

Gang Rip Saw Practices

Phil Mitchell¹

There are several different lumber gang saw optimizing systems available. These systems have different capabilities and costs, and some are found more commonly in certain industry segments than in others. They all have in common, however, the following basic functions:

- optimization capability
- board measurement
- arbor configuration and board positioning
- gang sawing

Optimization Capability

Before any discussion on computerized saw processes can take place, a brief explanation of optimization should be given. Optimization is the adjustment of variables to obtain the best result, which in rough mill cut-up operations may be in terms of the highest yield, or the highest value. Many optimizers found in the rough mill have the capability of optimizing either for yield or for value. Thus the pattern selected to cut each board is usually an attempt to optimize either yield or value. The sawing solution determined by the optimizer that is cutting for yield may be different than the optimizer cutting to maximize value. Sawing to maximize the value of parts will generally sacrifice or waste clear wood. Whether this is good or bad depends on the operational goal of the rough mill and plant.

Board Measurement

The various technologies that can be used for board measurement results in a broad range of capability. Board width is the most important parameter required by the gang saw, and is the minimum amount of data collected at the measurement station. The simplest approach is to determine the board's width at a single point. The board width measurement is then used to match the available combination of arbor pockets that most closely fits the board width in the case of yield optimization, or that produces strips of highest value during value optimization.

More complex camera systems can be used to measure board width all along the length of the board. These systems can evaluate board taper and edges with wane, and use the effective board width in evaluating cutting solutions. When there is little variation in width from one end of the board to the other (small amounts of wane and taper), good results can be obtained using single point board width determination. With lumber that has significant amounts of width variation, however, optimization at the gang saw may be better accomplished with systems that evaluate board width all along the board length, rather than single point measurement.

¹ Phil Mitchell is an Assistant Professor and Wood Products Extension Specialist in the Department of Wood and Paper Science at NC State University, Raleigh, NC. This article is an excerpt from a series of articles that will be published by the Forest Service as the new rough mill operators guide. The full text of the articles will be available on North Carolina State University's Web site at www.ces.ncsu.edu/nreos/wood.

Arbor Spacing and Board Positioning

Yield Optimization at the Gang Saw. Obtaining a high yield from a fixed-blade gang rip saw depends upon correctly designing (setting up) the sequence of arbor pockets (saw spacings). Ideally, for each board, it is desirable to have available adjacent arbor pockets whose combined width (including saw kerf) matches the width of the board (Figure 1). An example will show how arbor design can be important for yield. Assume a 7-3/4 inch wide board that will be ripped with an arbor that has 2-, 2.25-, 2.75-, and 3-inch wide pockets available. A saw kerf of 3/16" will be assumed. Figure 1 illustrates an arbor designed with the following sequence of arbor pockets.

