SIMULATION FOR ROUGH MILL OPTIONS

By Jan Wiedenbeck

Simulation modeling demonstrates the feasibility of utilizing short lumber in a crosscut-first rough mill.

How is rough mill production affected by lumber length? Lumber grade? Cutting quality? Cutting sizes? How should equipment purchase plans be prioritized? How do personnel shifts affect system productivity? What effect would a reduction in machine set-up time have on material flow? Simulation modeling is being widely used in many industries to provide valuable insight into questions such as these.

Simulation is "the process of designing a model of a real system and conducting experiments with this model for the purpose of understanding the behavior of the system and/or evaluating various strategies for the operation of the system." It provides a means of learning about a system which cannot be observed or experimented with directly. Typical uses of simulation modeling include (1):

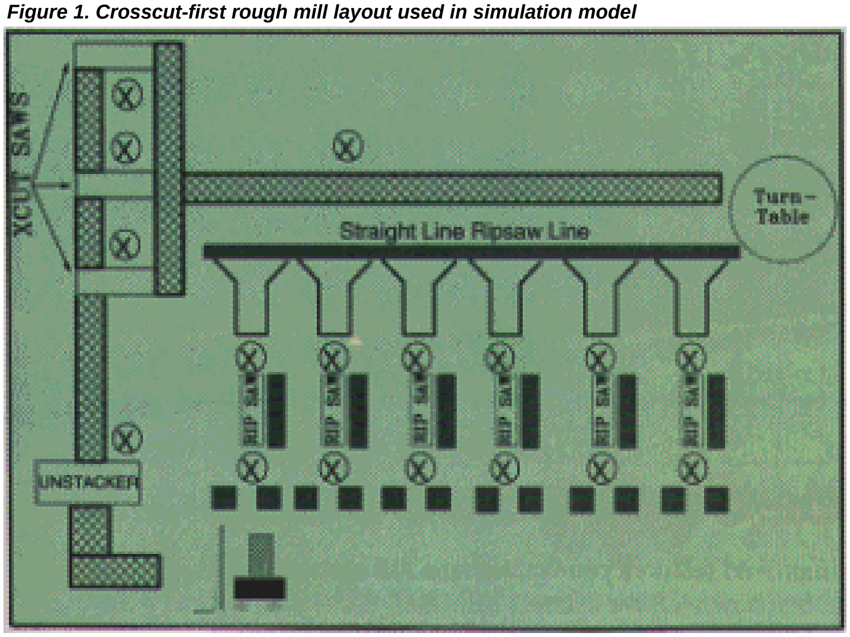
- Evaluation of new systems.
- Comparison of system alternatives.
- Prediction of performance under forecasted conditions.
- Sensitivity Analysis: Which factors have the greatest influence?
- Optimization: Which scenarios produce best system response?
- Relationships: How are system elements interrelated?
- Bottleneck Analysis: Where are backups occurring? How can they be remedied?

Simulation's status in industry

Analysts predict that the use of simulation will rapidly increase during this decade. By the year 2000 it is expected that 40 percent of U.S. manufacturing engineers will be utilizing simulation as a decision support tool. This compares to an estimated usage rate of 17 percent in 1988 (2) In 1990, the U.S. Department of Defense designated simulation modeling to be one of the 20 most important industrial technologies (3). Evaluation of process alternatives using simulation will soon be performed on a continual basis by production controllers and engineers just as managerial accountants have adopted the use of spreadsheets to enable them to examine a multitude of "what if" scenarios (4).

In the wood products industry simulation modeling is being used in research and by a few of the most innovative companies but it has not yet been widely adopted.

Figure 1. Crosscut-first rough mill layout used in simulation model



Case study: Using simulation to estimate effect of lumber length

Recently completed research conducted by the USDA Forest Service Virginia Tech University examined various processing issues associated with using short hardwood lumber to produce furniture and cabinet parts. Yield estimates, derived from both computer studies and mill studies were combined with processing rate estimates obtained from in-mill timing studies, to obtain an estimate of the potential value of short length lumber to a crosscut-first furniture/cabinet manufacturer. A simulation model was used to perform this evaluation.

Simulation modeling was the best analysis method to use this instance since opportunities to observe, first-hand, the processing of short lumber in furniture or cabinet rough mills are extremely limited. Experiments designed to produce throughput and part value data would be very disruptive to rough mill operations. In addition, possible problems associated with short lumber handling in actual rough mills might complicate the experimental procedure and bias the results. The assumption that handling problems would be remedied can be built into a simulation model.

