Using Manufacturing Simulators to Evaluate Important Processing Decisions in the Furniture and Cabinet Industries

Janice K. Wiedenbeck, Project Leader
USDA Forest Service, Northeastern Forest Experiment Station
Princeton, West Virginia, U.S.A.

Philip A. Araman, Project Leader
USDA Forest Service, Southeastern Forest Experiment Station
Brooks Forest Products Center
Blacksburg, Virginia, U.S.A.

Abstract

We've been telling the wood industry about our process simulation modeling research and development work for several years. We've demonstrated our crosscut-first and rip-first rough mill simulation and animation models. We've advised companies on how they could use simulation modeling to help make critically important, pending decisions related to mill layout, lumber inputs, technology adoption, scheduling, etc. And we've heard the excitement of industry personnel turn into frustration when they learn that this valuable tool called simulation will cost more than they want to spend, will require time to learn to use, and may require even an experienced programmer several days to several weeks to adapt to a new problem. We are taking steps to remove these implementation barriers. We are converting our existing rough mill models to generic and flexible models that can be quickly adapted to simulate a wide variety of industrial processing alternatives. We will launch the rough mill manufacturing simulation program with the help of the Robert C. Byrd Hardwood Technology Center by mid-1995.

Introduction

Manufacturing simulation, also know as process simulation modeling, systems simulation modeling, and flow simulation, is underutilized by the furniture and cabinet industries. Manufacturing simulation is a type of computer programming in which a manufacturing system (e.g. a rough mill, a machine shop, a finishing area, etc.) is represented or modeled on the computer. Included in the model are representations of equipment and operators, material (e.g. lumber and parts) and material flow, and activities, priorities, and decisions (e.g. how does and operator choose between multiple jobs).

Manufacturing simulation can be used to investigate questions involving entirely new manufacuring facilities, renovations to existing facilities, and modifications and equipment upgrades to ongoing manufacturing operations (2). The investigations may look at either physical modifications, procedural modifications (e.g. scheduling), or both.

A wide variety of information can be provided by a simulation-based investigation. Key performance measures captured by simulation often include: system throughput (pieces per unit time), value of production per time period, queue and inventory sizes, and equipment and personnel utilization.

Simulation is a much more effective industrial engineering tool when coupled with animation. Animating a simulation model saves a lot of time during model building by allowing the programmer to spot material flow problems and pinpoint their location. More importantly, animation enhances the ease with which a model can be explained to a client (decision-maker), it allows a system expert to survey the model to make sure it adequately represents the manufacturing operation, and it increases model credibility by removing the "black box."

Necessary inputs to a process simulation model typically include: processing rate data, downtime data, operator availability data, transporter and conveyor speeds and distances, and product yield data (Figure 1).

Product yield data for a furniture or cabinet industry rough mill consists of information on the number and size of parts produced at each machining operation (e.g. crosscut saws and rip saws). Individual machine yields vary considerable depending on product (cutting bill) and raw material (lumber size and grade). The yield data is difficult to collect in the mill so it is usually generated by running cut-up simulations of the crosscutting and ripping operations.

While simulation modeling is not yet widely used by wood products companies, it is expected that by the year 2000, 40 percent of U.S. manufacturing engineers will be utilizing simulation as a decision support tool (1). In 1988 the usage rate by manufacturing engineers across all manufacturing industries was approximately 17 percent. Many companies are adopting this decision support technology because it is such a flexible and powerful tool.

Simulation Opportunities in the Furniture and Cabinet Industry

Changes in raw material, processing, or product may have a major impact on important production and profitability variables. Sometimes the impact of the changes can be predicted using available industrial engineering tools and institutional knowledge. However, there may still be some level of uncertainty associated with these predictions. If the uncertainty has a high cost risk factor associated with it, simulation, a comprehensive decision support tool, can be used to reduce the uncertainty.

