Accelerated Drying of Plantation Grown *Eucalyptus cloeziana* and *Eucalyptus pellita* Sawn Timber

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Abstract

The objective of this study was to gain an understanding for drying sawn timber produced from fast-grown, well-managed Queensland hardwood plantations using accelerated drying methods. Due to limited resources, this was a preliminary study and further work will be required to optimize schedules for industrial implementation. Three conventional kiln trials, including two for 38-mm-thick, 19-year-old plantation Gympie messmate (*Eucalyptus cloeziana* F. Muell.) and one for 25-mm-thick, 15-year-old plantation red mahogany (*Eucalyptus pellita* F. Muell.), and two vacuum kiln drying trials, one each for 38- and 25-mm-thick Gympie messmate, were conducted. Measurements of final cross-sectional moisture content, moisture content gradient, residual drying stress, and internal and surface checking were used to quantify dried quality. Drying schedules were chosen based on either existing published schedules or, in the case of the vacuum drying trials, existing schedules for species with similar wood density and dying degrade properties, or manipulated schedules based on the results of trials conducted during this study. The findings indicate that both species can be dried using conventional drying techniques with acceptable grade quality in approximately 75 percent of the drying time that industry is currently achieving when drying native forest timber of the same species. The vacuum drying time was 60 percent less than conventional drying for 38-mm-thick, 19-year-old Gympie messmate, although drying quality needs improving. The findings have shown that through careful schedule manipulation and adjustment, the grade quality can be optimized to suit the desired expectation. Additional research is required to further optimize the schedules to ensure acceptable grade qualities can be reliably achieved across all drying criteria and exploit opportunities to reduce drying times further.

Drying is critical for many product applications including furniture components, flooring, and decking. The benefits of drying include improved stability, improved control over visual and internal defects (such as checking), control of distortion, decrease in weight, increase in strength, improved gluability, and improved thermal insulation properties. Timber dried to the equilibrium conditions of its surroundings is a much more valuable commodity than its green counterpart for the majority of value-added product applications (Bootle 2004).

Traditionally, timber has been air dried in stacks, a method that requires very little energy input. Disadvantages of this method include a lack of control over drying conditions, long drying times (months or even years), and an increased potential for drying degrade. Kiln drying allows more control over the drying process, improving dried quality and often reducing drying times. Additional capital and operating costs that occur with kiln drying are potentially recouped through higher recovery of useable material, higher product value, and faster stock turnaround (Bootle 2004).

Both conventional and vacuum kiln drying were used in this study. Conventional kiln drying is currently the primary method of kiln drying timber in Australia. Conventional drying kilns generally provide control over temperature, relative humidity, and air flow. This ensures that drying conditions are in line with an appropriate drying schedule for the particular species, section size, and required quality. The rate of drying is increased by raising the drying temperature and/or lowering the relative humidity. Drying schedules generally utilize a range of different temperature and relative humidity steps throughout the drying process to

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ensure the drying rate is as fast as possible without compromising the required final quality.

In recent years, with emerging technological advancements in construction, computer control, and less expensive materials, vacuum drying hardwood timber has proven to be an economical alternative to conventional drying methods in many applications. There are several vacuum drying systems available commercially. The level of vacuum generated varies between systems but is generally in the range of 100 to 250 mbar (Ressel 1994). Under a vacuum, the temperature at which water boils is lowered. When drying above the boiling point of water, the internal moisture transport inside the board towards the surface is no longer driven by diffusion but is forced by an internal overpressure greater than the atmospheric pressure. As a consequence, the internal transport is greatly increased in comparison with the normal water diffusion coefficient, equating to faster drying (Gard and Riepen 2008).

