NONDESTRUCTIVE EVALUATION OF WETWOOD AND HONEYCOMB

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ABSTRACT
Lumber drying defects in the form of surface checks and honeycomb are especially severe in oak lumber and constitute a major source of value loss and waste. The Forest Products Laboratory, USDA Forest Service, has been involved in research aimed at developing a low-cost, industrial-type detection system to identify wetwood in green hardwood lumber and honeycomb in dry lumber. This report summarizes the results of a series of laboratory studies and equipment development efforts.

INTRODUCTION

Drying is a critical step in manufacturing hardwood lumber, especially when considering opportunities to improve lumber recovery and reduce both degrade and manufacturing costs. Degrade in the form of surface checks and honeycomb is especially severe in oak lumber and constitutes a major source of value loss and waste. Such drying defects are caused by internal stresses that develop from differential shrinkage patterns within pieces of lumber. Preventing drying defects requires close control of the movement of moisture through and from the lumber. Specifically, proper limits on temperature and humidity need to be maintained in lumber dry kilns.

To minimize loss and excessive secondary manufacturing costs, it is important to minimize degrade during drying. An inspection strategy may be useful for identifying and removing lumber that contains drying defects before processing costs are incurred. Defects of particular interest are honeycomb and closed surface checks. These defects are hidden, yet they result in significant downgrade. X-ray nondestructive evaluation (NDE) techniques have been shown to be useful for identifying defects (Vick 1970). However, the use of such techniques is limited by cost constraints.

Ultrasonic NDE techniques may provide an essential tool for lumber inspection. These techniques have been researched and have been used extensively to grade wood veneer and inspect wood structures (Ross and Pellerin 1994). The underlying premise for ultrasonic NDE is that the speed of sound transmission is sensitive to various factors that determine the quality of wood products.

We conducted a series of research studies aimed at using ultrasonic NDE techniques to identify wetwood in green lumber and honeycomb in dry lumber.

RESULTS OF LABORATORY STUDIES

Our efforts began with a series of controlled laboratory tests to determine if there was a fundamental relationship between the speed of sound transmission (perpendicular to the grain) and the presence of wetwood in oak lumber. The results of these studies indicated a strong relationship between sound transmission rate and wetwood, especially in red oak lumber (Ross and others 1992, 1994; Ross 1994; Verkasalo and others 1993).

EQUIPMENT DEVELOPMENT

Based on these encouraging results, we designed and constructed a prototype unit for a series of pilot plant trials. The unit consists of two 84-kHz rolling transducers coupled to an ultrasonic transmitter and receiving unit (Figs. 1 and 2). A similar type of unit is used in manufacturing facilities to evaluate the quality of veneer for production of laminated veneer lumber.

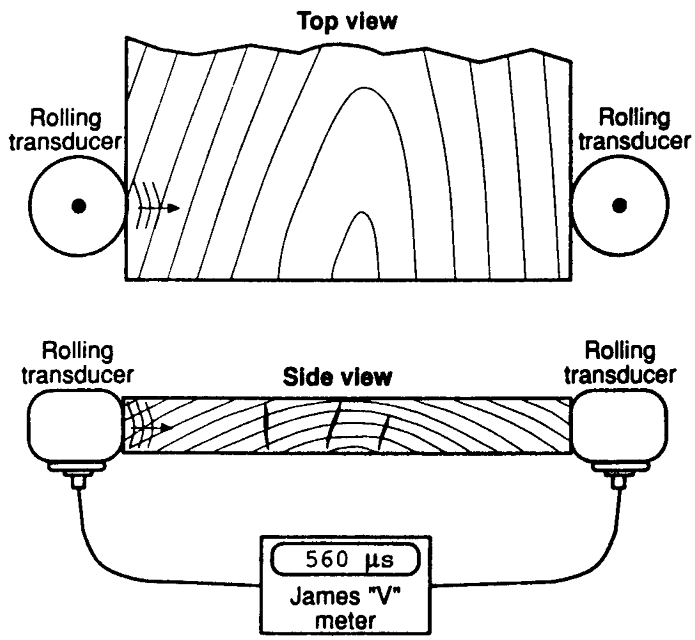

Figure 1. Schematic of prototype unit for ultrasonic nondestructive evaluation (NDE) of lumber.

TESTS ON GREEN LUMBER

A series of green red-oak lumber specimens were processed through the prototype unit and then dried in a cooperator's dry kiln (Ross and others, in preparation). After drying, l/4-in. (6-mm) cross sections were removed from the specimens at each point where the NDE tests were performed. These cross sections were then visually inspected for honeycomb and surface checks. Sound transmission times, computed on a per foot (meter) basis, and results of the visual inspection of the corresponding cross-sections are shown in Table 1. Based on these results, we conclude that the speed of sound transmission can be used to identify defect-prone material in red oak lumber prior to drying.