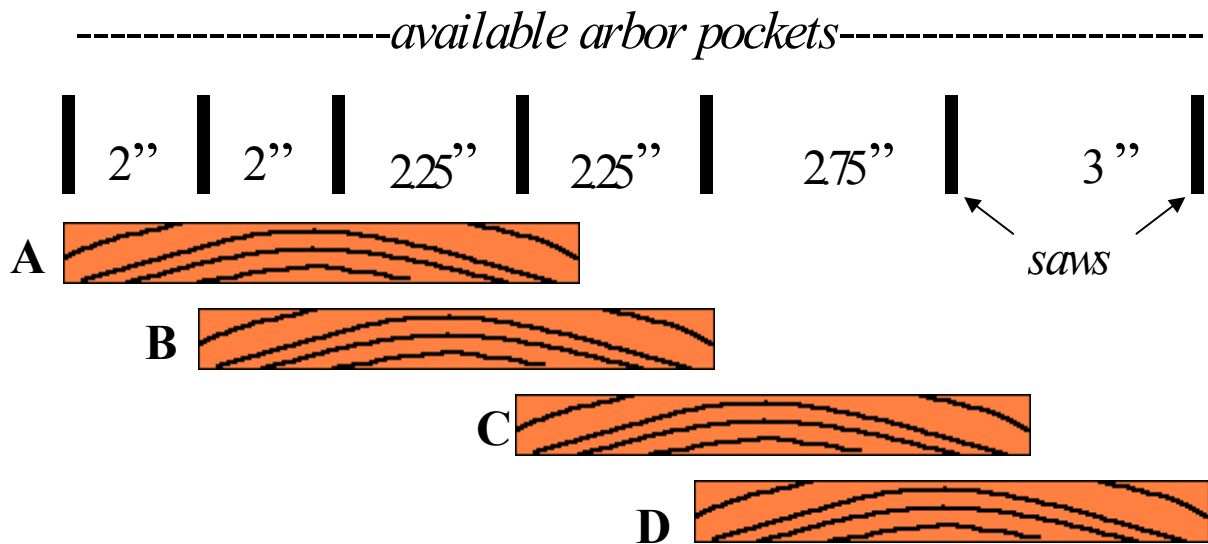


Figure 1. Six arbor pockets and seven saws (3/16" kerf) are shown with four possible positions that a 7-3/4" wide board might be fed.

Also shown in Figure 1 are potential locations that the board might be fed into the saw. The possible combinations of arbor pockets shown above result in the following yields:

A=2 + 2 + 2.25 + 4 (3/16) = 7.0" or	90.3% utilization	80.6% strip yield
B=2 + 2.25+ 2.25+ 4 (3/16) =7.25" or	93.5% utilization	83.9% strip yield
C=2.25 + 2.75 + 3 (3/16) = 5.5625" or	71.8% utilization	64.5% strip yield
D=2.75 + 3 + 3 (3/16) = 6.3125" or	81.5% utilization	74.2% strip yield

Other pocket combinations into which the board may be fed result in lower yield or exceed the board width of 7.75 inches. The results of any of these potential placements indicate that this arbor design does not fit this board well. Given these choices, our optimizer would have chosen B, and achieved a 83.9% yield at the gang saw. This is a respectable yield and we might be satisfied since the yield is higher than 80%, often given as a minimal acceptable yield from a gang saw. But consider this lost opportunity. Had the arbor been slightly different, we could have boosted yield, as shown below:

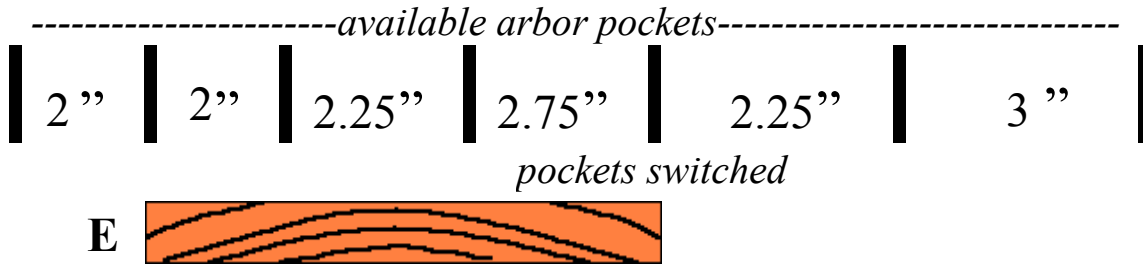


Figure 2. Feeding a 7-3/4" wide board into a well designed arbor resulting in a maximum strip yield.

$$E = 2 + 2.25 + 2.75 + 4(3/16) = 7.75'' \text{ or } 100\% \text{ utilization } \quad 90.3\% \text{ strip yield}$$

By simply swapping the position of the 2.25- and 2.75-inch pockets on the arbor resulted in a 6.4% boost in yield. This simple example illustrates the importance of arbor design. Further, consider that had a significant number of boards been 7.75-inches wide, the potential impact of arbor design on yield is increased.

There are thousands of combinations possible when designing the sequence of saw spacings to place on an arbor. Many gang optimizers offer arbor design programs as part of the software package, and software is available from universities to assist arbor design as well.