Conventional kiln drying has been established in Australia for many years with much research conducted for developing and optimizing conventional drying schedules for eucalyptus species (Rozsa and Mills 1991). Very little vacuum drying research has been conducted on eucalyptus species either within or outside of Australia. Sánchez et al. (1996) carried out vacuum drying trials in Chile using 31-mm-thick southern blue gum (*Eucalyptus globulus* L. Her.) and mountain ash (*Eucalyptus regnans* F. Muell.). Boards were dried under a continuous vacuum from green to 10 percent moisture content (MC). The experimental results were satisfactory, with normal shrinkage levels, collapse, and internal checking, for 10 to 15 days drying time. Sánchez et al. (1999) similarly carried out vacuum drying trials using 28-mm-thick rose gum (*Eucalyptus grandis* W. Hill ex Maiden). Boards were dried under a continuous vacuum from green to 9 percent MC in 10 days, again exhibiting satisfactory dried quality. Fernandez-Golfin and Alvarez Noves (1996) compared the drying rate and quality between conventional and superheated steam vacuum drying of southern blue gum on a laboratory scale. The drying quality from all trials was considered high. The conventional drying time for 27- and 50-mm-thick material was 29 and 79 days, respectively. The drying time was greatly reduced for the vacuum trials in which the 27- and 50-mm material dried in 5 and 16.5 days to similar final MCs, respectively.

Background

In March 2006, Cyclone Larry crossed the north Queensland coast near Innisfail as a Category 5 cyclone, bringing with it wind speeds estimated at 320 km/h. While the damage bill for primary industries was estimated at $470 million, with agricultural crops and forests being devastated over an area of approximately 12,500 km^2 (Hopewell et al. 2007), a unique opportunity arose to salvage quality plantation material from large plots of 15-year-old red mahogany (*Eucalyptus pellita* F. Muell.) and 19-year-old Gympie messmate (*Eucalyptus cloeziana* F. Muell.) in the Innisfail area. Although both plots were destroyed by the cyclone, large numbers of stems remained with minimal or no visible damage that could be salvaged for the purposes of a wood quality, processing, and product study. As plantations of this age and quality are rare in Queensland, the opportunity to collect this valuable information was seized and suitable logs were salvaged soon after the cyclone. This report focuses solely on the drying component of the study.

The objective was to gain an understanding of the potential for drying sawn timber produced from fast-grown, well-managed Queensland hardwood plantations using accelerated drying methods. To meet the project objective, three conventional kiln trials (two Gympie messmate and one red mahogany) and two vacuum kiln drying trials (Gympie messmate only) were conducted.

Equipment

A 0.2-m^3 laboratory-sized kiln was used for the conventional drying trials. The kiln is electrically heated and humidity is provided via a small electrically heated boiling tank. Additional humidity control is provided by a pair of proportionally controlled vents. Air is circulated using a single proportionally controlled fan. The MC of the kiln stack is calculated using a load cell to measure the weight of the stack during drying. Temperature and humidity are measured using wet and dry bulb T-type thermocouples.

Vacuum drying was conducted using a 2-m^3 superheated steam vacuum drying kiln supplied by Brunner-Hildebrand, Germany. The kiln consists of a water-cooled vacuum pump, a condenser fan, a circulation fan (reversible), heating coils, and a steam bath. Because venting is not a possible control mechanism to release steam in a vacuum kiln, this kiln uses a condenser fan instead. The condenser fan cools an exposed section of the external kiln wall by drawing atmospheric air across it. This allows excess steam to condense on this section of the wall to be removed by gravity into an external condensate receptacle. The kiln is powered entirely from electricity. This would generally not be the case for an industry kiln, which would use cheaper onsite energy alternatives (e.g., steam, hot oil, gas).

Average board MCs were measured throughout drying using resistance-type probes inserted into six sample boards at 1/3 thickness. Average board MC was used to change the kiln temperature and relative humidity conditions via a predetermined schedule. Kiln temperature was measured using two platinum resistance temperature detectors (PT100 RTDs) located on each side of the kiln stack. Relative humidity was measured using the average of two disposable (replaced every kiln charge) equilibrium moisture content (EMC) wafers. Data was recorded via a data acquisition board and personal computer designed specifically for the kiln.