TESTS ON DRIED LUMBER

A series of dried red oak lumber specimens were also evaluated using the prototype unit (Fuller and others 1994, in press). The methods were identical to those described for the green lumber. As shown in Table 2, the results were excellent.

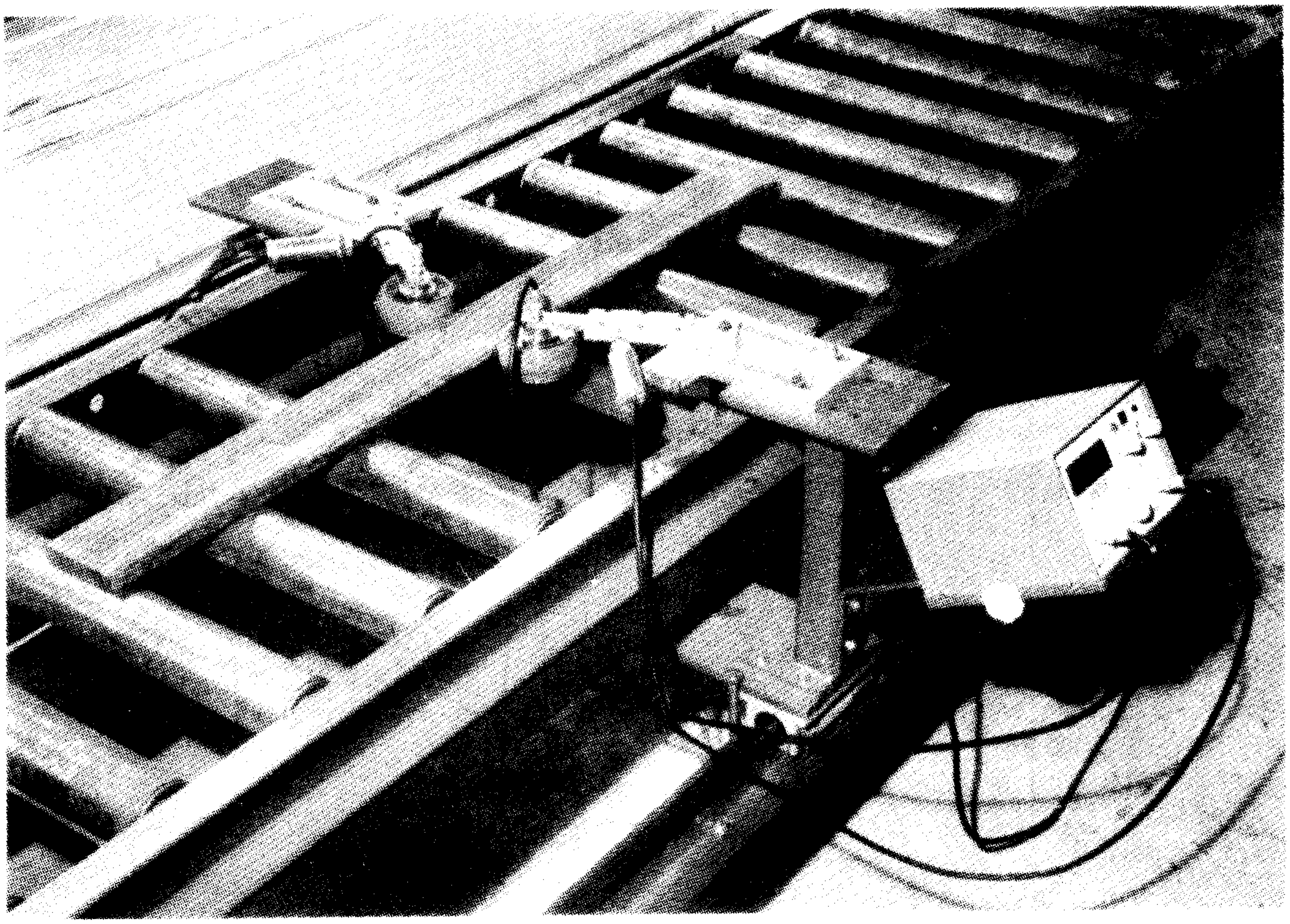

Figure 2. Prototype unit used for ultrasonic NDE of lumber.

To highlight the relationship between sound transmission time and the presence of honeycomb and surface checks, Figures 3 and 4 show this relationship for two specimens within an individual board. As illustrated, large increases in transmission times are directly associated with the presence of honeycomb and surface checks (Fig. 3). Naturally occurring defects, such as a knots, resulted in localized increases in transmission time (Fig. 4), whereas honeycomb and surface checks tended to result in a large increase in transmission time over a greater area of the board (Fig. 3).