A good arbor can be designed by hand. The main objective is to develop as many different pocket combinations as possible on the arbor. The ability to do this will depend on the width of the parts required and the total width of the arbor. Wide part requirements (and thus wide pockets) will result in fewer pockets on the arbor and therefore reduce the number of pocket combinations possible. Conversely, a gang saw with a wide arbor will be able to hold more pockets than a gang saw with a narrower arbor. With these thoughts in mind, the following suggestions are offered as arbor design guidelines:

- use at least three or four different widths on the arbor, more is generally better;
- evaluate lumber widths to determine the most frequently occurring widths;
- design combinations of arbor pockets to closely match the predominant lumber widths (be sure to include kerf in the calculations);
- determine the percentage of the total area of the cutting bill in each part width;
- as a starting point, use two arbor pockets for part widths containing more than 25% of the total cutting bill area, and consider three arbor pockets for part widths greater than 50%. Often widths comprising less than 1% of the total cutting bill area can be omitted on the arbor and obtained by salvage operations;
- do not repeat the same sequence of pocket combinations if possible (in order to create different pocket combination alternatives for the optimizer);
- use thin kerf blades to increase the amount of arbor space available for pockets which may allow a more efficient arbor design. Compared to a conventional saw kerf of 0.156", a thin kerf saw (with 0.100" kerf) will save 0.056" in kerf per saw blade, resulting in an increase of over 1/2" of arbor space on a 10 blade arbor.

Value Optimization at the Gang Saw. The previous example focused on recovering yield from the board by maximizing the amount of strip volume produced. In some situations, it is more desirable to maximize the value of the strips produced by the gang saw. The following example will illustrate a case where the value driven solution differs from the previous yield based solution. Assume each of the different strip widths have been assigned the value shown:

2-inch wide	\$1
2.25-inch wide	\$2
2.75-inch wide	\$4
3-inch wide	\$5

As might be expected, the wider strips are valued more than narrower strips. The resulting strip value and yield for the five previously described solutions are presented below. If the gang saw optimizer is selected to maximize value, then the selected solution is D with a maximum *value* of \$9, while the maximum *yielding* E solution has a value of only \$7.

	<u>Strips Produced</u>	<u>Strip Value</u>	<u>Strip Yield</u>
A	2, 2, 2.25	\$1 + \$1 + \$2 = \$4	80.6% strip yield
B	2, 2.25, 2.25	\$1 + \$2 + \$2 = \$5	83.9% strip yield
C	2.25, 2.75	\$2 + \$4 = \$6	64.5% strip yield
D	2.75, 3	\$4 + \$5 = \$9	74.2% strip yield
E	2, 2.25, 2.75	\$1 + \$2 + \$4 = \$7	90.3% strip yield

More complex technology is incorporated in vision assisted optimizers that often utilize video cameras and other scanning technologies (x-ray, laser) to identify and locate defects. This allows the gang saw optimizers to extend the value concept to maximize the total value of the *parts* that can be obtained from each board. This approach generally uses vision technology to identify major defects on one or both sides in addition to the board size and shape. Part sizes from the cutting bill and part values are used by the gang saw optimizer to determine the best combination (best either in terms of yield or value) of parts to cut from the board. The optimizer predicts where the defects will be located when the strips are processed at the chop saws, and determines the maximum obtainable value or yield of parts. (In most cases this estimated solution is not shared with the automatic chop saw.)

Value cutting will usually force the recovery of wide and long parts, sacrificing yield in order to obtain those parts that are more valuable. Whether this is desirable or not depends on the objectives of the rough mill and the grade of lumber being cut. For instance, a casket manufacturer that requires a large number of long and wide parts is justified in force cutting for value from a reasonably high grade of lumber, but trying to do so from a low grade of lumber will likely result in a large amount of waste.