Experimental Materials and Methods

Initial measurements

The limited log supply consisting of 16 Gympie messmate and 12 red mahogany logs, approximately 1.8 m long, restricted the scope of the drying trials. Allocated logs were used to provide 100-mm-wide boards, either 25 or 38 mm thick, and were processed using a standard back sawing pattern. The number of specimens used in each trial is provided in Table 1.

Before drying, 25-mm-long cross sections were removed while the boards were docked to the required lengths (governed by the kiln capacity) for initial green MC determination in accordance with AS/NZS 1080.1 (Standards Australia 1997). The ends of each board were coated with an impermeable wax emulsion to reduce the develop-

Table 1.—Kiln trial type, material species, dimension, and number of boards.

Trial	Kiln type	Species	Nominal dimension (mm)	No. of boards
C1	Conventional	*Eucalyptus cloeziana*	38 by 100 by 900	30
C2	Conventional	*E. cloeziana*	38 by 100 by 900	30
C3	Conventional	*E. pellita*	25 by 100 by 900	40
V1	Vacuum	*E. cloeziana*	38 by 100 by 1,900	55
V2	Vacuum	*E. cloeziana*	25 by 100 by 1,900	55

ment of end drying defects and help ensure results gained from short board length trials are transferable to the industry practice of drying longer lengths.

Kiln drying methodology

A total of five drying trials were conducted, consisting of three conventional kiln trials (trials C1 to C3) and two vacuum kiln trials (trials V1 and V2). The nominal board dimension (i.e., targeted dimension of dried rough sawn boards), number of boards seasoned in each trial, kiln type, and species are listed in Table 1. For each of the five trials, the target final cross-sectional MC was 10 percent.

Boards allocated for trials C1 and V1 were stickered into the respective kilns immediately after preparation. Boards for the remaining trials were plastic wrapped and stored in a cool room at 10°C. The number of boards available (Table 1) for use in vacuum trials V1 and V2 only partially filled the vacuum kiln chamber. To maintain air flow integrity during drying, boards were stickered centrally in the vacuum kiln between dry ''fill'' boards of a similar thickness. To reduce distortion, a concrete stack weight of 444 kg (approximately 220 kg/m^2) was used.

Table 2 shows the drying schedules adopted for each conventional trial. In the absence of a published recommended drying schedule for 38-mm Gympie messmate, the schedule used for trial C1 was developed by adjusting a recommended schedule reported by Rozsa and Mills (1991) for 25-mm Gympie messmate. The 38-mm schedule was milder than the recommended 25 mm. Due to the unacceptable levels of surface checking recorded for dried boards from conventional trial C1, a milder drying schedule was chosen for trial C2. The schedule adopted for conventional trial C3 for 25-mm red mahogany was recommended by Rozsa and Mills (1991) and coincidentally was identical to the schedule used for conventional trial C1. A 24-hour equalization phase was used for trial C3 instead of the 36-hour phase adopted for C1 and C2 given the smaller board thickness. As the average final cross-sectional MC recorded for trial C1 was slightly higher than the target MC, the equalization EMC conditions were lowered from 11.5 to 11 percent for trials C2 and C3.

The vacuum kiln used for the study uses software that includes a number of preset schedules for various timber species (predominantly American and European species) of varying thickness. Only two preset schedules pertaining to native Australian eucalypts exist (mountain ash and southern blue gum). The drying properties of these ''ash'' type species are very different from those for most subtropical and tropical eucalypt species considered for plantation development in Queensland (including Gympie messmate and red mahogany). This difference is mainly due to ash's susceptibility to severe collapse. For this reason, existing vacuum drying schedules for Australian species were judged to be unsuitable.