The mill

Figure 1 shows the layout of the crosscut-first mill modeled in this study. During the first phase of the modeling process the mill layout was diagramed, conveyor distances and speeds were measured and machine processing rates were timed. Particular attention was paid to those operations which were most strongly influenced by lumber length Part yields from short (4 to 7 feet), medium (8 to 13 feet), and long (14 to 16 feet) length lumber were determined. In-mill data collection activities during this and subsequent phases of the modeling process required about 80 hours.

The model

The SIMAN/CINEMA simulation and animation software programming language was used to translate the mill information into a simulation model. Machine processing rates and material properties (lumber width, length and yield) were treated as distributions. **Figures 2** and **3** show the distributions for two of the most important processing variables proved to be lumber length dependent: the number of crosscut pieces removed from a board and the cutting lengths of the pieces removed. Lumber width, a very important material property for rough mills that puts a premium on wider, fixed-width cuttings, was the same for the short, medium and long lumber.

The crosscut time required per cutting produced varied with lumber length and was also related to the number of cuttings removed from the board. The number of

TABLE 1
Economic Factors Used in After-Tax Cash Flow Analysis

ECONOMIC FACTOR	ASSUMPTION
Price of dry red oak lumber	$800 per mbf
Value of residue as fuel	$10 per ton = $20 per dry mbf
Average rough mill labor rate	$6.75 per hour
Fringe benefit rate	30 percent of wage rate
Minimum attractive after-tax rate of return	12 percent
Overhead costs	Used $/hour figure based on 30% of total costs for medium length lumber model
Income tax rate	34 percent
Costs of converting system to process short lumber	a - no changeover costs b - moderate costs ... $15,000 c - extreme costs ... $30,000 + $45,000 forklift
Planning horizon	5 years
Forklift depreciation schedule	5-year property: Accelerated Cost Recovery System
Timing of conversion costs	Costs incurred during first year

crosscut pieces cut out of the piece of lumber influences the crosscut time per piece because there is a set-up time associated with the cutting of each piece of lumber. Time is required to load the board on the crosscut saw's infeed table, to visually inspect the board, to make a clean-up cut on the lead end of the board and to clear the remaining woodblock from the saw table after the cutting is taken. If more cuttings are removed from a board, the set-up time per cutting board is reduced. Board length influences crosscut time per piece because longer boards are heavier, and thus harder to move, than shorter boards.

Lumber length influenced both the number of crosscut pieces obtained from a board and the distribution of cutting lengths obtained from a board at the crosscut saws. The cutting bill used in this particular simulation study was selected by the rough mill supervisor. The rough mill supervisor tried to choose a cutting bill that would match up well with the short length lumber. The cutting lengths in the cutting bill ranged from 14 inches to $40\frac{3}{8}$ inches.

Several return trips were made to the mill to collect additional data and observe material routings in order to refine the representation of lumber and parts flow. Finally, the animated model was shown to the mill's management.

Preliminary results obtained from the simulation model were discussed. The mill personnel were satisfied that the simulation model was an accurate representation of the company's rough mill.

TABLE 2
Results of Crosscut-First Rough Mill Simulation

PERFORMANCE MEASURE	SHORT LUMBER (4-7 feet)	MEDIUM LUMBER (8-12 feet)	LONG LUMBER (13-16 feet)
Part volume per hour (bf)	1567-1709	1686	1716
Part value per hour ($)	3599-4139	3876	3948
Unstacker operator utilization	23%	15%	12%
Crosscut saw utilization	94%	93%	94%
Rip saw utilization	61%	66%	68%
Number of pieces in rip queues	15	61	73

Breakeven purchase price of short, dry, red oak lumber (compared to $800 per mbf going market rate for longer length lumber): $671 - $800

Using the model

We next designed and ran simulation experiments to determine the economic consequences of processing short, medium and long lumber in the crosscut-first rough mill. Thirty simulation runs were executed — 10 runs each for the short, medium and long lumber processing scenarios. Each run simulated 1½ hours of actual rough mill production.

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The average values for rough part production volume, part value and various machine utilization rates were generated by the simulation model. These production figures formed the basis of an economic analysis of the feasibility of producing rough dimension parts from short lumber.

