379

PRIORITIZING PARTS FROM CUTTING BILLS WHEN GANG-RIPPING FIRST

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ABSTRACT

Computer optimization of gang-rip-first processing is a difficult problem when working with specific cutting bills. Interactions among board grade and size, arbor setup, and part sizes and quantities greatly complicate the decision making process. Cutting the wrong parts at any moment will mean that more board footage will be required to meet the bill. Using the ROugh MIll RIP First Simulator (ROMI-RIP), different part prioritizing methods were examined. The "best" method of prioritizing part sizes appears to be both cutting bill and lumber grade dependent. Dynamic prioritization strategies, in which the emphasis placed on different part sizes shifts during optimization, are more efficient than more simplistic prioritization strategies for almost all cutting bills.

How well different dimension parts can fit into specific boards is critical to efficient rough mill processing. Interactions among board lengths and widths, lumber quality, and part requirements impact yield, raw material costs, and rough mill productivity. An efficient rough mill cut-up simulator must consider both part size and quantity requirements for each part and must be able to adjust priorities as high priority part needs are met. This means that the simulator must be able to prioritize parts dynamically. The ROMI-RIP (9) rough mill rip-first simulator offers multiple means of prioritizing or valuing different part sizes in a cutting bill, including several dynamic prioritization strategies.

Due to the large number of variables and their interactions, there are countless ways of prioritizing the parts in a cutting bill. It is therefore unlikely that any single prioritizing method will work equally well for all cutting bills and processes. A good prioritization system minimizes the amount of lumber and number of processing steps required to fill a wide range of cutting bills cut from different lumber grade mixes. This paper discusses the development and compares the performance of three dynamic prioritization methods.

Most earlier lumber cut-up simulators lacked dynamic prioritization capabilities. Some used exponential weighting factors to build in a preference for one part over another. For example, the rough-end YIELD program (8), and the Forest Products Laboratory's YIELD program (11) used the formula:

$$Priority = Length^2 \times Width$$

to emphasize longer lengths and minimize the number of short parts. However, $L^2 \times W$ does not allow the user to set width priorities nor does it include a mechanism for considering part quantities.

Other simulators have used different strategies. RIPYLD (7) and OPTYLD (4) optimized for part area with no consideration of numbers of parts. GR-1ST (5), and later AGARIS (10), optimized for total area in primary parts. These simulators could, however, shift preference from longer lengths to shorter lengths. This was accomplished by specifying that either a single longest length, two longest lengths, or three longest lengths be cut from each clear area within a strip. All of these simulators optimized for part area and had a tendency to prefer narrow widths over wider ones. This is because narrow widths allow better fitting of parts between defects. A crosscut-first version of CORY, CORY USDA-1 (1), also has this capability. This version of CORY was especially developed to be cutting option compatible with the AGARIS simulator.

OPTLYD (4) and CORY (2) can prioritize parts based on a dollar value. More desirable parts are given a higher value and less desired parts are given a considerably lower value. However, the values assigned to the parts are often arbitrary. In reality, it is often difficult to determine the actual value of any single part flowing through the mill. This makes value strategies very dependent on the assumptions of the person running the simulation. In addition, the part valuation strategy also lacks the ability to consider diminishing need as parts are cut. However, it is believed that it is pos-

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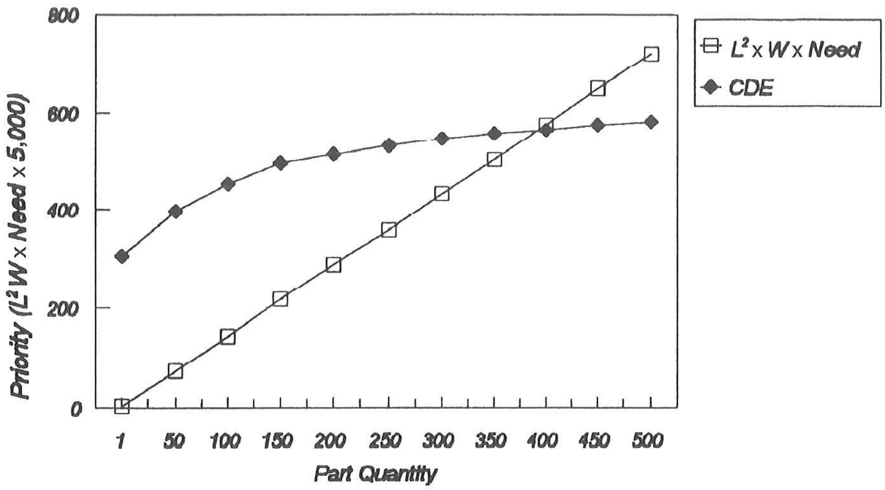

