Computer-Generated Optimum Hardwood Log Sawing Using Internal Defect Information

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ABSTRACT

The planning of how the hardwood log can be sawn to improve recovery of high-value lumber has always been hampered by the limited information provided by external defects, and whatever internal defects are eventually revealed on the cut log faces by the sawing pattern. With expanded export and domestic markets, low-quality logs, increased competition from non-wood products, social pressures to manage public lands for nontimber resources, and the reduced profit margin between log costs and lumber prices, the hardwood products industry has been exploring alternative means of improving value yield. The long-term goal of this project is to provide science and technology-based methods and information that will benefit the hardwood products industry through improved product yield.

SUMMARY

Hardwood timber is a substantial economic staple in the Eastern United States. Primary hardwood processors there produce more than 10 billion board feet of sawn hardwoods annually. Most of their facilities are relatively small (< 10 MMBF/year) and are located in rural areas. Therefore, *the survival of hardwood manufacturing mills is important for the economic well-being of many rural communities.* To survive in a highly competitive marketplace, sawmill operators are faced with important decisions about the operation of their mills. These operational changes are precipitated by expanded markets (both export and domestic), low-quality raw material, increased competition from non-wood products, social pressures to manage public lands for nontimber resources, and the reduced profit margin between log costs and lumber prices. There is increased demand for high-quality hardwood lumber and veneer with foreign markets consuming over 5% of the hardwood volume producted in 1987 and accounting for more than 20% of hardwood mill revenues as of 1986. More than 60% of hardwood tree volume in Virginia's Northern Mountain region is in tree grade #3 (U.S. Forest Service scale) or below. The profit margin between lumber prices and log costs can vary considerably, especially for the select oaks. More socially acceptable alternatives to clearcut harvesting are expected to increase stumpage prices for all species, due to increased harvesting costs per MBF removed. To meet current and future consumer needs for hardwood products, sawmill operators must: (1) produce high quality and consistent products from current growing stocks of low-grade timber, and (2) increase the value of their final products by increasing the value of each board sold.

To manufacture the highest value products possible from hardwood logs, decisions made during the first stage of processing must be good ones. The hardwood log breakdown practice is both geometric and defect-oriented owing to the nature of hardwood's end utilization in fine furniture, flooring, and millwork. For producers of hardwood lumber, the objective is to maximize the volume and grade of lumber that generates the highest dollar value for the mill. Higher lumber grades have larger proportions of clear wood on each face, which requires highly judgmental breakdown decisions in patterns such as grade sawing or around-sawing with resaw. Perhaps the greatest obstacle is the uniqueness of each log--every log is different in terms of shape, size, and internal defect configuration. Over the years, the human sawyer has been making saw placement decisions based on limited information provided by the external view of log shape, visible external defects, and whatever internal defects are eventually revealed on already cut log faces. Non-invasive internal scanning of solids has opened up new avenues in the log breakdown planning problem.

This project, which began on September 1993, has four phases based on four objectives. The first objective is to transform tomographic scan data into an information form that can be used for log processing decisions, and to expand this information bank by computationally "growing" additional logs and defects on computer as reuseable information for hardwood log processing studies. This phase will involve the characterization of log and defect pattern signatures, and the synthesis of log and defect data using randomized reproductions of these signatures. The second objective is to use this information bank to determine an optimum strategy for hardwood log breakdown, with an integrated view of related downstream decisions such as edging, trimming, and secondary processing. This phase will involve the evaluation of common and alternative sawing strategies using a microcomputer-based interactive graphics sawing simulator. The third objective is to synthesize from the preceding step a real-time, operational model for automatically generating optimum hardwood log processing instructions which the sawyer and the operators of downstream processes can carry out. Logic programming and object-oriented modelling will be used, coupled with explorations of other reasoning-based paradigms. The fourth objective is to validate the effectiveness of the operational model in obtaining the optimum value yield using the logs and defect in the information bank. A batch mode sawing simulator for the automatic execution of specified sawing patterns will be developed as a rapid tool for sawing pattern validation.

The proposed research has several long term impacts. Firstly, it is environmentally beneficial to improve the utilization of wood resources, Wood is a natural and renewable resource. Improving the extraction of valuable wood from every hardwood log means that in the long term fewer hardwood trees need to be cut. Tree stand inventories indicate a growing number of lower grade trees, suggesting the need for more efficient methods of primary processing. Secondly, it helps the rural economies. The primary beneficiaries of the technologies arising from this type of research will be family-ran hardwood sawmills which are mainly situated in rural communities with fewer than 500 employees. Current reports show that small businesses such as these have a better potential for helping our economy grow. Thirdly, the proposed method of integrating the decisions for downstream operations in the primary hardwood processing stage is a full realization of integration philosophy. Finally, many of the problems encountered in the domain of primary hardwood processing have parallels in the more traditional contexts of design and computer integrated engineering which are not fully resolved or have only approximate and sub-optimal solutions. As such, this project offers the prospect of returning viable solutions to intractable problems in the design and manufacturing domain, through the insights that will be gained from looking at similar problems from a different perspective.

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