DESIGNING A FIXED-BLADE GANG RIPSAW ARBOR WITH A PENCIL

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ABSTRACT

This paper presents a step-by-step procedure for designing the "best" sequence of saw spacings for a fixed-blade gang ripsaw arbor. Using the information contained in a cutting bill and knowledge of the lumber width distributions to be processed, thousands of possible saw spacing sequences can be reduced to a few good ones.

When planning to use a gang rip saw with fixed blade spacings, one of the most important questions a manufacturer will ask is "How do I design the best arbor?" There are thousands of ways to arrange a few different saw spacings. Most are poor and unrealistic. Some commercial procedures require historical information that new users do not have. With a piece of paper and a pencil, however, a very good approximation of the "best" arbor can be made.

An arbor is not just a sequence of saw spacings. It is a series of combinations of saw spacings that overlap and interact. As long as the combinations are present, it makes no real difference for large board samples whether the spacings within them are arranged 1-2-3, 3-1-2, or 2-3-1 as long as the boards are straight and free of wane. The effects of crook or sidebend on yield have been discussed earlier.[1,2] The problem then is how to come up with combinations that do not preclude other needed combinations. Two things are needed: 1) a cutting bill; and 2) a knowledge of raw material widths.

Let's assume that a manufacturer is using a 24-inch arbor and has the capability to feed a board where the best yield in strips will be achieved. This is typical of today's gang-rip-first rough mills. Perhaps a laser light system or an operator with excellent judgment is available. The pencil arbor design technique will work on any fixed-blade gang ripsaw arbor, however.

There are five steps to the pencil technique. First, determine the percentage of the total area of the cutting bill in each part width. Second, determine the width distribution of the lumber to be ripped. Third, develop a table of ratios of strips (and kerf) for each board width category. Fourth, layout the arbor with trial and error (a little experience will greatly reduce the number of tries needed). Fifth, test the arbor by determining yields with the ROMI-RIP gang-rip-first simulator.[3]

Let's illustrate the technique using the cutting bill shown in Table 1. First, determine the percentage of the total area of the cutting bill in each part width. The length, width, and number of pieces in each part size are multiplied together, their products are totaled for each part width, and the percentage in each part width is determined by dividing the total area per part width by the grand total of the area of all parts. In our example, over 70 percent (72.7%) of the entire cutting bill is in the 1.75- and 2.25-inch part widths. We want to be sure that our arbor contains a sufficient number of spacings to obtain these widths. Keep in mind that, for parts of the same length, it takes twice as many l-inch-wide parts as 2-inch wide parts for the same surface area percentage.

Second, determine the width distribution of the lumber. In an earlier paper,[4] the importance of this knowledge is described in greater detail. But, for this procedure, we only need to know where to put our emphasis. Consider the distribution of widths for 2A Common found in a 1992 red oak data bank (Fig. 1).[5] The large amount of 5-1/4- to 7-3/4-inchwide lumber means we want to be sure to get our 1.75- and 2.25-

[1] Gatchell, C.J. 1990. The effect of crook on yields when processing narrow lumber with a fixed gang ripsaw. Forest Prod. 1 40(5):9-17.

[2] Gatchell, C.J. 1991. Yield comparisons from floating blade and fixed arbor gang ripsaws when processing boards before and after crook removal. Forest Prod. J.41(5):9-17.

[3] Thomas, R.E. 1995. ROMI-RIP: Rough Mill RIPfirst simulation. Gen. Tech. Rept. NE-206. USDA Forest Serv., Northeastern Forest Expt. Sta., Radnor, Pa.

[4] Gatchell, C.J. 1990. Predicting strip width distributions from gang ripsaw setups. Forest Prod. J. 40(1):50-52.

[5] Gatchell, C.l, J.K. Wiedenbeck, and E.S. Walker. 1992. 1992 data bank for red oak lumber. Res. Pap. NE-669. USDA Forest Serv., Northeastern Forest Expt. Sta., Radnor. Pa.

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TABLE 1. – Example cutting bill used to illustrate arbor design procedures.

