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SAWMILL SIMULATION: CONCEPTS AND COMPUTER USE

Abstract. Product specifications were fed into a computer so that the yield of products from the same sample of logs could be determined for simulated sawing methods. Since different sawing patterns were tested on the same sample, variation among log samples was eliminated; hence, the statistical conclusions are very precise.

What is the best way to saw a log into boards for selected products or product parts? Until now, answers to this question have been approximations because of limited research techniques. Many different sawing patterns can be used, and researchers have had difficulty deciding which pattern will give the highest yield. The reason for this indecision is simple: once a sample of logs was sawed, it could not be reassembled and sawed again. Different log samples had to be used for each method. Because of the natural variation from log to log, and therefore from sample to sample, there has always been a question whether differences in product yields were caused by sawing pattern or by sample variation.

In the course of a study to determine the best way to convert low-grade hardwood logs into pallet parts, we developed a technique to solve the problem of variations between samples. Using computer simulation, we were able to compare the predicted yields of any number of sawing patterns from only one log sample. Because only one sample is used, the technique is very precise.

This paper gives a general description of the computer simulation technique. Detailed instructions and computer programs for researchers, production managers, and others who may wish to use this technique are found in a companion research paper by Reynolds.[1]

General Procedure

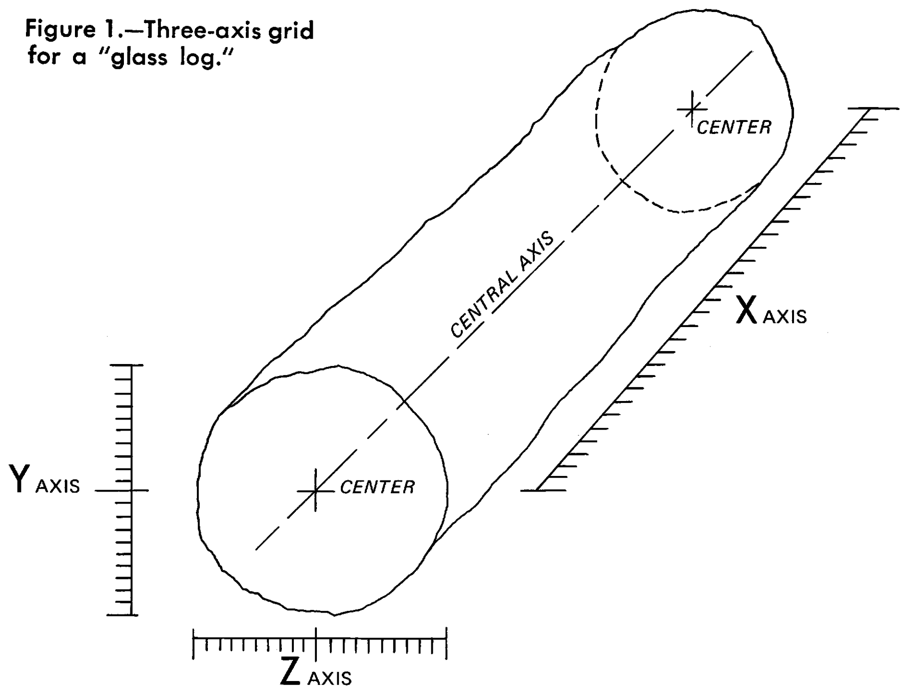
Computer simulation of a sawmill operation requires two basic computer programs: DEFECT and YIELD. Program DEFECT is used to simulate the conversion of a log sample into boards by using any sawing pattern. Program YIELD, developed by the USDA Forest Service's Forest Products Laboratory in Madison, Wisconsin, is used to examine the DEFECT-produced boards and to indicate the yield of preselected product parts.

Sawmill simulation by program DEFECT follows these steps:

1. Select enough sample logs to properly represent the quality of raw material normally used.

[1] Reynolds, Hugh W. SAWMILL SIMULATION: DATA INSTRUCTIONS AND COMPUTER PROGRAMS. U.S.D.A. Forest Serv. Res. Paper. In press. NE. Forest Exp. Sta., Upper Darby, Pa.

Figure 1.—Three-axis grid for a "glass log."



2. Live saw these logs into boards, identifying the boards so that they can be oriented to their proper place in the log.
3. Identify all defects on the boards by class, size, and location; and encode both the boards and the defects into a three-dimensional grid system (fig. 1).
4. Within the computer, reassemble the boards into their respective logs.
5. Prepare sawing instructions for each of the chosen sawing patterns to show the sequence and plane of the boards to be generated. Computer program DEFECT allows boards to be produced in any sequence, horizontally or vertically. And the program displays defects as they appear in each new board.

The output of program DEFECT is then used as the input for program YIELD. Program YIELD simulates the ripping and trimming of the boards and provides cutting yields by thickness, length, and width according to the product specifications used. The grade of these cuttings is determined by the grade of the boards produced in program DEFECT.