Figure 1. — A comparison of the influence of number of needed dimension parts on part priority for two dynamic part prioritization strategies, *Length*^{2} × *Width* × *Need* and Complex Dynamic Exponent (CDE) from the ROMI-RIP rough mill cut-up simulator.

sible to develop static part values that perform as well as dynamic strategies for some conditions. Unfortunately, there is no known method of practically determining the part values.

CORY also allows parts to be prioritized using a variation of the longest-length-first strategy (6). For this method, the user enters a variable exponential weighting factor to change the length class preference for random-width dimension parts. By changing the exponent, the user can change the preference from short to moderate to longer length parts. The prioritization formula used for this prioritization strategy is:

$$Priority = Length^{weight} \times Width$$

where:

Weight = a user-supplied exponential weighting factor

Many industrial gang-rip-first systems optimize for total strip area based on the width of the board. These systems measure each board and indicate which pre-set saw spacings will most efficiently process the board into strips. Optimizing chop saws then optimize the placement of cuttings in each strip. Some chop saws use dynamic prioritization strategies based on the number of parts of each size that are needed. These strategies are proprietary and vary among manufacturers.

Some gang ripsaw and chop saw manufacturers are developing methods of integrating the two saw optimizing systems. Typically, an additional computer is used to keep track of all part counts from the chop saws. The computer then pools the information and assists the gang-rip optimizer in deciding which strips should be sawn from each board.

ROMI-RIP, the ROugh MIll RIP First Simulator (9), is a program for IBM-compatible computers that simulates gang-rip-first operations using digitized board data and cutting bills consisting of as many as 300 part sizes and associated quantities. ROMI-RIP uses dynamic prioritization strategies based on both part size and quantity. These strategies allow ROMI-RIP to select the best gang-ripsaw spacings and part lengths for each board. ROMI-RIP also can simulate a communication link between the cut-off saw and the gang-rip system. This allows the cut-off saw to send information back to the gang-rip system, indicating which strip widths are most needed and which are no longer required. This is like the central computer integration method just discussed.

Development of a Dynamic Part Prioritization Strategy

In the development of ROMI-RIP, several dynamic strategies were implemented that consider both the size and quantity for each part. A dynamic strategy does nothing more than introduce current needed quantity information into a prioritization strategy. The goal of these part prioritizing methods is to maximize the production of needed part sizes while minimizing the lumber footage required to produce the parts. The ROMI-RIP strategies assign a weighted area or priority to each part based on its size and needed quantity. Cuttings for each board are based on optimization of total weighted primary part area. With ROMI-RIP's dynamic strategies, part priorities are continually updated based on how many parts of each size remain to be cut.

Simple Dynamic Cutting Bill Part Prioritization

An easy way to introduce dynamic, quantity-based information is by adding *Need* (the needed quantity of a specific part size at any moment in time) to the $L^2 \times W$ strategy (where L is the length and W is the width of the part). This gives the prioritization formula:

$$Priority = L^2 \times W \times Need$$

Priority decreases as *Need* decreases, making this a dynamic strategy. However, this strategy has some problems. One problem is that no additional emphasis is placed on wider width parts. For example, consider a cutting bill that requires 1,000 1- by 60-inch parts and 1,000 3- by 60-inch parts. The priority associated with three 1- by 60-inch parts will be the same as one 3- by 60-inch part. The $L^2 \times W \times Need$ strategy does not make a distinction as to which part size is preferable. Obviously, if at all possible, the 3-inch-wide part should be cut, since it will be much harder to obtain than the 1-inch-wide part.