Table 3 outlines the drying schedules adopted for both vacuum drying trials. The schedule chosen for trial V1 was a preset schedule provided for jatoba (*Hymenaea courbaril* L.). The schedule was chosen on the understanding (supported by Simpson and Verrill 1997) that in general timbers of similar densities often have similar drying characteristics. The average dried density of mature jatoba is 910 kg/m^3 (Lincoln 1991), which is similar to that reported by Bootle (2004) for mature Gympie messmate (1,010 kg/m^3). Due to marginal surface checking results recorded for dried boards from vacuum trial V1, a milder drying schedule was chosen for trial V2 using the preset schedule for sugar maple (*Acer saccharum* Marshall). The milder schedule was chosen because sugar maple has

Table 2.—Conventional kiln drying schedules for trials C1, C2, and C3.

	C1 and C3 schedule			C2 schedule		
	Dry-bulb temperature (°C)	Wet-bulb temperature (°C)	Equilibrium MC (%)	Dry-bulb temperature (°C)	Wet-bulb temperature (°C)	Equilibrium MC (%)
MC change points (%)						
>60	45.0	42.0	16.0	45.0	42.0	16.0
60	45.0	41.0	14.0	45.0	42.0	16.0
50	50.0	45.0	12.5	50.0	46.0	14.0
40	50.0	45.0	12.5	50.0	46.0	14.0
30	55.0	47.0	10.0	55.0	50.0	12.5
25	60.0	50.0	8.5	60.0	52.0	10.0
20	70.0	55.0	6.5	70.0	60.0	8.5
15	70.0	50.0	5.0	70.0	55.0	6.5
Equalization						
C1, C2 (36 h)	65.0	59.5	11.5	65.0	59.0	11.0
C3 (24 h)	65.0	59.5	11.0			

Table 3.—Vacuum kiln drying schedules for trials V1 and V2.

	V1 schedule			V2 schedule		
	Dry-bulb temperature (°C)	Wet-bulb temperature (°C)	Equilibrium MC (%)	Dry-bulb temperature (°C)	Wet-bulb temperature (°C)	Equilibrium MC (%)
MC change points (%)						
>70	58.0	53.4	13.0	60.0	54.0	11.0
70	60.0	54.4	12.0	61.0	54.8	11.0
60	61.0	54.5	11.0	62.0	55.7	11.0
40	62.0	55.5	11.0	62.0	55.5	10.0
35	64.0	56.3	10.0	63.0	55.7	10.0
30	65.0	56.5	9.5	64.0	55.3	9.3
25	67.0	56.0	7.7	66.0	55.0	7.9
20	71.0	54.0	5.6	68.0	52.0	6.1
15	75.0	62.0	6.9	71.0	58.0	6.9
Equalization						
V1 (36 h)	72.0	65.5	11.0			
V2 (24 h)				65.0	58.0	11.0

similar wood air-dried density and a propensity to surface check (Lincoln 1991). Although the V2 drying schedule appears harsher in terms of temperature and humidity than that used in trial V1, the schedules cannot be directly compared due to the different board thicknesses used between trials. Although presented as conventional stepwise schedules, the dry and wet bulb temperatures were ramped between MC change points for the vacuum drying trials.

Final measurements

After drying, boards were removed from the kiln and assessed for dried quality based on the final average and distribution of, cross-section MC, MC gradient, surface and internal checking, and residual drying stress.

Final dried cross-sectional MC was determined from 25-mm-long sections removed no closer than 400 mm from board ends using the ovendry method in accordance with AS/NZS 1080.1 (Standards Australia 1997). A separate conjoining 25-mm section was removed to determine MC gradient. MC gradient (expressed as percentage) was determined by ripping the section into approximate 1/3 thickness pieces, oven drying in accordance with AS/NZS 1080.1 (Standards Australia 1997), and calculating the difference between the central (core) section and the average of the two outside (case) sections.

Each board was assessed for surface checking in accordance with AS 2796.3 (Standards Australia 1999), whereby a board was deemed to make Select (best) grade boards if no surface checks on either face were greater than 250 mm long or 1 mm wide. The percentage of Select grade boards and surface check–free boards were recorded. The presence of internal checking was determined on a present or absent basis by visually inspecting the freshly sawn end of each board after the MC sections were removed.