Program DEFECT

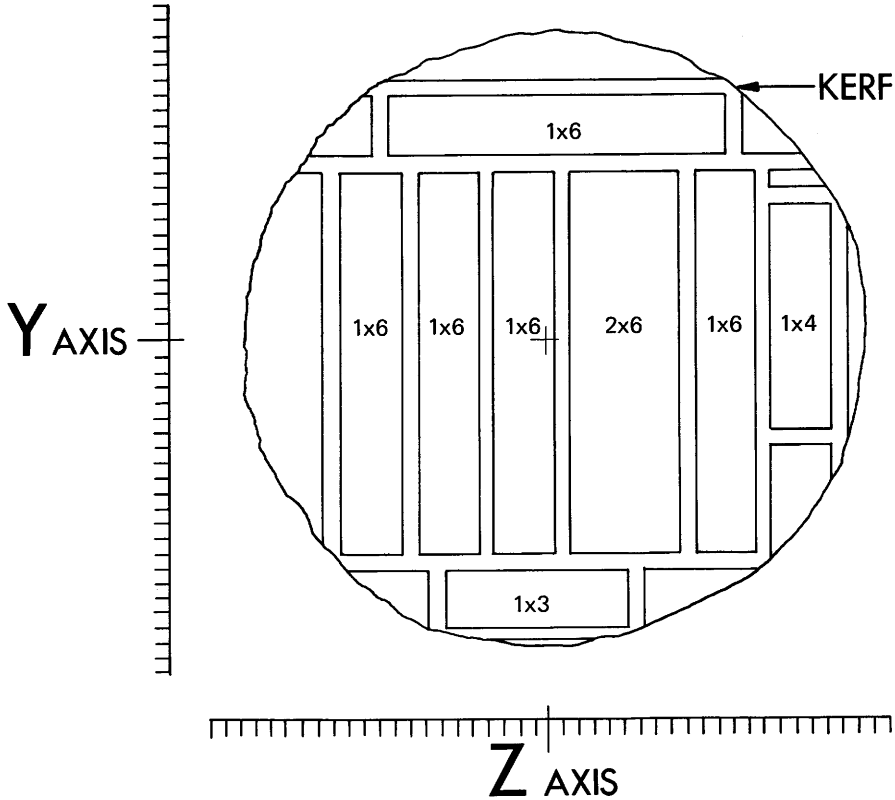
Constructing the log model. — The central axis of each log in the sample is located by marking the center of both ends of the log (fig. 1). Boards are then sawed parallel to the Y axis. Using the central axis as a reference, each board surface is identified by the Z-axis location it held before sawing. Similarly, the board width is identified by Y-axis values and the board length by X-axis values.

Defects in each board are grouped into classes that depend upon the products being considered. Each class includes those defects that would cause rejection of the piece for a particular use. For example, if the yield of parts for pallets, flooring, or dimension stock is to be determined, then three classes of defects can be used. When the yield of pallet parts is being computed, program DEFECT will ignore the flooring and dimension classes of defects.

Program DEFECT provides for reassembly of the boards into their original log form. Because board outline and defect location have been converted to numerical data, they are "visible" to the computer; therefore, the reassembled log can be considered a "glass log."

Specifying the sawing patterns. — The glass logs are sawed into boards according to predetermined sawing patterns (fig. 2). It is necessary

Figure 2.—Typical sawing pattern.



to draw a pattern for each diameter class to be studied. The computer sawing instructions are based on the Y-axis and Z-axis coordinates of each board. The sawing pattern predetermines the thickness and width of the boards to be produced.

Program YIELD

As stated above, the output of program DEFECT is used as the input for program YIELD. This output consists of boards of log length and of predetermined width, thickness, and quality. Program YIELD is used to simulate the conversion of these boards into cuttings. Product specifications are written for program YIELD that include length, width, thickness, and quality of desired cuttings. Program YIELD determines the optimum combination of product sizes that can be made from each board, and gives the best method for crosscutting and ripping each board to get these cuttings.

After the yield of product cuttings from each board is obtained, the yield from all boards in each log and for each sawing pattern can be compiled. In this way, the best method for sawing logs, based on yield of product parts, can then be determined.

Use of Sawmill Simulation

The potential value of sawmill simulation will depend upon the initial decisions of the research or production manager. Value of the technique will depend mainly on the adequacy of the sample, the extent to which defects are classified, the sawing patterns chosen for study, and the specifications of the product or component parts.

Users of program DEFECT should keep in mind that sawmill simulation has these limitations:

- The logs are sawed according to a prearranged pattern.
- Horizontally and vertically sawed boards are made according to the orientation of each log at the time it was converted into the three-dimensional grid "glass log." Rotation of the log between sawing techniques is not possible at the present stage of development of program DEFECT.
- The boards are sawed parallel to the central axis of each log. As written, the program does not allow for taper sawing.

Our work is a continuation of other Forest Service research. Peter and Bamping[2] used a partially automated simulation technique. The development of program YIELD[3] at the Forest Products Laboratory preceded our sawmill simulation work, and program DEFECT was written to be compatible with program YIELD. Future simulation developments by the Forest Products Laboratory will enable the board output of program DEFECT to be graded and tallied in terms of standard hardwood lumber.

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[2] Peter, Ralph, and James H. Bamping. THEORETICAL SAWING OF PINE LOGS—A NEW TECHNIQUE FOR EVALUATING SAWING METHODS. Forest Prod. J. 12 (11):549-557. 1962.

[3] Wodzinski, Claudia, and Eldona Hahn. A COMPUTER PROGRAM TO DETERMINE YIELDS OF LUMBER. U.S.D.A. Forest Prod. Lab. Misc. Pub., 33 pp. Forest Prod. Lab., Madison, Wis. 1966.