Another problem with $L^2 \times W \times Need$ is that the decrease in priority is linear (**Fig. 1**). When half the needed quantity for a part size has been cut, the priority for that part size is reduced to half the original priority. This can mean that the priority of hard-to-get part sizes will decrease too quickly, causing emphasis to shift to other easier to obtain parts (**Fig. 1**). This may lead to more board footage being required to fill the cutting bill.

Dynamic Exponential Cutting Bill Part Prioritization

A part prioritization strategy that uses an exponential weighting factor based on quantity requirements gives consistently better results than a static exponent strategy. Because part requirements can range from 0 to tens of thousands, they cannot be directly used as an exponential weighting factor. An acceptable weighting factor is one that is small enough not to generate large priority values, yet produces distinguishable differences for different part quantities. Repeated computer runs show that weighting factors greater than 1.0 and less than 3.0 are most desirable.

The goal of a dynamic priority is to have a low priority value (near 1) for the last few parts of any specific part size. If the starting exponent is large (more than 3), an extremely large priority value will be generated and the value of the weighting function will have to change very quickly as part needs are met. The fast shift in prioritization values can mean that emphasis may shift from hard to get part sizes too rapidly, making those part sizes hard to obtain under the prioritization scheme.

By applying the square root and natural log transformations to the needed part quantity, an acceptable weighting factor (*WF*) is generated. The general formula for deriving *WF* is:

$$WF = (\sqrt{\ln (Need + 0.01)} \times MF) + 1.0$$

Need is the current required quantity of a specific part size and always has a value of 0 or greater. Adding 0.01 to *Need* avoids taking the natural log of 0. The natural log (ln) of (*Need* + 0.01) typically returns a value between 0 and 15. The square root of the natural log term is multiplied by *MF*. *MF* is a multiplication factor and was originally introduced as 0.1 to reduce the resulting value one order of magnitude. Lastly, 1.0 is added to ensure an exponential weighting factor of at least 1.0. Thus, if *Need* is 500, *WF* would be approximately 1.25.

By varying *MF*, the weighting factor can be tailored to provide distinctly different results. This is used, in part, to provide two dynamic exponential strategies: Simple Dynamic Exponent (SDE) and Complex Dynamic Exponent (CDE).

The SDE strategy uses an *MF* value of 0.14. This value was arrived at based on repeated runs using many different cutting bills and grades of lumber. Using this *MF*, a single exponential *WF* is generated for each part size. Thus, the prioritization for SDE is:

$$SDE\ Priority = (Length \times Width)^{WF}$$

It is important to note that SDE prioritizes part length and width equally.

The CDE strategy increases the priority of parts having low initial quantities.

TABLE 1. — Descriptions of cutting bills used to examine part prioritization strategies for the ROMI-RIP cut-up simulator.

Cutting bill	Widths	Lengths	Comments
(Easiest)			
1	4[a] 1.5 to 2.75[b]	9 12 to 48	Mostly short and narrow.
2	7 1.75 to 5.25	14 10 to 31.5	Most parts are narrow. Wider parts are narrow.
3	3 2 to 2.75	5 16 to 32	Most parts are in wider widths.
4	4 2 to 4.75	7 11 to 53	Long wide and short narrow parts with good distribution in between.
5	7 1.5 to 4.25	12 19.5 to 87.75	Wide cuttings are short. Good distribution of lengths and widths.
6	2 2 and 3.25	6 15 to 97	Mostly short (41 in. and under) and narrow parts.
7	2 1.5 and 3	8 18 to 72	Large gap between short and long lengths; 3-in. width requires twice as many parts in longest lengths as a single short length.
8	4 2 to 4.25	10 15 to 72	Most parts are long and wide with very few short and wide parts.
9	5 2 to 4.5	5 16 to 84	Widest parts are short. Equal numbers of short and long parts.
10	5 4 to 6	3 29 to 84	Only one short and two very long lengths. More long, wide parts than short.
(Hardest)			

[a] Number
[b] Range (in.)