Residual drying stress was calculated using the ''rip-cup'' method in accordance with AS/NZS 4787 (Standards Australia 2001). For each board, a 50-mm-long cross section was removed no closer than 400 mm from board ends. Drying stress was quantified by measuring the width (W) of each cross section before ripping the section in a plane parallel to the widest face through the center of the thickness, and measuring the gap (D_{gap}) between the concave/convex faces within 5 minutes of ripping. The degree of drying stress (D_{stress}) is the ratio of gap width and section width expressed as a percentage as follows:

$$D_{stress} = (D_{gap}/W) \times 100$$

In accordance with AS/NZS 4787 (Standards Australia 2001), drying quality classes were assigned for cross-sectional MC, MC gradient, and residual drying stress. Quality classes within the standard are based on 90 percent of samples adhering to predetermined allowable limits dependent on the final target value for each property measured. Table 4 shows the limits for the various quality classes as described within the standard. For the purpose of this study, dried quality was deemed acceptable if 90 percent of samples fell into quality class B or better. Similarly, surface checking results were deemed acceptable if 90 percent of samples made Select grade.

Results and Discussion

Much of the quantitative data are presented here as scattergrams. Scattergrams are a visual representation of quantitative results and are particularly useful for visually comparing numerical data. Data are represented on a scattergram as individual, disconnected symbols. The plot allows the reader to observe the distribution of quantitative data around the mean, represented by a horizontal line.

Initial cross-sectional MC

The initial cross-sectional MC results for each trial are presented in Tables 5 and 6 and Figure 1. Independent parametric and/or nonparametric tests indicate no significant difference exists between the initial cross-sectional MC

Table 4.—Allowable MC and drying stress limitations for 90 percent of samples per quality class.

Quality class	Cross-sectional MC (%)	MC gradient (%)	Drying stress (D_{stress})
A	9–12	1	0.5
B	8–13	2	1
C	7–14	3	2
D	6–15	4	3
E	5–16	5	4

Table 5.—Summary of MC and residual drying stress results for conventional kiln drying trials.

	Trial C1				Trial C2				Trial C3			
	Initial cross-sectional MC (%)	Final cross-sectional MC (%)	MC gradient (%)	Drying stress (D_{stress})	Initial cross-sectional MC (%)	Final cross-sectional MC (%)	MC gradient (%)	Drying stress (D_{stress})	Initial cross-sectional MC (%)	Final cross-sectional MC (%)	MC gradient (%)	Drying stress (D_{stress})
Average	52.5	11.9	3.1	0.88	52.4	11.3	1.4	0.33	68.7	9.9	1.6	0.42
Maximum	85.8	15.9	9.5	1.39	68.6	14.0	4.4	0.73	100.	12.0	4.4	1.02
Minimum	36.6	8.9	0.2	0.44	36.7	9.6	−0.4	0.00	45.2	8.0	−0.3	0.02
SD	10.3	1.8	2.0	0.26	8.8	1.2	1.1	0.84	13.5	1.1	1.1	0.60
Grade quality		C	Fail	C		B	B	B		B	C	B

Table 6.—Summary of MC and residual drying stress results for vacuum kiln drying trials.

	Trial V1				Trial V2			
	Initial cross-sectional MC (%)	Final cross-sectional MC (%)	MC gradient (%)	Drying stress (D_{stress})	Initial cross-sectional MC (%)	Final cross-sectional MC (%)	MC gradient (%)	Drying stress (D_{stress})
Average	73.2	10.1	2.8	0.79	50.4	8.7	2.3	1.50
Maximum	123.0	16.1	10.1	1.32	59.7	11.6	4.7	2.24
Minimum	55.9	7.8	0.4	0.00	32.8	5.9	0.1	0.62
SD	15.2	1.8	2.2	0.42	6.9	1.2	1.0	0.21
Grade quality		B	E	C		C	C	C

population means of trials C1 and C2 ($P = 0.813$), C1 and V2 ($P = 0.876$), C2 and V2 ($P = 0.556$), and C3 and V1 ($P = 0.280$). Remaining pairwise test combinations resulted in significant differences ($P < 0.0001$). As trial C3 was the only trial drying red mahogany, it is not unusual that the mean moisture content was significantly different from that of most of the other trials, all of which were drying Gympie messmate. For reasons unknown, the mean initial MC for trial V1 was significantly different (higher) than all other Gympie messmate trials.