Part length	Part width (in.) 1.25	1.75	2.25	2.75	3.25	3.75	4.5	% of total surface area
(in.)	(No. of parts)							(%)
8.0	501	407	376	250	203	141		6.6
16.5	532	1,002	376	423	516			25.3
19.5	156	203	579				78	8.4
23.0	94	469	110				63	6.3
27.0	94	141			47			2.0
31.5	63							2.1
37.0	50	344	282	94				10.7
45.0	125	156	78	50				5.5
55.0		344	266					14.9
65.0		250	313	50				15.0
82.5		110						3.2
% of total surface area	7.6	36.2	36.5	9.2	7.4	0.8	2.3	100.0

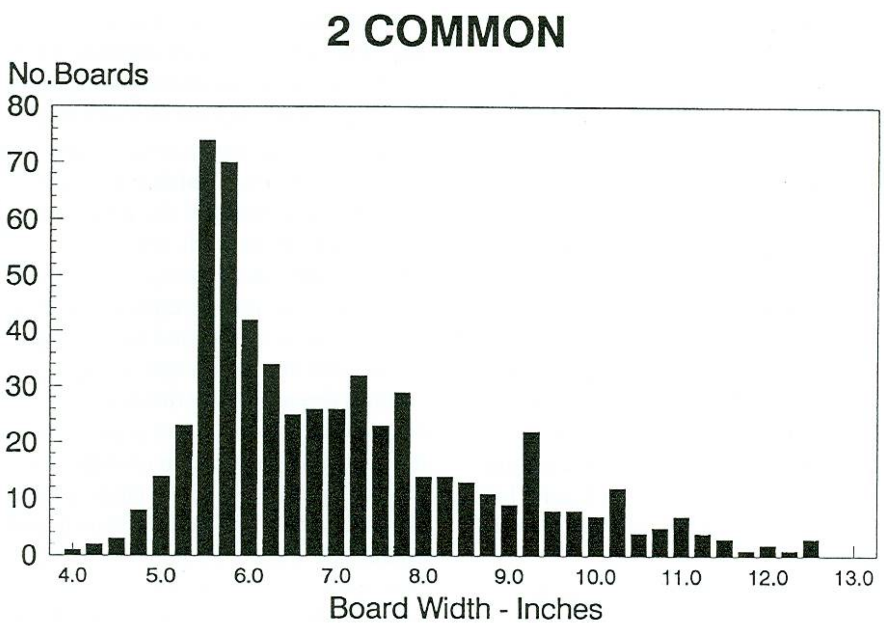

Figure 1. - No. 2A Common board-width frequency distribution.

inch widths from as much of this material as possible. If you do not know your board width distributions, a half day or so on the lumber yard with a ruler is highly recommended. Or, you may wish to substitute the results of a Forest Service study currently underway at Princeton, W.Va., in which lumber width distributions used by several furniture manufacturers are being measured.

The third step is building the table of ratios (Table 2). The denominator of the ratio is the number of strips that will be used ripped from a given board width. The numerator is the number of strips of a given width that will be used. For any board width, the total of the ratios with the same denominator is one. The idea here is that the total of strips plus kerf will equal the board width. In our example, all kerfs are 1/4 inch. A 1/4- inch kerf on each edge is used for cleanup. Thus, the 4.5-inch strip width will fit precisely in the 5-inch board width (ratio of 111). In Table 2, combinations of ratios plus kerf that fit precisely in a board width are shown in bold numbers. Ratios in parentheses are a second possibility. Best fit combinations that do not fit precisely in a board are shown in italics. Use brackets or parentheses to separate different combinations with the same denominator value for the same board width.

Consider the 5.25-inch board width in Table 2. For our cutting bill, there are two realistic possibilities. For two strips, there is 3/4 inch of kerf (l/4-in. cleanup on each edge and a 1/4-in. kerf between the strips). The two possibilities are two 2.25-inch strips or one 1.75-inch strip and one 2.75-inch strip. Arbitrarily, we start with the two strips that are 2.25 inches wide because we need so many of them (36.5% ofthe total cutting bill area) and enter the 2/2 ratio in the 2.25-inch column. The other combination is noted in parentheses by putting the 1/2 ratio in both the 1.75 and the 2.75 column. If, later on, too many 2.25-inch strips are produced, the emphasis can be changed. Ideally, both combinations would be found on the arbor and the operator or an automated gang-rip system could choose the combination to be used based on the parts still required by the cutting bill.

Let's look at some other ratios in Table 2. No combinations of needed widths and kerf will precisely fit the 5.5-inchwide boards. One solution is to use the 2/2 ratio as a "best fit" combination and allow 1/4 inch of waste.