This allows those parts to be obtained at earlier, more opportunistic times. With SDE, it is possible for a hard to obtain part with a low required quantity not to be prioritized until late in processing. This can lead to more board footage being required to meet the cutting bill. The weighting factor formula for CDE is:

$$WF = (\sqrt{\ln(Need \times \max(1,(35 - Count)) \times SF)} \times MF) + 1.0$$

As before, the natural log and square root transformations are used to generate acceptable weighting factors. The only difference is the addition of extra terms to give priority to part sizes that have low initial requirements. The max function returns the largest value of its arguments, either 1 or (35 – *Count*). *Count* represents the number of parts of a particular part size that has been generated. This term places a preference on the first 35 parts of each size. Once those 35 have been obtained, the priority decreases for that part. For each of the first 35 parts, the value of the term is increased by 15. In general, if a preference for more than the first 35 parts is used or a larger value is added for each part, the prioritization system can become overloaded looking for the initial low quantity parts. Performance decreased for almost all cutting bills when the preference count was raised significantly above 35.

CDE uses two *MF* values to generate two different exponents, one for length and one for width. The *MF* value for the length exponent is 0.14, the same as used with SDE. The *MF* value for the width exponent is 0.07, half of the length *MF* value. This formulation provides an emphasis on longer parts but also prefers wider parts over narrower parts of the same length and quantity. Many variations of the length and width *MF* values were examined across many different cutting bills and lumber grades. As with SDE, the *MF* values incorporated into ROMI-RIP performed the best in the majority of cases, requiring the least amount of lumber to meet the cutting bills. Thus, the complete prioritization formula for CDE is:

$$Priority = Length^{WF_{Length}} \times Width^{WF_{Width}}$$

METHODS USED IN COMPARING THE PERFORMANCE OF SEVERAL PART PRIORITIZATION STRATEGIES

The performance of the dynamic exponential strategies developed as part of the ROMI-RIP program (9) were compared to both static and dynamic versions of longest-length-first prioritization strategies included in the previous generation of gang-rip-first cut-up simulators. Performance was measured in terms of the board feet (BF) of lumber required to meet a series of cutting bills. Performance was investigated not only for different cutting bills, but also for different lumber grades (FAS, Selects, No. 1 Common, and No. 2A Common). A decrease in the board footage required to meet a cutting bill translates into a higher yield in required parts for a prioritization strategy and improved cutting efficiency.

Ten cutting bills, most of which were obtained from actual mills, form the basis for this comparison. These bills are briefly described in **Table 1**. They are arranged according to their level of difficulty. The 10 cutting bills were ranked from "easy to meet" to "hard to meet" based on part sizes and quantities. An easy cutting bill is one that 1) has a wide range of lengths and widths; and 2) emphasizes short (approximately 40 in. and less) lengths and narrow widths (approximately 2 in. and less). Please note that the board footage requirements for these bills vary considerably, as no effort was made to scale the bills to require the same amount of lumber.

The cutting bills are sawn from randomly sorted FAS/Selects, No. 1 Common, and No. 2A Common lumber samples (3). In some instances, the lumber sample size was not large enough to meet the cutting bill. In addition, obtaining required cuttings in the lower grades of lumber presents extra difficulties. Due to the nature of the CDE strategy, part quantities could not be reduced without giving CDE an unfair advantage over the other strategies (remember that CDE adjusts priorities to meet low initial part requirements). Instead, the lumber sample was mixed with another grade to provide a 50/50 grade mix. For FAS runs, the FAS data were combined with Selects data. For No. 2A Common runs, the data were mixed with No. 1 Common data. Both grade mix data files were created using random selection and equal amounts of lumber for each grade. The tables of results (**Tables 2** through **5**) indicate the grade mix used in each comparison study. All No. 1 Common runs used entirely No. 1 Common lumber data.

All runs used a best-spacing-sequence arbor, which is similar to the all-movable-blades arbors that are commercially available. For each board, the computer program determines the optimum fixed blade saw sequence. In addition, ROMI-RIP uses a feedback control mechanism between the optimizing chop saw and gang rip systems. This information is used by the dynamic methods to emphasize strip widths with high required part counts and de-emphasize strip widths with low or no required parts.