Final cross-sectional MC and MC gradient

The final cross-sectional MC and MC gradient results for each trial are presented in Tables 5 and 6 and Figures 2 and 3. The average final cross-sectional MC (11.9%) recorded for the 38-mm Gympie messmate material dried in trial C1 was higher than the 10 percent MC target, thus achieving the unacceptable grade quality C. By the equalization EMC conditions for trial C2 being lowered, this result was improved so that the average final cross-sectional MC of 11.3 percent was recorded with a lower standard deviation and range than trial C1. Consequently the acceptable grade quality B was achieved. The same EMC conditions from trial C2 were used to equalize the 25-mm red mahogany material in trials C3 and V1, which also achieved the acceptable final cross-sectional MC grade quality B, averaging 9.9 and 10.1 percent, respectively. Four ‘‘wet’’ outliers were present (Fig. 2) after vacuum trial V1 and later inspection showed that the three wettest outliers were sawn from the same log. The final average cross-sectional MC

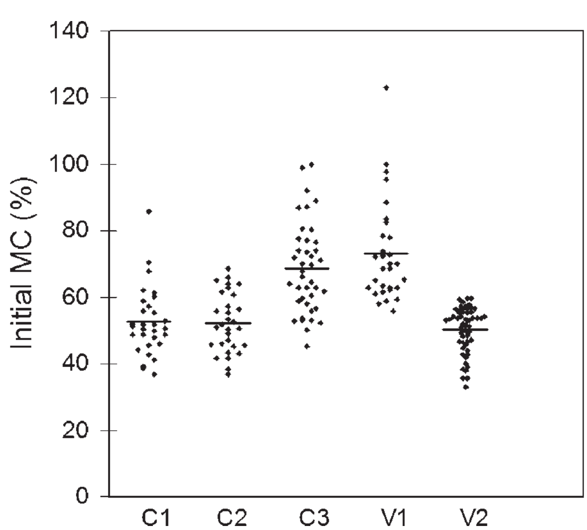

Figure 1.—Initial cross-sectional MC scattergram for all trials.

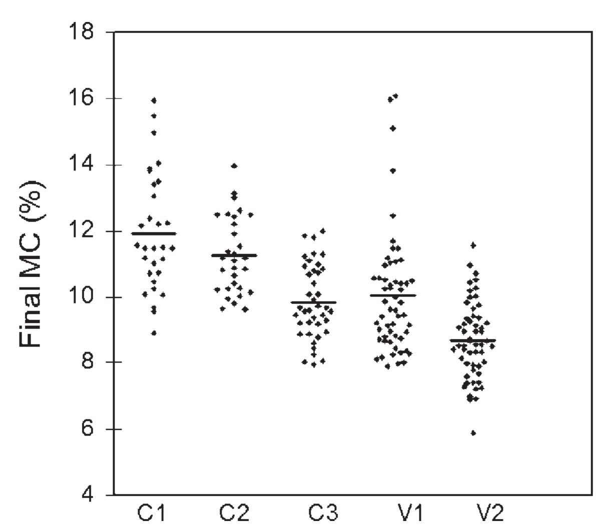

Figure 2.—Final cross-sectional MC scattergram for all trials.

