NOTE

TIME-RELATED SHAPE CHANGES ASSOCIATED WITH THE AIR-DRYING OF WOODEN SAMPLE STICKS

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ABSTRACT

Computer modelling of the behaviour of *Pinus radiata* D. Don wood during and after drying is dependent on the availability of data and this requires rapid and accurate measurement of wood samples. The testing of a prototype device designed to facilitate measurement of dimensions and distortion in standard sample sticks has indicated that crook and twist movement can be expected after the equilibration of moisture content.

Keywords: wood drying; crook; twist; time; measuring techniques; *Pinus radiata*.

INTRODUCTION

Wood is a complex material and, although many attempts have been made to increase our understanding of wood properties and their relationships with environmental factors, much remains to be done.

The movement of wood in finished products can cause problems (e.g., the sticking of window frames) but cannot be predicted with confidence, mainly because of the inadequacy of information available for database development. Computer models have been developed to simulate the effects of moisture variability on deformation of boards and small sticks. For example, Ormarsson (1995) used the Finite Element Method (Ottosen & Petersen 1992) to integrate static and dynamic physical effects in simulating the effects of moisture variation on deformation processes in Norway spruce (*Picea abies* (L.) Karsten) boards and small sticks. So far, none of these models has incorporated the effects of the time factor once constant (dry) weight has been achieved. This is probably because traditional methods employing a marble table-top and dial gauges for measurement of distortion are themselves time-consuming and unsuitable for large numbers of samples.

In order to develop a more efficient method for measuring small sticks, we designed a device (subsequently named "*StickMaster*") that would quickly position and hold the stick while automatically recording dimensions in three planes. We report here an example of its use and some of the results that were obtained during the testing of the prototype.

MATERIALS AND METHODS

The *StickMaster* Measuring Box

The *StickMaster* system was designed to measure dimensions and distortion in standard wood samples (sticks approximately $300 \times 20 \times 20$ mm in size — ASTM 2000). The stick to be measured is supported at six reference points in accordance with the 3-2-1 principle for measurement of orthotropic materials. This principle requires three points of contact between a primary datum plane and the object to be described, two points of contact between a secondary datum plane and the object, and one point of contact between a tertiary datum plane and the object.

The prototype *StickMaster* (Fig. 1) contained six fixed contact points. Three Linear Variable Differential Transformers (LVDTs)*, spring-loaded to hold the stick in position, were used to measure the distance between points of contact and the three datum planes. Three Laser Displacement Sensors (LDSs)† were used in a similar way to measure distortion. All six sensors were connected to a computer and the measuring procedure was controlled through LabVIEW™ software (LabVIEW 1998). All sensors were calibrated before use and readings were confined to the linear range. Measurements were carried out in a darkened room to prevent light interference with laser readings. A plastic stick was used to calibrate the device.

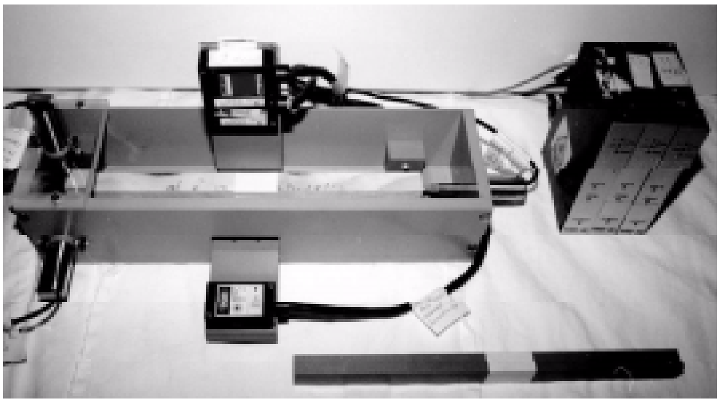

FIG. 1–*StickMaster* measuring box with sensors mounted.

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* Solatron LVDT model DFg 2.5. Sensitivity 780mV/mm (response time 1.5 ms), non-linearity ±0.3% of full scale of 5.0 mm. The resolution depends on the number of bits in the A-D converter used.

† Koden LDS model AMS-90. Resolution 50 mm (@10 Hz), non-linearity ±0.6% of full scale of 40 mm.