Table 1. Correlation between drying defects and sound transmission time in green red-oak lumber.

	Number of cross sections (%)	
Sound Transmission time (µs/ft [µs/m])	Honeycomb or surface checks	No honeycomb or surface checks
>400 (>1310)	51 (82)	11 (18)
<400 (<1310)	117 (23)	386 (77)

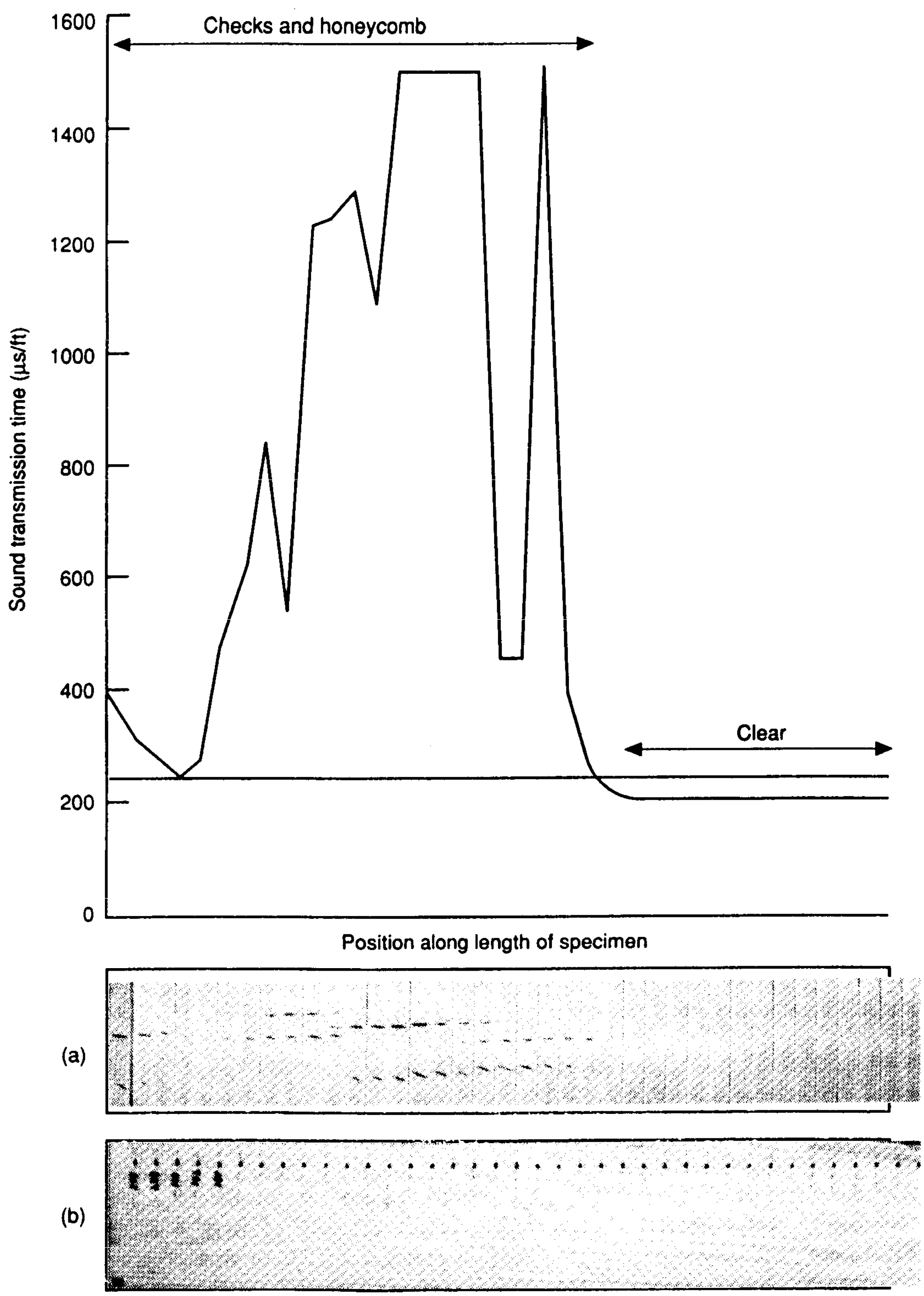

Figure 3. Sound transmission time as a function of position of test unit along length of specimen. (a) Internal specimen characteristics; (b) surface specimen characteristics.