Another difference between optimizers whose goal is to fill the board with useful strips and those with the goal of predicting the parts available when the strips are chopped is the manner in which defects are handled. Optimizers that evaluate only the size and shape of the board do not take into account where the defects may be located in the strip that exits

the gang saw. This type of optimization may result in a defect, such as a knot, being split in half by the saw and thus becoming a defect in each of the two strips (Figure 3, case a). On the other hand, if the defect were identified and located by a vision assisted optimizer, the opportunity would exist for the knot to be placed in only one narrow strip (Figure 3, case b). Of course, this concept depends heavily on how well the defect detection system correctly identifies and locates defects. With a less than perfect vision, the final yield from a board may differ from that predicted by the gang optimizer since the human



a) filling the width of the board with usable strips, and splitting the knot between strips.



b) locating strips with regard to the parts obtained, and locating the knot in only one strip.

Figure 3. Different methods of ripping. In case a) the board has been ripped to maximize strip yield, while in case b) the board is ripped to maximize part yield, obtaining a long clear strip by placing the knot wholly in the other strip.

grader that marks defects in front of the chop saw may see more (or fewer) defects than the vision assisted optimizer.

One disadvantage unique to gang rip first cut up systems is the inability to efficiently cut boards containing crook (side bend). Gang ripping of full length boards containing a significant amount of crook can result in large yield losses. Research has shown that about one in four kiln dried boards have 1/2-inch or more of crook. One-half inch of crook in a 10-inch wide board will result in a 5% yield loss. Given that 90% of today's hardwood lumber is narrower than 10 inches, this means 1/4 of all boards will lose at least 5% yield due to crook. Losses due to crook will be much higher with narrower lumber. To avoid losses due to crook, many gang rip optimizers can identify crooked boards and re-route them to an offline cross cut saw to cut the boards in half lengthwise before being ripped. Rough mills that have both gang-rip first and crosscut-first cut up lines should be vigilant in their efforts to route crooked boards through the crosscut-first system.

The boards leave the optimizer and travel to the gang saw infeed. They must remain singulated in order to keep the determined solution with the proper board. The purpose of the positioning infeed is to convey the board and position it in alignment with the saws recommended by the optimizing computer. Some systems use a movable fence to position the board in front of the correct set of gang saw pockets. Other infeed systems use belts to position the board. These belts are able to swivel the board in order to feed it into the gang saw by aligning it at an angle, which might be an advantage if the board has

excessive crook or taper. Pinch rollers then clasp the board and hold it in place as it feeds into the saw.

Gang Sawing

Three types of optimizing gang saws are commonly found. These are:

1. fixed blade gang saw with movable fence (often called fixed arbor, best feed);
2. fixed blade gang saw with movable outer saw; and
3. all blades movable saw.

The fixed blade gang saw with a movable fence is the predominant gang saw found in furniture gang rip first rough mills. Even the most optimized arbor design will not completely eliminate the waste edging strips produced on a fixed blade gang saw. For operations that utilize a fixed blade gang saw, the generation of waste edging strips is particularly problematic. These waste edging strips represent a visible measure of the level of gang saw performance (specifically the efficiency of the arbor design). Extra labor is typically required to remove the strips and feed them to a guillotine or saw where they are cut into pieces that can be managed by the waste conveyor.

One limitation of the fixed blade gang saw is it cannot generate random width parts. The solution to this problem and that of the waste edging strips is to use a dual arbor gang saw in which one arbor is equipped with two movable blades. The movable blades are capable of moving to the outer edges of each board to: 1) generate a random width strip, and 2) eliminate or reduce the size of the waste edging strip. Although there were problems with the initial implementation of this technology, its application today is much improved. The advantage of using a dual arbor gang saw that has both fixed and movable blades is the potential to saw random width strips from the lumber and thus increase yield. This is a particularly good arrangement for a manufacturer with strong product potential in panels and a handful of fixed width sizes. One must be careful, however, in implementing the production of random width strips from the gang saw, that the amount of random width parts produced by the gang saw does not exceed the glue room's capacity to glue them into panels. Another caution is the random widths must not be too close (typically $\frac{1}{8}$ " to $\frac{1}{4}$ ") to the width of the fixed width strips in order to differentiate strip widths at the chop saw and parts at the sorter.