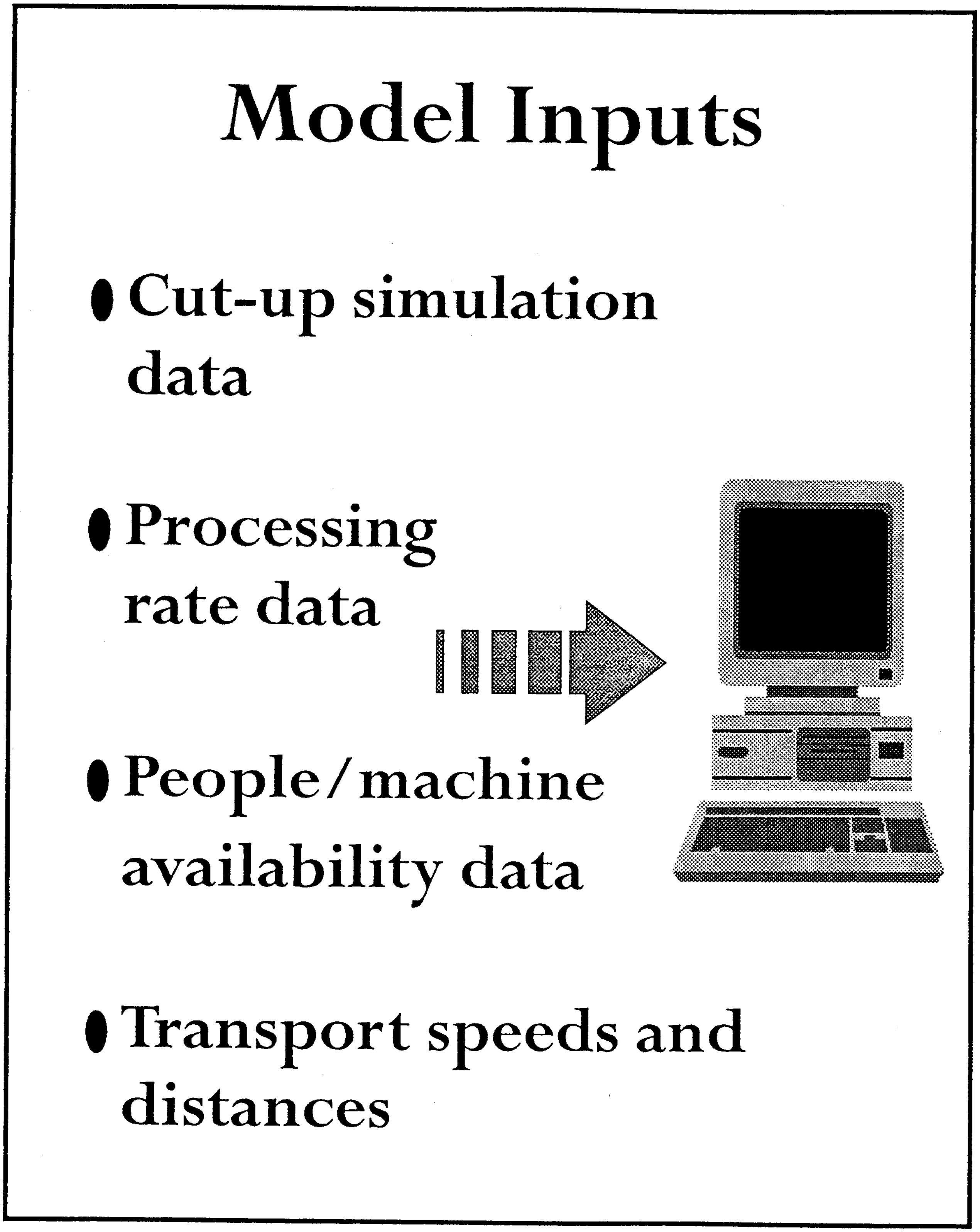

Figure 1. Input data requirements for a manufacturing simulation model.

Following is a partial list of some potential applications of process simulation modeling in the furniture and cabinet industries:

1. To investigate the impact of lumber length on productivity and profitability (3,4).

2. To investigate the impact of lumber length sorting on productivity and profitability.

3. To investigate the impact of lumber grade sorting on productivity and profitability (refer to work of Steele and Gaze).

4. To investigate the impact of outside dimension purchases on order and machine scheduling.

5. To investigate the production impact of rip- versus crosscut-first rough mill configurations.

6. To investigate the impact of establishing machining cells for processing part families (refer to work of Kline and Sarin).