Cash flow analysis
Some of the economic factors included in the after-tax cash flow analysis are shown in **Table 1.** The most notable of these economic factors is the system conversion cost profile which gives three estimated cost levels associated with adapting a rough mill system to handle short length lumber.

An economic measure that is more easily understood than the present worth value is the break even price of dry, short length lumber. This is the dry lumber purchase price that balances the cash flows for the short lumber and the medium length lumber alternatives. This price was calculated for each of the short lumber alternatives in which the present worth of the short lumber production system was lower than the present worth of the medium length lumber production system. All of the yield, production, and price estimates used in this example are based on red oak.

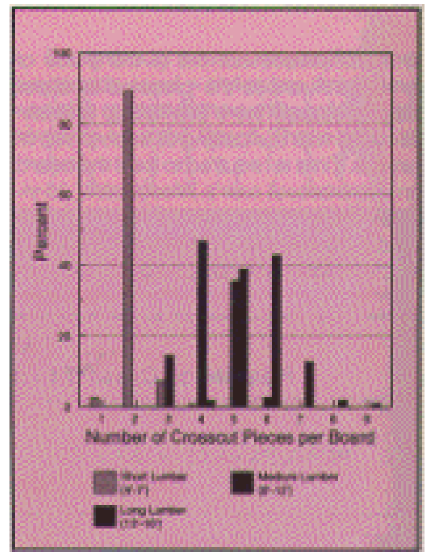

Figure 2. Distribution of number of pieces crosscut from each board.

Short lumber use is feasible
Table 2 shows the results of the simulation and economic analyses for the crosscut-first model. The results consist of range rather than point estimates for many of the measured variables. Varied yield and cutting length distributions were incorporated into the short lumber simulation model producing these ranges. Some of the yields estimates were based on mill study data and some of the estimates were based on a computerized cut-up program's output. The higher short lumber production figures are based on the data generated in the mill study. These volumes are high, in large part, because the 6-foot-long lumber produced an abundance of longer parts.

Only when the more pessimistic estimate of the distribution of cutting lengths obtainable from short lumber was entered into the simulation model did the longer length lumber models outperform the short lumber model. Even for this most pessimistic case, a short lumber purchase price discount of only $150/mbf would yield a return with a comparable NPV to that generated when longer lumber is processed.

Thus, simulation showed that the production of rough furniture parts from short lumber in a crosscut-first rough mill can be economically feasible with careful matching of cutting bills and short lumber input schedules. Simulation runs with

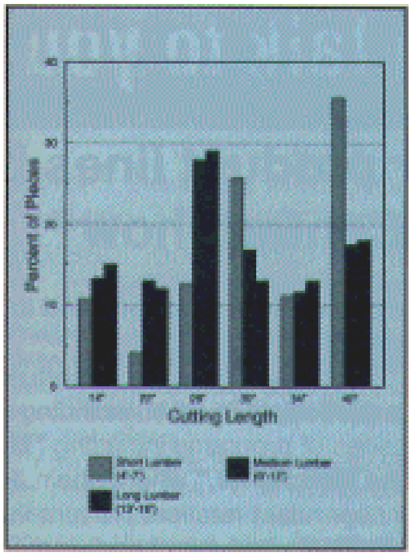

Figure 3. Distribution of cutting lengths obtained at crosscut saw.

modified models will show how short lumber packages might be intermixed with longer packages to optimize material flow through the rough mill. We will also be using this tool to determine how equipment changes might affect productivity.

Decision support tools

For medium and large companies that employ production planners' industrial engineers whose time is devoted to planning and scheduling-type activities, simulation modeling should quickly become an in-house decision support tool.

Simulation modeling is used in research and by innovative companies but has not yet been widely adopted.

Programs known as manufacturing simulators are available and are easily understood and applied. These programs enable users to develop models quickly with the aid of menus and graphics; programming is not required (5) An informative article, titled "Selecting Simulation Software for Manufacturing Applications: Practical Guidelines and Software Survey" by Laughery, appeared in Industrial Engineering in May 1989.

For smaller companies that have limited personnel resources, simulation studies can be carried out with the assistance of research or consulting personnel who have expertise in systems modeling. A model of a smaller operation can usually be developed in a few weeks if the company has available or can assist in the collection of the necessary data. ■

Sources

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