All blades movable saws have historically been found in the millwork industry, where the ripped stock is generally moulded and not edge glued. However, many of today's saws with movable blades are capable of producing a glueable edge, unlike earlier moving blade saws. With this limitation removed, most value added industries can take advantage of the higher gang saw yields which result with movable blade saws. Because the gang saw has movable blades, the optimizer can position the saw blades based on board width, part widths, and defects when they are accurately identified and located by scanning. These gang saws are capable of placing the saw blades at the best location for *each* board. This relieves personnel of the burden of daily arbor design required for fixed blade gang saws. As with a fixed blade gang saw, the optimized decision made by a movable blade gang saw can be based on maximizing the yield or the value of the ripped

strips produced. The saw operators and mill supervisors must understand the function of the saw's computer-based optimization software in order to correctly evaluate and adjust optimization parameters.

What happens at the gang saw will have significant impact on productivity throughout the rest of the rough mill. The capacity of most gang saws is such that they can swamp downstream operations. In such situations, it makes good sense to slow the gang operation down either by slowing the feed through the saw or by encouraging the gang operator to carefully observe the optimizer's decision, and override it if a better sawing decision is obvious. One manner in which the gang can overwhelm the chop saw markers is by producing a large amount of narrow strips. Narrow strips sometimes are needed by the cutting bill, but often are added to the arbor to make up for the deficiencies of what would otherwise be a low yielding arbor. This may or may not be justified; it will slow down the volume of wood processed by the chop saws because the volume of wood marked per strip is reduced. In addition, these narrow strips tend to jam the chop saw infeed and the saw itself.

In some cases, productivity at the gang saw is reduced due to narrow lumber. Narrow lumber is more and more common and is a challenge to the gang saw both in terms of productivity and yield. In gang sawing narrow lumber, there are fewer pocket combinations available that produce an acceptable yield compared to gang sawing wide lumber. The use of moving saw blades, either as a dual arbor or an all blade movable saw, to produce a combination of random and fixed width strips, is a method of improving the yield from narrow boards. In operations that use moving saw blades but do not cut random width parts, an effort should be made to insure that part width combinations are available that match the lumber width.

Operator Process Control Responsibilities

The misconception often presented by computerized optimization systems is that they will operate correctly without human intervention. In reality, however, the operator must verify that the saw has been set up correctly and is functioning properly. The operator must perform a number of process control quality checks to insure the following:

- Accuracy of board width and length. The actual dimensions of the incoming lumber needs to be compared to the measurements obtained by the optimizer. If the measurements do not agree, the sensors or cameras that measure dimension need to be calibrated.
- Accuracy of ripped strips. The width of ripped strips needs to be measured using calipers that measure to 0.001-inch. Strips that are not sawn to the specified width may indicate that the incorrect arbor spacers were used in building the arbor, or that movable saw blades are not correctly adjusted.
- Accuracy of laser line or video imaging system alignment. In order for the board (or movable saws) to be in the correct position, the laser lines or video cameras must be in correct alignment and calibration.
- Size of edging strips. When the gang saw is set to maximize the yield of strips, wide edging strips suggest a poor arbor design on a fixed blade gang saw, or too few widths available on the all blades movable gang saw.

- Best side up, or down. With single sided video camera systems capable of identifying defects, operators will need to turn the best face toward the cameras for clear one face parts. The worse face will need to be turned toward the camera system when cutting clear two face parts.
- Crooked lumber. The operator will need to divert crooked lumber from the gang rip saws as its first cut.

Because the breakdown of the lumber package generally occurs at the gang saw infeed, it is a convenient location to evaluate the lumber moisture content. This can be done by checking each board with an inline moisture meter, or using a systemized method of spot checking and recording moisture contents of a sample portion of the incoming lumber with a hand held moisture meter. Moisture content needs to be evaluated to insure that the lumber meets product moisture content specifications. Failure to do so will likely cause problems in machining, gluing, assembly, and finishing.

This article was published in FDM, November 2001, pp 54-57.