Next, look at the 6.75-inch width. We can get all yield in 1.75- and 2.25-wide strips with two 1.75 strips and one 2.25 strip. With three strips you have ratios of 2/3 and 1/3 and 1 inch of kerf (two 1/4-in. cleanups and two 1/4-in. kerfs separating the strips). As we have called for 2.25 inch-wide strips in all but one of the narrower board widths, we put parentheses around the ratios for the 1.75- and 2.25-inch strip widths and look for other combinations. We see that a 2.75-inch and a 3.25-inch width also will fit the 6.75-inch-wide board. Recall that ratios with the same denominator must add to 1 for a single board width. We emphasize the 1/2 ratios because we are concerned with having enough 3.25-inch strips.

With an eye to the percentage needs for each strip width, we continue to develop ratios for each board width. For the 7.25-inch board width, we can illustrate the point that a given spacing can be found in more than one combination. In this case, two 1.75-inch spacings can be combined with two 1.25-inch spacings OR one 1.75-inch spacing can be combined with two 2.25-inch spacings. A similar comparison is shown for the 8.25-inch board width.

You don't have to do ratios for all board widths. First, all board widths will not precisely contain allowable saw spacings plus kerfs. Some combinations will have to be used that will generate some edging waste. Second, if you have the ability to pick the best place to feed the board, then wider boards with excessive defects on the edges (wane is common) can be fed through narrower combinations of spacings with beneficial effects on processing efficiency. This eliminates long edge defects and the resulting strips can be simply cut to length. Otherwise, these long defects or defective areas must be removed at the salvage rip and crosscut saws. Finally, when the initial arbor is laid out, other combinations will become apparent that will fit the wider boards. For our example, we've developed ratios for board widths from 5 through 8-1/4 inches. Other combinations for wider boards can be seen or approximated simply by adding adjacent widths together and accounting for kerf.

The fourth step in the. pencil technique is to design the arbor spacings using combinations of the ratios shown in Table 2. Here, bring in all considerations. Will you sort lumber to width and use two arbors? Or, must everything be done with one pass? If you must use only one pass, must you include all of the part widths? For example, the 3.75-inch width represents less than 1 percent of the total cutting bill area. Perhaps that could be gained from salvage from the 4.5-inch-wide strips. After all, the required length of the 3.75-inch-wide cuttings is only 8 inches. In short, why use space on the arbor for needs that might be better met another way. As can be seen in Table 2, the choice was made to leave the 3.75 width off Arbor 3 because those parts could be obtained from salvage.

Arbor spacing design is much easier, initially, if you do not limit yourself to your specific arbor size. An oversized arbor map can be separated into two smaller arbors or otherwise altered to fit your arbor width. In the beginning, we will consider arbors wider than 24 inches.

Arbor design is begun by drawing a line and putting spaces on it that represent the ratios. A 2/2 ratio means two spacings of a given width must be adjacent to each other. If there are more than two spacings in a combination, then they must be adjacent to each other in any sequence. Take the ratios for the 5.75-inch board width. You can have a 1.25-inch spacing followed by two 1.75-inch spacings or, perhaps, a 1.25-inch spacing between the two 1.75-inch spacings. The final arrangement will depend, in part, on how these sequences fit into other combinations.

For this report, four arbors were designed, with specific requirements for each. The commas in the sequences represent 1/4-inch saw kerfs. For comparison purposes, Arbor 1 was composed WITHOUT using the procedures outlined in this technical note. The requirements were that every spacing be represented and that the arbor be 24 inches or narrower. Arbor 1 was 23.5 inches wide and looked like this:

Arbor 1:
4.5, 3.25, 3.75, 1.75,2.75, 1.25, 2.25, 1.75

For Arbor 2, the 3.75-inch spacing was left out and three spacings of the same width were adjacent to each other. This resulted in the following arbor:

Arbor 2:
4.5, 1.75, 1.75, 1.75, 2.25, 2.25, 2.25, 2.75, 1.25,3.25,

Arbor 2 is 26.5 inches wide, including kerf.

For Arbor 3, the restriction was added that any spacing could only occur a total of two times anywhere on the arbor. Spacings of the same size did not have to be adjacent to each other. The arbor was to be a maximum of 24 inches wide. The needed 3.75-inch-wide parts would come from salvage rather than by cutting them on the gang ripsaw. The design of this arbor is explained in detail later.