7. To investigate mill redesigns associated with implementing scanning technologies.

8. To investigate the production and labor impact of replacing manual chop saws with automated chop saws.

9. To investigate the impact of Just-In-Time-type demand on machining operations and costs.

10. To investigate the production impact of finger-jointing.

There are several people who have used or are using simulation modeling who might be able to provide information and assistance to companies that want to look into the possibility of using simulation to investigate operational issues:

Ed Adams - hardwood sawmill simulation - USDA Forest Service, Princeton, West Virginia
Bruce Anderson - rough mill simulation - USDA Forest Service, Princeton, West Virginia
Phil Araman - rough mill simulation - USDA Forest Service, Blacksburg, Virginia
Agnes Delamare - furniture finishing mill simulation - CTBA, Pont-a-Mousson, France
Carl Eckelman - machine shop and rough mill simulation - Purdue University
M. Ganzalez - furniture mill simulation - Institute of Technology of Costa Rica
Dave Groom - rough mill simulation - R. C. Byrd Hardwood Technology Center, Princeton, West Virginia
Vic Harding - rough mill simulation - Louisiana State University
Earl Kline - machine shop simulation - Virginia Tech
Wenjie Lin - hardwood sawmill and rough mill simulation - Auburn University
Tom Manness - softwood sawmill simulation - University of British Columbia

Roger Meimban - hardwood sawmill simulation - University of Illinois
Guillermo Mendoza - hardwood sawmill simulation - University of Illinois
M. Moya - furniture mill simulation - Institute of Technology of Costa Rica
Ryszard Szymani - secondary processing simulation - Wood Machining Inst., Berkeley, California
Fran Wagner - softwood sawmill simulation - University of Idaho
Jan Wiedenbeck - rough mill simulation - USDA Forest Service, Princeton, West Virginia

Wood Industry's Use of Simulation

How is process simulation modeling being utilized by wood products companies? We are very active in the simulation modeling area yet we only know of a handful of companies that do in-house simulation modeling. Another handful of companies have paid someone to do a simulation modeling project to help them make a specific decision. Many other companies have expressed interest in using simulation models but one or another obstacle (addressed in the next section) has prevented them from doing so to-date.

Manufacturing simulation has been used in the softwood lumber industry by a few companies to look at a range of issues. One company has used simulation on several major capital projects to look at layouts, bottlenecks, etc. Another company has used simulation on one capital project and to investigate the feasibility of removing a couple of major production bottlenecks. Another company is using simulation to determine how log quality and size affects productivity and lumber grade. This comprehensive project has progressed to the point that the company is now using the model to value timber tracks for setting bid prices.

Industrial applications of simulation in the furniture and cabinet industries have addressed mill redesign and technology adoption issues. The use of simulation in this wood industry segment has been very limited. We expect this to change as more people learn about simulation and, more user-friendly simulation software tools become available.

Industrial Implementation Issues

The major implementation issues for companies considering the use of manufacturing simulation as a decision support tool are: 1) time-to-completion of a simulation project, 2) financial justification of a simulation project, and 3) confidentiality in those cases where an external simulation analyst is brought in to work on the project.

The first implementation issue, time-to-completion of a simulation project, is critical for many companies. When a company looks to an outside source for simulation expertise it is typically working under a tight timeline on a specific project. It can take several weeks to several months to model a manufacturing system depending on the system's size and complexity, data availability, software availability, and the prior experience of the person(s) doing the modeling. This time frame is not adequate for most companies.

As more people in industry become familiar with the capabilities of simulation, decision-makers will begin turning to simulation at an earlier phase in the life cycle of a capital project; this will allow sufficient time for executing a simulation analysis.

Even the most data-rich companies do not have the type of data required to build an accurate simulation model. For example, what is your rough mill's lumber length and width distribution within each lumber grade? What is your lumber grade mix? How long does it take to process each board/strip/cutting through your mill's planer? Crosscut-saw? Moulder? Rip saw? How are these processing rates affected by lumber grade? How are they affected by lumber length? By lumber width? By lumber thickness? By drying degrade?