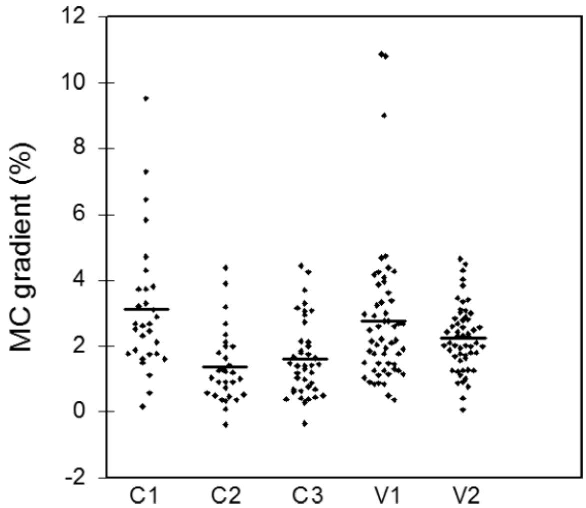

Figure 3.—Final MC gradient scattergram for all trials.

results for trial V2 were unacceptably low (8.7%), achieving grade quality C. The reason for this was that the humidity control during the equalization phase failed, resulting in 24 hours of extra drying at an EMC of approximately 6 percent instead of equalizing at the intended 11 percent EMC setpoint.

The MC gradient grade quality results (average and standard deviations) for trials C1 and C2 were similarly improved from the highly unacceptable Fail grade quality for trial C1 to acceptable grade quality B by using a milder schedule and adjusting the EMC conditions (Table 5). Unacceptable MC gradient grade quality results were recorded for trials C3, V1, and V2 achieving grade qualities C, E, and C, respectively. Further adjustments to final conditioning and equalization treatments are required for future trials to improve MC gradient results to within acceptable limitations.

Residual drying stress

Residual drying stress results for each trial are presented in Tables 5 and 6 and Figure 4. For trial C2, the drying stress grade quality was improved to acceptable B grade compared with the unacceptable C grade achieved in trial C1. This improvement can be attributed to the milder drying schedule used and adjustments to the equalization EMC conditions between trials. Acceptable drying stress grade quality results were recorded for conventional trial C3 (grade quality B).

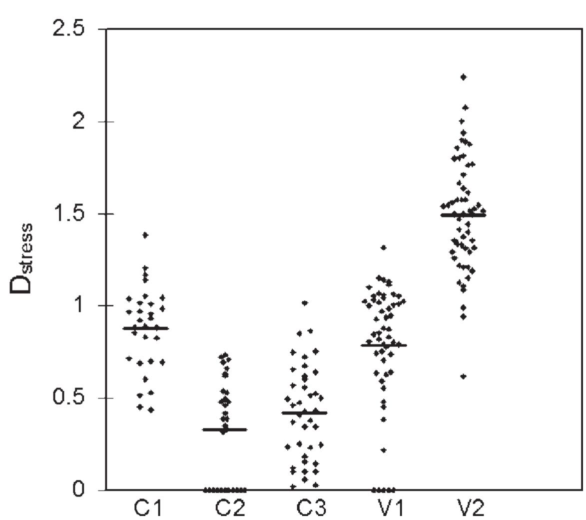

Figure 4.—Residual drying stress scattergram for all trials.

The drying stress grade quality results for both vacuum drying trials V1 and V2 achieved the unacceptable C grade. Only 5.5 percent of boards in trial V2 achieved the acceptable grade B, a result influenced directly by the equalization stage failure during this trial. For trial V1, 81.1 percent of boards achieved grade B. This result is clearly evident in the residual drying stress V2 trial scattergram shown in Figure 4. These results suggest improvements to the equalization phase, particularly for vacuum kiln drying, are required to maintain residual drying stress results within acceptable limitations. Additionally, different initial moisture contents recorded for both the V1 and V2 trials (even though they were sawn from the same species and plantation) may have some influence on these results.

