Drying of sapwood, heartwood and mixed sapwood and heartwood boards of *Pinus radiata*

S. Pang

Experiments were performed to examine drying rates of *Pinus radiata* boards in stacks of all sapwood, all heartwood and mixed sapwood and heartwood, using a tunnel dryer. Drying temperatures were 90/60 °C and airflow was reversed every three hours, with an average air velocity of 5.0 m/s. For stacks of all sapwood and all heartwood boards, the influence of board thickness and position of thicker and thinner boards in the stack was also examined. Boards with thicknesses of 37 and 45 mm were placed within a stack of 40 mm boards, and individual drying curves during drying were compared. Due to the higher initial moisture content of sapwood, the drying time for the all sapwood stack was almost twice as long as that for the all heartwood stack. In the mixed stack, the initial drying rate for sapwood was faster and that for heartwood slower than in segregated stacks, so that the difference in the drying time between sapwood and heartwood was less. To dry to an overall average moisture content of 10%, the all heartwood stack needed 20 hours, the sapwood stack 35 hours and the mixed sapwood/heartwood stack (55% sapwood) 30 hours. The drying rate for individual boards in the sapwood and heartwood stacks was related to thickness, but the differences were negligible once the overall moisture content fell below 10%.

Trocknen von Kiefern- und Sphänanlagen aus reinem Splintholz und Kernholz sowie von Mischungen von beiden

In einem Röhrentrockner wurden die Trocknungsrate von Brettern aus reinem Splintholz und Kernholz, sowie aus gemischten Anteilen bestimmt. Die Trocknungszeit betrug 90/60 °C, der Luftstrom (5 m/s) wurde nach jeweils 3 Stunden umgekehrt. Bei den Brettern aus reinem Splintholz und Kernholz wurde auch der Einfluß der Brettdicke und der Lage der dickeren oder dünneren Bretter im Stapel bestimmt. Dazu wurden Bretter der Stärke 37 und 45 mm innerhalb des Stapels mit 40 mm dicken Brettern gelagert und die einzelnen Trocknungskurven registriert. Aufgrund der höheren Ausgangsfeuchte in Splintholz war hier die Trocknungszeit fast doppelt so lang als bei reinem Kernholz. Bei gemischten Stapeln war die anfängliche Trocknungsrate des Splintholzes höher, die der Kernholz Bretter geringer als bei reinem Splintholz. Dadurch war der Unterschied ihrer Trocknungszeiten geringer. Zum Trocknen auf eine mittlere Feuchte von 10% waren für Kernholz 20 Stunden erforderlich, für die Splintholz 35 Stunden und für die gemischten Proben (55% Splintholz) 30 Stunden. Die Trocknung der einzelnen Bretter war zunächst abhängig von ihrer Dicke; diese erwies sich aber als vernachlässigbar, wenn die mittlere Endfeuchte unter 10% betrug.

1 Introduction

For *Pinus radiata* timber, the higher initial moisture content for sapwood as compared to heartwood means that sapwood takes much longer to dry (Simpson and Haslett 1998). However, in a stack comprising mixed sapwood and heartwood boards, the drying times of the sapwood and heartwood components will differ from values obtained when drying all sapwood and all heartwood boards. This is because drying conditions within the mixed stack are different from those in segregated stacks.

Another factor which may affect the drying rate is board thickness. The effect of thickness is well recognised, e.g., using accelerated conventional temperature (ACT) schedules, 50 mm thick boards of *Pinus radiata* need 6 to 10 hours longer to dry than 40 mm boards (Anon 1996). However, once again this effect cannot be directly extrapolated to the drying of a stack with boards of variable thickness. When a thicker than normal board is placed in a layer adjacent to boards of normal thickness, the thicker one will support more stack weight and the fillet space over the thicker board will be less than over the other boards. Thus, the air velocity over the thicker board will be higher than over the others, which consequently enhances the drying of the thicker one. On the other hand, if a thinner board is placed adjacent to the normal boards within a layer, the air velocity becomes slower due to the larger void space over the thin board. Airflow velocity is related to the external heat- and moisture mass-transfer coefficients to a power of about 0.78 which in turn affects the drying rate (Pang 1996a).