Collecting this data can take a lot of time depending on what the focus of the model is and how precise the model needs to be. If it can be assumed that the present grade and length mix of lumber being run in the rough mill will be maintained, then lumber length and grade-based processing rate data is less critical. Data collection is already becoming less cumbersome. Wood products industry simulation modeling experts are becoming more familiar with the data requirements and are attempting to standardize the data collection process.

The second implementation issue, financial justification of a simulation project, can be difficult for a company that does not have manufacturing simulation experience. If other industrial engineering analysis approaches have been used yet questions remain as to the number of machines needed to perform a task, the simulation project can be justified based on the potential for cost avoidance (e.g. eliminate need for $75,000 machine).

An industrial engineering department head for one of the softwood lumber companies that uses simulation regularly told us "$15,000 to $25,000 spent up front on simulation pays for itself monthly for the life of the project." He also suggested that simulation can be justified by "looking at the last major capital project conducted by your company and asking yourself how much did you have to redo after the initial installation? If simulation catches a fraction of these problems before-hand, it can be justified in terms of the lost production costs and capital investment costs that can be avoided."

A third implementation issue for many furniture and cabinet companies concerns information security when dealing with an outside simulation specialist. The U.S. Forest Service has a contractual mechanism, the Cooperative Research and Development Agreement (CRADA), that allows its scientists and programmers to work with a company on a specific research problem for a given sum of money. Data, information, and research results that are specific to the project are maintained as confidential for an agreed upon length of time (usually two to three years). Universities and other public and private research centers offer similar contractual instruments to ensure limited confidentiality for a company that has funded a research effort.

For a consultant or researcher working with a company on a simulation project, another implementation issue exists. When working with a company that has not formerly used simulation the simulation expert must make sure company personnel have a clear understanding of the type of information that the simulation model can provide; expectations must be reasonable and they must be well-defined. For example, a model built to look at the feasibility of replacing a piece of equipment may not require as much detail as a model built to look at the production impact of producing a new part grade.

Industrial Implementation Strategy

An important partnership has been forged between the U.S. Forest Service Southeastern Forest Experiment Station's research project in Blacksburg, Virginia (Phil Araman), the Northeastern Forest Experiment Station's research project in Princeton, West Virginia, and the Robert C. Byrd Hardwood Technology Center (Dave Groom) in Princeton, West Virginia in a effort to make computer simulation/animation tools more widely available to the furniture and cabinet industries by mid-1995. A generic and flexible rough mill simulation model will be the first product of this partnership.

The Forest Service has been involved in multiple rough mill simulation studies during the last five years. Both crosscut-first and rip-first rough mills have been modeled. One set of modeling experiments addressed the impact of lumber length on rough mill productivity (3,4,5). More recently Wiedenbeck and Araman have been involved in a CRADA with an industrial cooperator using manufacturing simulation modeling to assess technology adoption alternatives.

These simulation studies have given the Forest Service scientists an opportunity to collect a lot of data from multiple mills that is not readily available otherwise (e.g. throughput rate by strip length on manual and automated chop saws). Additional data will be collected at other mills. This data requires a lot of time to collect; data collection is typically the most time-consuming step in the modeling process (see previous section).

All of the rough mill processing rate data will be compiled in a data bank. This pooled data from multiple (unidentified) mills will be available for use by companies seeking simulation assistance from the Byrd Center. Using the data contained in the data bank will increase the size of the confidence intervals associated with various productivity measures, but will also decrease substantially the time-to-completion of simulation modeling projects. Mills that want more precise simulation estimates can provide their own data; the Byrd Center can assist companies in formulating a data collection plan.

A trained programmer at the R.C. Byrd Center will do the actual modeling. The generic and flexible simulation/animation model will be object-oriented and user-friendly. Blocks of simulation code representing commonplace types of rough mill machine centers (e.g. gang-rip-first saws with fixed blades, with a movable outer blade, and with totally movable blades) will be preassembled. When a particular piece of equipment is selected, machine-specific questions are asked related to material queuing and flow, code segments are modified internally based on the user's response, and the machine icon can then be placed on the rough mill layout.

Even if the company chooses to use the data contained in the data bank, they must provide information on questions related to lumber grades, product grades, product sizes, resource priorities, decision variables, and project goals at the outset of the simulation modeling project.

We will soon see manufacturing simulators working for the wood industry, providing answers to management's what if questions.

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