Arbor 3:
1.25, 1.25, 1.75, 1.75,2.25,2.25,2.75, 3.25,4.5

Arbor 3 is 23.5 inches wide, including kerf.

For Arbor 4, the 3.75-inch spacing was added at the left end of Arbor 3. This resulted in a 27 .5-inch arbor:

Arbor 4:
3.75, 1.25, 1.25, 1.75, 1.75,2.25,2.25, 2.75, 3.25,4.5

Consider the design for Arbor 3. The start of the design was dictated by the need to work with the narrower board widths (the greatest number of boards is here) and the narrower strip widths (the greatest number of parts is in the combination of 1.75- and 2.25-inch widths). In Table 2, the ratio for the 5.25-inch board width is 2/2 under the 2.25-inch strip width. Two 2.25-inch spaces

TABLE 2. - Saw spacing ratios for Arbor 3. Combinations of ratios plus kerf that fit precisely in a board width are shown in bold numbers. Ratios i/1 parentheses are a second possibility. Those that are only a best fit are shown in italics.

Board width	Width (in.)						
	1.25	1.75	2.25	2.75	3.25	3.75	4.5
(in.)							
5.00							**1/1**
5.25		**(1/2)**	**2/2**	**(1/2)**			
5.50			*2/2*				
5.75	**1/3**	**2/3**					
6.00			*1/2*	*1/2*			
6.25			*1/2*	*1/2*			
6.50			*1/2*	*1/2*			
6.75		**(2/3)**	**(1/3)**	**1/2**	**1/2**		
7.00		*2/3*	*1/3*				
7.25	**(2/4)**	**(2/4)**					
		1/3	**2/3**				
7.50		*1/3*	*2/3*				
7.75		*1/3*	*2/3*				
8.00		*1/3*	*2/3*				
8.25	**(1/4)**	**(2/4)**	**(1/4)**				
			2/3	**1/3**			

were placed next to each other in the middle of the line as a starting point. The 5.5-inch-wide boards could also be accounted for with 2/2. For the 5.75-inch-wide boards, two 1.75-inch spacings and one 1.25-inch spacing were needed. These were put to the left of the pair of 2.25-inch spacings. Yes, they could have been put to the right. After scanning the 1.75-inch strip column, it was noted there were four other instances where a pair of 1.75-inch spacings could have been used (for 6.75-, 7.0-, 7.25-, and 8.25-inch-wide boards). So two 1.75-inch spacings were entered adjacent to each other and the 1.25-inch spacing was put to the left of them. This procedure was continued until all board widths through 8.25 inches were accounted for. At this point, it was noted that wider boards could be accounted for with various combinations of saw spacings and the arbor development was arbitrarily concluded.

Last, step 5, ROMI-RIP3 is used to evaluate the four arbors. The ROMI-RIP program continues to process lumber until all parts requirements in the cutting bill are met. So the most efficient arbor design will use the least amount of lumber. This evaluation was done with 2A Common lumber with the following results:

Arbor	Board feet of 2A Common	Primary yield (%)
Arbor 1	5,993	54.8
Arbor 2	5,478	60.4
Arbor 3	5,467	60.5
Arbor 4	5,478	60.4

Arbor 1, without any real design behind it, produced about 5 percent less primary yield than all other arbors. The results from Arbors 2, 3, and 4 were remarkably similar. Arbor 3 would probably be the best choice since it is less than 24 inches wide. Make nothing of the left to-right ascending sequence of saw spacings in Arbor 3. That sequence resulted from my interpretation of cutting bill needs and lumber width distributions. A different interpretation could result in different ratios and, therefore, different combinations.

Could a more efficient arbor be designed? Possibly. However, the yields from the 2A Common lumber and the amount of board footage are about the same for the three best arbors. This suggests that we are on an upper plateau of arbor design for this cutting bill and we probably could not do much better. But, different arbors would be generated if the number of parts in the various part widths were changed or the board width distribution had more wide boards and fewer narrow boards.

With a little trial and error and a pencil with an eraser, the procedure can be mastered in just a few tries. For information on ROMI-RIP and lumber width distribution studies, contact the Forestry Sciences Lab, 241 Mercer Springs Road, Princeton, WV 24740.