems. If the wood does not move in a straight line, the saws will be damaged as the wood presses sideways. Also, the wood must be consistently controlled as it goes through the saws. The machine frame must be rigid.

A second aspect of feeding wood is selecting the proper feed speed for each depth of cut. Overfeeding will probably cause the saw to snake heavily, but under feeding can also result in fine sawdust that packs between the wood and the saw body, thus generating heat. And, once the feed speed is determined, the timing of press rolls needs to be correct to ensure the wood is not bumped nor released too soon.

Finally, debris removal is also a factor. Most guided saws are arranged to the saw throws the sawdust away from the guides. This lessens the likelihood of sawdust, splinters, or shim pieces jamming in the guides.

Compromises and Limits of Thin Kerf Sawing

Plate Thickness
Most of the difficulties with thin saws are related to the flexibility of the plate. As mentioned above, the bending stiffness of the blade, including the teeth, is proportional to the cube of the thickness, so the loss in stiffness is significant. Fortunately, the cutting forces are roughly proportional to the kerf, *k*, so there is some decrease in the forces that would bend the saw, but the decrease is not as much as the loss in stiffness. The other option to reduce the cutting forces is to reduce the feed speed, *f*.

As an approximation, sawing deviation is proportional to.

$$s = {fk}/{h^3}$$

Table II is a comparison of a thick and a thin saw cutting the same material and producing about the same sawing accuracy. Note that the thin saw is fed slower by a factor of five, but the factor *s* is almost the same, indicating that the sawing deviation should be about the same for the two saws.

Table II. Feed Speed Comparison for Thick and Thin Saws

Plate thickness	0.080" (2 mm)	0.040" (1 mm)
Side clearance	0.018" (0.46 mm)	0.015" (0.38 mm)
Kerf	0.115" (2.92 mm)	0.070" (1.78 mm)
Feed speed	350 ft/min (107 m/min)	70 ft/min. (21 m/min)
Factor 's'	78610 (39.1)	76560 (37.4)

Side Clearance

Saw kerf can also be reduced by decreasing the side clearance. Often, it is preferable to reduce side clearance instead of plate thickness. However, there is a minimum side clearance at which the saw will start to snake. The factors that determine the minimum side clearance are:

1. The amount of spring-back of the wood fibres. Usually the softer species of wood require more side clearance
2. The smoothness of the cut surface. Large bites per tooth create rough surfaces from the tooth marks and torn fibres. Reducing the bite and the radial side clearance angle result in a smoother finish. An additional benefit of thin plate saws that are fed slowly is that they require less side clearance, so a further kerf saving is possible.
3. Variable plate thickness. Experience with variable thickness or stepped thickness plates is indicating that the side clearance is needed around the rim of the saw. The central body of the plate can be almost as thick as the kerf with no major effect on sawing deviation. (However, this does not apply if the sawing deviation is large, which would force more contact between the plate and the sawn surfaces.)

Until recently, a side clearance of 0.010-0.15" (0.25-0.38 mm) was considered to be the minimum possible, especially for sawmills. However, a side clearance of 0.005" (0.12 mm) is now being run successfully. The down-side is that the saws burn up if the wood stops in the cut.

Fibre Loss

The amount of wood fibre lost in sawing is more than the volume removed by the tooth (kerf loss). If the board must be sawn oversize to avoid skip at the planer because the thickness varies too much, then this extra allowance (deviation or planer loss) must be added to the total fibre loss.

For large kerfs, the blades are very thick so there is little deviation loss. Kerf loss increases by the same amount that the kerf increases. For small kerfs, either the blade is very thin or the side clearance is too small. In either case, the sawing deviation will be large and increase a large amount for a small decrease in kerf. These trends, and the effect on total fibre loss are shown in Figure 2.

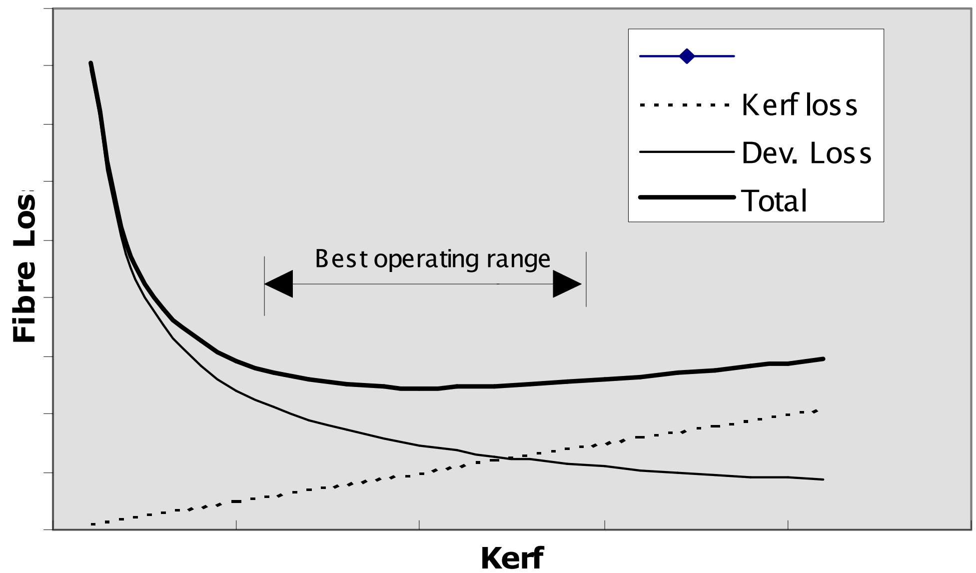

Figure 2. Effect of Kerf on Fibre Loss.

Note that there is a kerf where the total fibre loss is minimized. To optimize recovery, this is the kerf to use. This optimum kerf can only be found by trial-and-error, to a willingness to experiment is needed to obtain maximum recovery. Fortunately, the bottom of the total fibre loss curve is fairly flat. When close to the optimum kerf, a small change in kerf has little effect on fibre loss, which means that the normal changes in side clearance from resharpening do not have to be worried about.

Vibration

The increased flexibility of the plate may allow more vibration. All circular saws several critical (rotation) speeds at which they completely lose stiffness. With thick saws, the lowest critical speed is usually well above the operating speed of the saw, so this was not a problem. As saws have become thinner, the critical speeds dropped into the range of operating speeds. Thin kerf saws usually run between two critical speeds so the correct operating speed must be found. In addition, the amount of tension in the saw and the saw temperature also affects the critical speeds. It is, therefore, imperative that the tensioning be very consistent and that the saw temperature is controlled.

Another vibration problem is washboarding, which is more prevalent in thin saws. The cause of washboarding is not known, but the vibration is in the body of the blade, not just the teeth. Also, the tooth impact frequency is involved. There are several changes that may stop the washboarding:

1. Change the blade rotation speed, often by up to 20%.
2. Change the number of teeth or use variable pitch saws.
3. Reduce the plate thickness even further.
4. Increase the radial side clearance angle.

Conclusions

Successful operation of thin kerf saws requires attention to the basic details of saw and feed system maintenance. With thicker saws, many problems are hidden by the rigidity and strength of the saw plate. With thin kerf saws, there can be no excuses for incorrect or inconsistent work.

As a final point, reducing kerf should be the last step in a saw improvement program. Details that must be addressed first are:

1. Maintenance and alignment of the feed system, guides, collars, etc.
2. Grinding accuracy.
3. Proper control of the wood during sawing
4. Improvement of surface finish
5. Find the minimum side clearance.
6. Evaluate whether the saws should run for shorter times.