Preparation of Sticks

As part of a larger study, a 350-mm-thick disc of timber was taken at a height of approximately 10 m from the stem of a 35-year-old *P. radiata* tree from a forest in the Tarawera Valley, 30 km north-east of Rotorua in the North Island of New Zealand. Immediately after felling, a table saw was used to cut 13 knot-free sticks, each measuring $300 \times 20 \times 20$ mm, from a bark-to-bark vertical slab taken from the disc.

Drying Treatments

Green sticks were placed on end in wire racks which ensured free air flow between them and minimised constraints to distortion (Fig. 2). An air-conditioning unit was used to hold air temperature at 20°C and relative humidity at 50% for a total of 335 hours. The sticks were then oven-dried at 103°C for a further 67 hours. No steam reconditioning was carried out.

FIG. 2–Wire rack used for air-drying sample sticks.

Measurements and Calculations

Using the *StickMaster* prototype, dimensions and degree of distortion were measured in each stick at 0, 24, 66, 92, 113, 192, and 335 hours from the commencement of air-drying, and on achievement of oven-dry weight. The weight of each stick was recorded at each measurement time.

Distortion

Distortion was measured at the mid-point of each stick, using the *StickMaster* laser sensors. All distortion in the radial and tangential planes was referred to as “crook” since no distinction can be made between “crook” and “bow” in samples which have a square cross-section. The degree of crook was determined as the length of lateral displacement of the intersection of the radial and tangential axes at the mid-point of each stick. The degree of “twist” was determined as the angle of rotation of the mid point of the longitudinal axis.

Wood moisture content

The amount of moisture in each stick was determined by weighing and was expressed as a percentage of the final oven-dry weight of the stick.

RESULTS

Moisture Content

Moisture loss curves (Fig. 3) showed that air-drying was completed during the period 66–92 hours, and that stick moisture content remained constant at 11% of oven-dry weight during the remaining 243 hours of air-drying conditions.

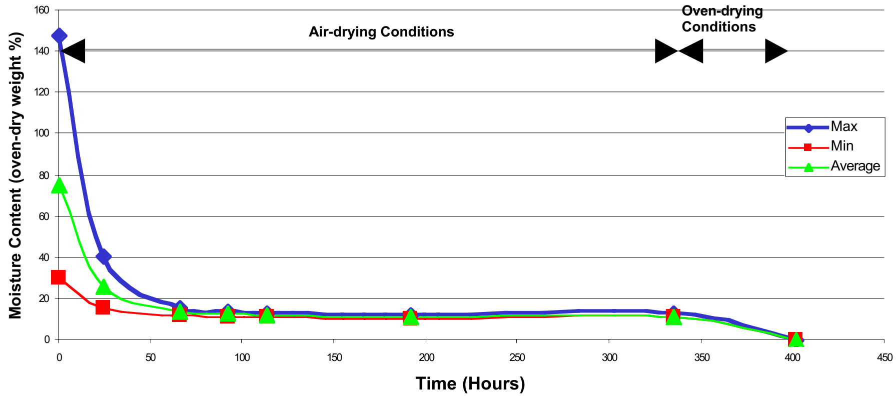

FIG. 3–Rate of moisture loss from 13 sample sticks during an air- and oven-drying regime.

StickMaster Operation

The average time required for *StickMaster* measurement of dimensions and distortion in one stick was 52 seconds.

Sample Stick Distortion

Movement in each orthotropic plane was observed at every measurement time (Fig. 4, 5, and 6). There was a considerable amount of between-stick variability. The degree of crook or twist was not related to the measured rate of moisture loss.

DISCUSSION

This limited study demonstrated two points of interest. The first was that the development of an instrument system for rapid measurement of distortion in wooden sticks is practicable. The *StickMaster* system offers advantages over traditional methods in terms of operating efficiency and automated recording, both of which would reduce experimental error. In time-related studies, the accuracy of observations would be increased by a shorter measurement period and the rapid return of sample sticks to experimental treatment conditions. Although the *StickMaster* system requires refinement and rigorous testing, it has potential for improving the quality of data used in computer modelling.