RESULTS

Tables 2, 3, 4, and **5** compare the board footage requirements for 50 percent FAS and 50 percent Selects, No. 1 Common, No. 2A Common, and 50 percent No. 1 Common and 50 percent No. 2A Common lumber grade mix analyses, respectively. The column titled "CDE (Adjusted)" in **Tables 4** and **5** shows CDE results for increased MF values. The upper number in these tables' cells is the amount of lumber, in board feet, required to meet the cutting bill's requirements. The lower, italicized number is the percentage difference in lumber volume required for the given prioritization strategy versus the best performing strategy for that cutting bill.

FAS COMPARISONS

Due to the ease with which most of the cutting bill requirements could be met by FAS lumber, there is very little difference in the performance of the dynamic prioritizing strategies (**Table 2**). For FAS overall, the $L^2 \times W$ strategy performed the worst for the sample cutting bills. In one instance (cutting bill 9), $L^2 \times W$ required 24 percent more lumber to meet the cutting bill than the best strategy (SDE). On another cutting bill, $L^2 \times W$ used at least 10 percent more lumber than the best dynamic strategy. CDE met the cutting bill requirements of five cutting bills while using the least board footage and SDE required the least board footage for four bills. $L^2 \times W \times Need$ obtained the best results for the remaining cutting bill. $L^2 \times W$ did not obtain a best solution for any of the cutting bills.

Cutting bill 4 has significantly different part requirements than the other cutting bills and required parts with an emphasis on wider rather than longer parts. SDE places the same emphasis on width as length, while all other methods emphasize length over width. Consequently, SDE performed much better than $L^2 \times W$

TABLE 2. — Board footage requirement comparison for 50 percent FAS and 50 percent Selects grade mix for sample cutting bills using different prioritizing strategies.[a]

Cutting bill	$L^2 \times W$	$L^2 \times W \times Need$	SDE	CDE
	(BF)			
1	4,262 *1.69*	4,232 *0.97*	4,209 *0.44*	4,191 *Best*
2	3,718 *1.39*	3,710 *1.18*	3,690 *0.61*	3,667 *Best*
3	3,873 *6.87*	3,624 *Best*	3,689 *1.79*	3,701 *2.10*
4	4,341 *17.03*	3,659 *0.25*	3,650 *Best*	4,058 *10.0*
5	4,894 *2.96*	4,775 *0.50*	4,753 *Best*	4,765 *0.25*
6	3,444 *1.30*	3,464 *1.90*	3,432 *0.90*	3,399 *Best*
7	4,632 *0.73*	4,652 *1.15*	4,632 *0.73*	4,599 *Best*
8	5,141 *0.78*	5,148 *0.92*	5,115 *0.28*	5,101 *Best*
9	1,602 *24.03*	1,289 *0.41*	1,284 *Best*	1,322 *2.89*
10	3,864 *0.36*	3,864 *0.36*	3,851 *Best*	3,977 *0.68*

[a] Upper number is the amount of lumber in board feet required to meet the cutting bill, lower number is the percentage difference from the best.

TABLE 3. — No. 1 Common board footage requirement comparison for sample cutting bills using different prioritizing strategies.[a]

Cutting bill	$L^2 \times W$	$L^2 \times W \times Need$	SDE	CDE
		(BF)		
1	4,907 *3.06*	4,869 *2.26*	4,762 *Best*	4,762 *Best*
2	4,270 *1.92*	4,282 *2.19*	4,211 *0.51*	4,190 *Best*
3	4,602 *5.66*	4,421 *1.51*	4,355 *Best*	4,355 *Best*
4	5,688 *15.70*	4,795 *Best*	5,222 *8.17*	5,808 *17.44*
5	6,292 *10.62*	5,862 *3.06*	5,696 *0.14*	5,688 *Best*
6	4,202 *Best*	4,355 *3.65*	4,227 *0.60*	4,211 *0.22*
7	5,445 *1.80*	5,410 *1.15*	5,348 *Best*	5,348 *Best*
8	6,771 *3.89*	6,510 *Best*	6,582 *1.09*	6,709 *2.96*
9	2,274 *16.37*	1,937 *Best*	2,149 *10.30*	2,061 *6.04*

[a] Upper number is the amount of lumber in board feet required to meet the cutting bill, lower number is the percentage difference from the best.