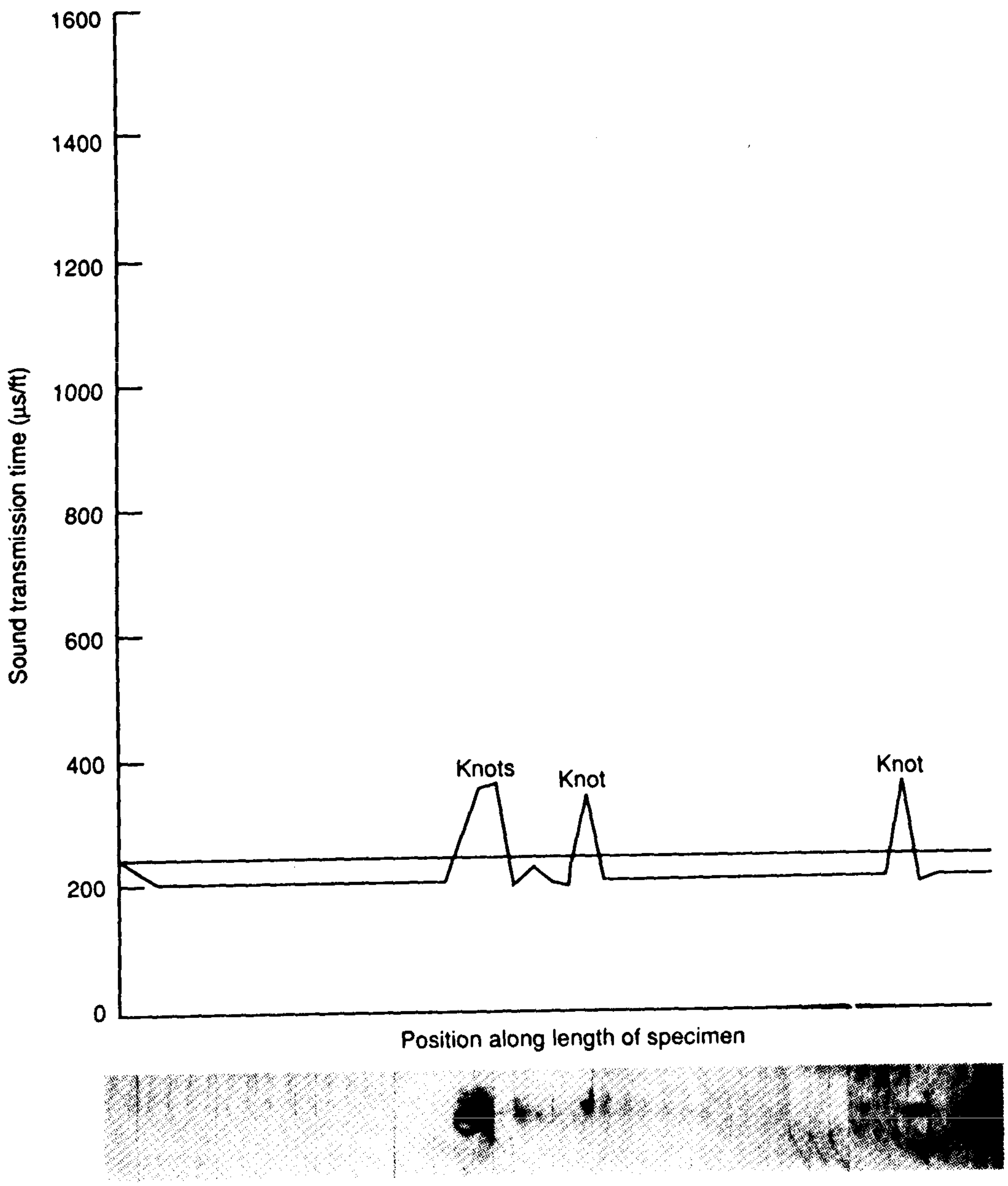

Figure 4. Sound transmission time as a function of position of test unit along length of specimen. Specimen contained no honeycomb or surface checks but did contain several knots.

Table 2. Correlation between drying defects and sound transmission time in dried red oak lumber.

	Number of cross sections (%)		
Sound Transmission time (µs/ft [µs/m])	Honeycomb or surface checks	No honeycomb or surface checks	Total number of cross sections
<250 (<820)	7 (3.5)	192 (96.5)	199
250-300 (820-984)	27 (31.8)	58 (68.2)	85
>300 (<984)	247 (98.0)	5 (2.0)	252

CONCLUSIONS

The results of our efforts have led us to the following conclusions:

- Sound transmission times, perpendicular to the grain, are significantly correlated to the presence of wetwood, which is prone to drying defects.
- Sound transmission times, perpendicular to the grain, are significantly increased by the presence of honeycomb and surface checks.
- Ultrasonic nondestructive evaluation (NDE) techniques show promise as an on-line inspection tool for detecting honeycomb and surface checks in dried lumber,

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