The objectives of this work were (a) to examine drying-rate differences for stacks of all sapwood, all heartwood and mixed sapwood and heartwood boards, and (b) to investigate the contribution of normal thickness variation to variation in drying time of individual boards.
### Table 1. Description of the drying tests

<table>
<thead>
<tr>
<th>Run</th>
<th>Wood</th>
<th>Pre-set times for measurements (h)</th>
<th>Number of boards in a layer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>37 mm</td>
<td>40 mm</td>
</tr>
<tr>
<td>1</td>
<td>All heartwood</td>
<td>0, 4, 12.6, 20, 27</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>All sapwood</td>
<td>0, 6, 14, 22.8, 28.8, 37</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>Mixed sap/heartwood</td>
<td>0, 6, 14, 22, 30, 40</td>
<td>22</td>
</tr>
</tbody>
</table>

### 2 Procedure

Three experimental runs were performed in a tunnel dryer to dry stacks of all heartwood boards (Run 1), all sapwood boards (Run 2) and a mixed charge of sapwood and heartwood boards (Run 3) using a 90/60 °C (dry-bulb/wet-bulb temperatures) schedule. Airflow was reversed every three hours, and the average air velocity was approximately 5.0 m/s. Details of the drying experiments are given in Table 1.

Test samples, comprising 100 mm wide boards, were stacked in two matched layers, 23 (Run 1 and 2) or 22 (Run 3) boards wide. Further, two layers of the same type of wet boards as the test samples were placed in the stack, one above and one beneath the two test layers. Each layer was separated by 18 mm stickers. The two test layers were supported by a load cell to allow continuous weight measurements during drying. To obtain drying-rate curves for individual boards, every test board was weighed at pre-set times during drying (given in Table 1). After the drying was completed, all the test boards were oven-dried, reweighed, and moisture contents during drying were calculated.

In Run 1 and Run 2, some thinner boards (37 mm thick) and thicker boards (45 mm thick) were placed in the test layers with the normal thickness boards (40 mm) in order to investigate the influence of board thickness on the drying rate. The arrangement of the test boards in each of the matched layers is illustrated in Fig. 1. Some of the abnormal thickness boards were placed near the stack edge and others close to the stack mid-width to examine the influence of board position on the drying rates. To investigate the drying of sapwood and heartwood boards in a mixed stack, the 12 sapwood and 10 heartwood boards were divided into four groups which were alternated across the stack width (Fig. 1c).

Test samples were cut either from a 100 (wide) × 40 (thick) × 6000 (long) mm board or from a 100 (wide) × 50 (thick) × 6000 (long) mm board, both being collected from a local sawmill. Some of the 40 mm boards were ripped to 37 mm thickness and all of the 50 mm boards were resawn to 45 mm thickness. All of the 6 m long boards were then used to prepare 600 mm long test samples. Two 20 mm cross sections were removed from each end of these test samples to obtain basic density and initial moisture content values. Finally, the test samples were end-painted twice before being stored in a cool store until drying.

### 3 Results and discussion

Changes in stack overall moisture contents as drying progressed were measured by a load cell, and are shown in Fig. 1a–c. Arrangement of boards in a test layer: a) all heartwood boards (mixed thickness) in Run 1; b) all sapwood boards (mixed thickness) in Run 2; c) mixed sapwood/heartwood boards in Run 3

**Bild 1a–c.** Anordnung der Bretter in einer Versuchsdecke: a) Schicht aus reinen Splintholz Brettern (verschiedene Dicken) für Lauf 1; b) Schicht aus reinen Kernholzbrettern (Verschiedene Dicken) für Lauf 2; c) Mischung aus Kern- und Splintholzbrettern (Lauf 3)