TABLE 4. — No. 2A Common board footage requirement comparison for sample cutting bills using different prioritizing strategies.[a]

Cutting bill	$L^2 \times W$	$L^2 \times W \times Need$	SDE	CDE	CDE (Adjusted)
			(BF)		
1	5,658 *5.30*	5,538 *3.06*	5,381 *0.13*	5,373 *Best*	5,473 *1.86*
2	5,031 *4.55*	4,924 *2.33*	4,825 *0.27*	4,825 *0.27*	4,812 *Best*
3	5,408 *4.74*	5,253 *1.75*	5,163 *Best*	5,174 *0.21*	5,183 *0.39*
6	5,434 *0.24*	7,005 *29.23*	6,076 *12.08*	5,664 *4.48*	5,421 *Best*
7	7,283 *15.04*	6,376 *0.71*	6,469 *2.18*	6,923 *9.35*	6,331 *Best*

[a] Upper number is the amount of lumber in board feet required to meet the cutting bill, lower number is the percentage difference from the best.

and CDE on cutting bill 4. To support this idea, CDE was modified to emphasize width more than length. The modified CDE strategy performed slightly better than SDE.

No. 1 Common comparisons

Due to extra difficulties in finding the required cuttings within a lower grade of lumber, there are greater differences among the strategies using No. 1 Common lumber than with FAS lumber (**Table 3**). In fact, cutting bill 10 could not be met by any of the prioritization strategies using the available No. 1 Common lumber sample and was dropped from the No. 1 Common analysis.

As with FAS, $L^2 \times W$ performed the worst overall with the No. 1 Common lumber sample. However, $L^2 \times W$ performed about the same as CDE on cutting bill 6, requiring 9 less BF to meet the cutting bill. Overall, CDE had the best solution on 5 of the 9 cutting bills.

Note the differences between the dynamic exponential methods and $L^2 \times W \times$ *Need* on cutting bills 4 and 9. With CDE, the higher BF requirement can be attributed to the multiplication factors (MFs) of the weighting function. By increasing the MFs, better performance is realized for these two cutting bills. In fact, doubling the MFs brought the CDE board footage requirements for cutting bill 4 down from 5,808 to 5,260 BF. However, the same increase in MFs for the other cutting bills resulted in only slightly lower board footage requirements for only two other cutting bills. Similar differences were seen when the CDE MFs were decreased. Cutting bills that required more BF with the higher MFs required slightly less BF with reduced MF values.

No. 2A Common comparisons

Obtaining the required part sizes in their needed quantities from No. 2A Common lumber is much more difficult. Cutting bills 4, 5, 8, 9, and 10 could not be met by any of the prioritization strategies using the available No. 2A Common lumber sample. As with No. 1 Common, cutting bill 10 was dropped from the No. 2A Common analysis. The remaining unmet No. 2A Common bills were analyzed using a 50 percent No. 1 Common and 50 percent No. 2A Common lumber mix. **Table 4** shows the performance of the different strategies for the cutting bills filled using 100 percent No. 2A Common lumber. **Table 5** lists the results for processing the 50 percent No. 1 Common and 50 percent No. 2A Common sample for the remaining bills.

By adjusting (increasing) the value of the CDE strategy MFs, significantly better results are obtained on two of the nine No. 1 Common cutting bills. With the No. 2A Common and No. 2A Common mix runs, this difference is more pronounced. On seven of the nine No. 2A Common or mixed cutting bills, better results are obtained with larger MF values. The increased MF values were determined from repeated runs looking at the possible MF values between 0.05 and 0.50. **Tables 4** and **5** include the column "CDE (Adjusted)" to show the increased performance of CDE with the best MF values. No additional performance could be gained by adjusting the SDE MF values for the 100 percent No. 2A Common analysis. However, significant differences could be obtained by tuning the SDE MF values for the 50 percent No. 1 Common and 50 percent No. 2A Common analyses. An additional column, "SDE (Adjusted)," showing the results of this tuning appears in **Table 5**.