Surface and internal checking

Table 7 shows the percentage of check-free boards (surface and internal) and the percentage of Select (best) grade boards in accordance with AS 2796.3 (Standards Australia 1999). Surface checking was present in varying degrees across all trials. For trial C1, 80 percent of boards made Select grade for surface checking, which is deemed unacceptable by the grading rules (at least 90% of boards must achieve Select grade). This was improved for trial C2 by adjusting the drying schedule such that a higher relative humidity was used throughout, resulting in an acceptable 90 percent of boards achieving Select grade. Even though the number of boards free of surface checks was slightly lower for trial C2 (43%) compared with trial C1 (57%), the checks were much smaller and less frequent along the length of the boards, resulting in a better grade quality overall. Only 7 percent of boards exhibited surface checks for trial C3; however, they were not severe or frequent enough to prevent 100 percent of boards making Select grade.

Acceptable surface checking was recorded for vacuum drying trial V1 with 64 percent of boards free of surface checks and 93 percent of boards meeting Select grade. A mild schedule was chosen for vacuum drying trial V2 which resulted in 89 percent of boards being surface check–free and 100 percent of boards meeting Select grade requirements.

All boards in each trial were free of internal checking.

Drying time

Moisture content as a function of drying time for each trial is shown in Figure 5. The MC values shown are the average values calculated from the load cell for the conventional kiln trials and the resistance probes for the vacuum kiln trials. The time to dry 38-mm-thick Gympie messmate in trial C1 was 20.3 days. This was lengthened to 23.2 days for similar material dried in trial C2 due to the milder drying schedule applied; however, improved (acceptable) dried quality was achieved. The conventional drying time for the 25-mm-thick red mahogany material was 17.7 days. The vacuum drying time for 38-mm-thick Gympie messmate boards dried in trial V1 was 13 days, approximately 60 percent shorter than that dried in conventional trials C1 and C2. The vacuum drying time

Table 7.—Surface and internal check results.

	Trial C1 (%)	Trial C2 (%)	Trial C3 (%)	Trial V1 (%)	Trial V2 (%)
Surface check–free boards	57	43	93	64	89
Select grade	80	90	100	93	100
Internal check–free boards	100	100	100	100	100

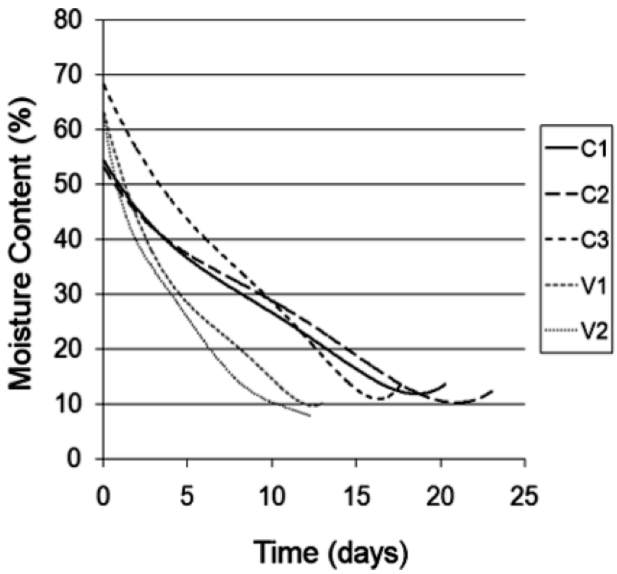

Figure 5.—Moisture content versus time drying curves for all trials.

for the 25-mm-thick Gympie messmate boards dried in trial V2 was 12.2 days, which was, as expected, shorter than for the 38-mm-thick boards dried in trial V1.

Conclusions

The study demonstrated that plantation Gympie messmate and red mahogany can be dried considerably faster than the drying times expected for drying native forest material of the same species and has provided a useful schedule benchmark. Additionally, vacuum drying appears to be considerably faster than conventional drying for drying plantation grown Gympie messmate although drying quality needs improving. The results allude to the substantial benefits of conducting multiple trials in which careful schedule manipulation and adjustment can be completed. Additional research is required to refine these schedules to ensure acceptable grade qualities can be reliably achieved across all drying criteria and exploit opportunities to reduce drying times further.

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