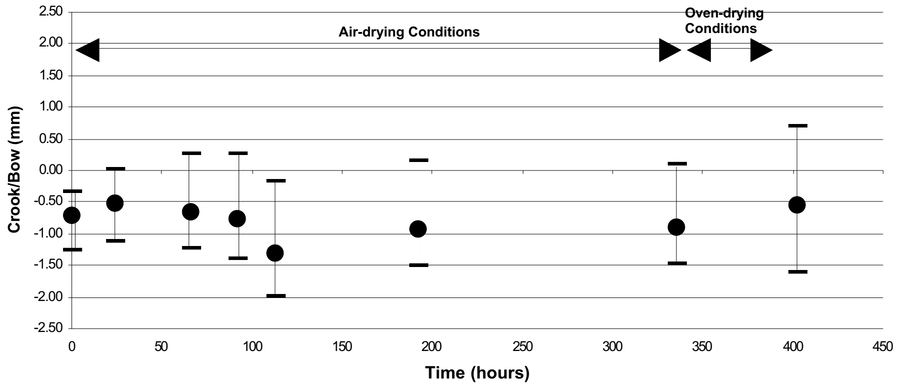

FIG. 4–Crook distortion of sample sticks in the radial plane during the air- and oven-drying regime. Mean and range for 13 sticks at each measurement time.

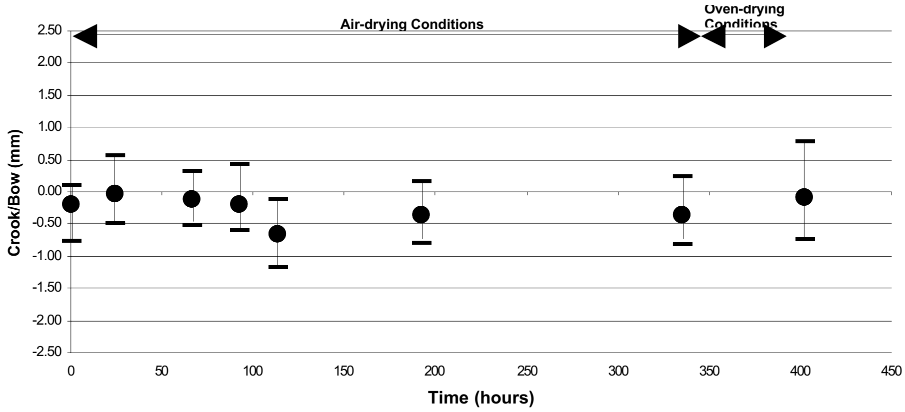

FIG. 5–Crook distortion of sample sticks in the tangential plane during the air- and oven-drying regime. Mean and range for 13 sticks at each measurement time.

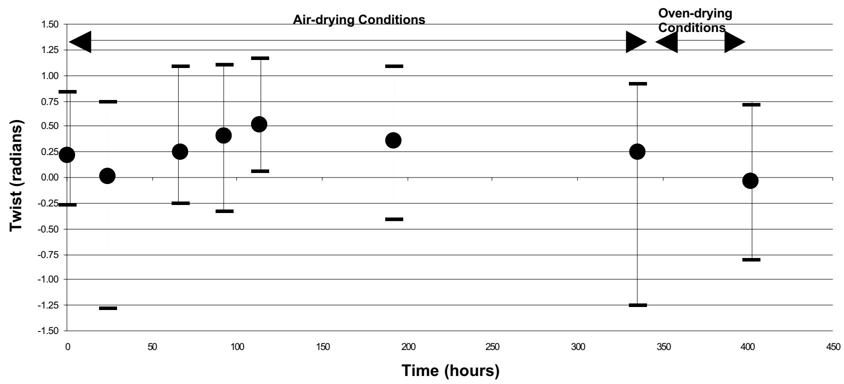

FIG. 6–Twist distortion of sample sticks in the longitudinal plane during the air- and oven-drying regime. Mean and range for 13 sticks at each measurement time.

Secondly, the data show unequivocally that distortion continued after equilibration of the moisture content of the sample sticks under air-drying conditions. This was an unexpected result which would repay further investigation. Continued movement is probably related to unevenness of moisture gradients within the samples, and is a factor that undoubtedly affects in-service performance of *P. radiata* wood. Recognition, quantification, and inclusion of this movement in computer models will assist prediction of the behaviour of *P. radiata* timber in its many applications.

CONCLUSIONS

The *StickMaster* measuring device has potential for improving the quality of data describing size and distortion in $300 \times 20 \times 20$-mm sample sticks. It is particularly suitable for the investigation of time-related effects. An early study has indicated that crook and twist distortion of *P. radiata* sample sticks is not reduced by equilibration of moisture content during air-drying.

ACKNOWLEDGMENTS

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