TABLE 5. — Board footage requirement comparison for 50 percent No. 1 Common and 50 percent No. 2A Common mix for sample cutting bills using different prioritizing strategies.[a]

Cutting bill	$L^2 \times W$	$L^2 \times W \times Need$	SDE	SDE (Adjusted)	CDE	CDE (Adjusted)
			(BF)			
4	7,199	6,180	6,998	6,040	7,221	6,000
	19.98	*3.00*	*16.63*	*0.67*	*20.35*	*Best*
5	7,221	6,416	6,250	6,305	6,375	6,305
	15.54	*2.65*	*Best*	*0.88*	*2.00*	*0.88*
8	8,350	7,671	7,902	7,582	7,957	7,618
	10.13	*1.17*	*4.22*	*Best*	*4.95*	*0.47*
9	3,508	2,907	2,927	2,703	2,907	2,676
	31.09	*8.63*	*9.38*	*1.01*	*8.63*	*Best*

[a] Upper number is the amount of lumber in board feet required to meet the cutting bill, lower number is the percentage difference from the best.

For both the 100 percent No. 2A Common, and 50 percent No. 1 Common and 50 percent No. 2A Common analyses, the dynamic strategies performed the best. The MF values used for the 100 percent run are different from those used in the mix runs. Typically, the 50 percent mix analyses were performed on more difficult cutting bills and responded better to larger MF values. In fact, for the mix analyses, the width and length MFs are both set to 0.30 versus a width MF of 0.18 and a length MF of 0.20 for the 100 percent No. 2A Common runs. For the SDE strategy, the optimal MF values also were 0.30. As expected, there is little difference between the adjusted SDE and adjusted CDE values for the 50 percent No. 1 Common and 50 percent No. 2A Common analyses.

For the 100 percent No. 2A Common runs (**Table 4**), the $L^2 \times W$ strategy performed the worst and the $L^2 \times W \times$ *Need* strategy performed almost as poorly. On cutting bill 6, $L^2 \times W \times$ *Need* required over 29 percent more lumber than the CDE Best strategy (7,005 BF versus 5,421). The SDE strategy also performed poorly on cutting bill 6. However, on cutting bill 3, SDE performed slightly better, requiring 20 BF less lumber than the CDE (Adjusted) strategy.

For the 50 percent No. 1 Common and 50 percent No. 2A Common, the differences between the $L^2 \times W$ and CDE Best strategies were very pronounced (**Table 5**). The CDE Best strategy required an average of 900 BF less per cutting bill than $L^2 \times W$. On cutting bill 5, the SDE strategy performed slightly better (55 BF less) than the CDE strategy. Overall, the $L^2 \times W \times$ *Need*, SDE, and CDE strategies performed almost equally.

Summary and Conclusions

The ability of dynamic prioritization methods to respond to changing part quantities allows these methods to meet cutting bill part requirements using less input lumber than the static $L^2 \times W$ prioritizing strategy. While the $L^2 \times W$ strategy does emphasize longer part lengths, it does not emphasize widths or quantity. For these reasons, it is a poor strategy for use with cutting bills. In almost every case, the dynamic strategies performed better than $L^2 \times W$. Overall, the CDE strategy performed the best.

The standard SDE and CDE MF values work best for FAS, No. 1 Common, and some No. 2A Common analyses. If SDE and CDE were incorporated into the optimization and control systems in today's rough mills, significant reductions in lumber requirements and processing costs would be achieved in most processing situations.

However, all cutting bills and boards do not respond the same to a prioritization strategy. Increasing the SDE and CDE MFs will reduce the board footage requirements for more difficult bills and lower qualities of lumber. In these circumstances, increasing the MF values 50 to 100 percent obtains the most performance gain. Decreasing the CDE MFs slightly reduces the board footage requirements for less difficult bills and higher grades of lumber. In general, smaller MF values always perform poorly with No. 1 and No. 2A Common lumber. This suggests that prioritization strategies for cutting bills should consider not only part size and quantity, but the quality or grade of the lumber currently being processed.

The next step is to design a prioritization system that is not only sensitive to part size and quantity, but to board quality and cutting bill difficulty as well. With the advent of scanning systems and current optimization and control systems, new prioritization methods and mechanisms can be realized. With proper part prioritization and scheduling, it will be possible to meet cutting bill requirements using significantly less board footage. This will mean less lumber handling and processing and less yield in unneeded parts.

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