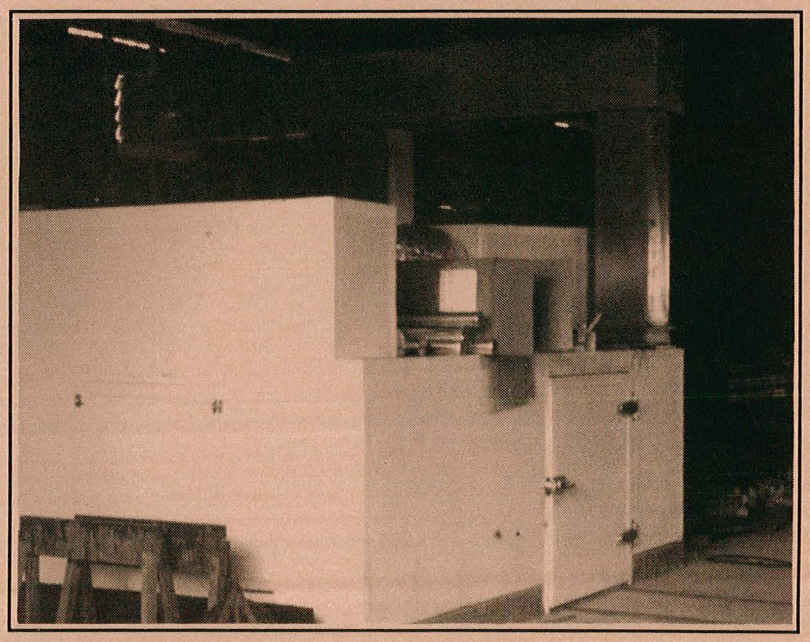
VALWOOD

Small Eucalypt Processing

Drying Regrowth Eucalypts Using a Low Temperature Batch Kiln

G.K. Brennan, B.R. Glossop and W.R. Hanks



Report No. 20

December 1990

Wood Utilisation Research Centre
Department of Conservation and Land Management

Drying Regrowth Eucalypts Using a Low Temperature Batch Kiln

G.K. Brennan, B.R. Glossop and
W.R. Hanks

Report No 20

December 1990

This report was part of a program of industrial research and development aimed at establishing techniques and developing equipment to allow processing of small eucalypt regrowth logs in a commercially viable manner, particularly with a view to use in high quality furniture. The research program was funded jointly by the Commonwealth Government under a Public Interest Project, the Department of Conservation and Land Management, and the Western Australian timber industry.

Wood Utilisation Research Centre
Department of Conservation and Land Management

CONTENTS

SUMMARY

Air-drying timber under Western Australian summer conditions results in surface checking, making it unsuitable for furniture use. Consequently, timber for value-added markets must be protected from harsh drying conditions, in particular immediately after sawing.

Drying schedules for 140 mm x 40 mm regrowth jarrah(*Eucalyptus marginata* Donn ex Sm.) and 140 mm x 30 mm regrowth jarrah and karri (*E. diversicolor* F. Muell.) boards were assessed in this trial by using a low temperature batch kiln.

Pre-steaming for two hours at 95°C wet bulb temperature in one of the kiln runs, then initial drying under a mild schedule, resulted in unacceptable checking in jarrah and karri after two days.

The results indicated that low temperature, high humidity and low air velocity schedules are needed in the initial stages of drying. A schedule of 20°C dry bulb temperature (DBT) with 1°C wet bulb depression (WBD) and air velocity 0.2 m/s could be recommended for initial curing of 140 mm x 40 mm regrowth jarrah boards. The recommended schedule for 140 mm x 30 mm regrowth jarrah and karri was 30°C DBT and 1.5°C WBD with air velocity 0.2 m/s.

The efficiency of the drying schedules was assessed by grading timber into Clear, Feature, Processing and Merchantable grades, using Wood Utilisation Research Centre (W.U.R.C.) rules. Sixty-one per cent of regrowth jarrah and 56 per cent of regrowth karri made Clear and Feature grades, provided that timber was docked to remove defects, and that lengths as short as 0.6 m were used.

INTRODUCTION

The seasoning of eucalypts is difficult compared with seasoning of softwood and many other hardwood species (Campbell 1978). Some of the problems encountered while seasoning include collapse, surface checking of backsawn faces, high shrinkage, steep moisture gradients and pronounced drying stresses and sets (Campbell and Hartley 1978). Backsawn boards are generally prone to surface checking, particularly the 'ash type' eucalypts of south-eastern Australia, which are consequently quartersawn to reduce the risk of surface checking (Campbell 1964).

Campbell and Hartley (1978) outlined some of the drying characteristics of wood from plantation and young regrowth ash-type eucalypts:

(i) shrinkage before reconditioning is generally higher in young than in mature material, especially in the tangential direction; this is not a problem if the timber is reconditioned before use in service

(ii) greater tangential shrinkage also indicates that collapse is greater in the younger material

(iii) wood sawn close to the pith may collapse, check and split irrespective of the drying conditions

(iv) warp (bow, spring or twist) is caused by the release of growth stresses and is greater in young than in mature wood; this is a problem of drying and conversion

(v) internal checks caused by collapse are more often associated with young than with mature material, particularly in wood from near the pith.

Regrowth jarrah (*Eucalyptus marginata* Donn ex Sm.) and karri (*E. diversicolor* F. Muell) presumably have similar drying characteristics to the regrowth ash type eucalypts and would be more difficult to dry than mature timber.

A survey by Mackay (1970) and recent seasoning studies by Brennan and Glossop (1989) showed that protection is needed in the early stages of drying to avoid surface checking in mature jarrah timber of Select or Joinery grade . Air drying under Western Australian summer conditions will result in surface checking which will downgrade timber from appearance grades to structural grades. Timber for the value-added markets needs protection immediately after sawing, and should be stored in a controlled environment room before being dried in a kiln. This can be achieved by enclosing and air-conditioning the docking and timber stripping areas.

Research in New Zealand by Haslett and Kininmonth (1986) had indicated that pre-staining and hot water soaking of red beech (*Nothofagus fusca*) timber was an efficient way to increase the drying rate. The principle could be used in drying regrowth eucalypts. An alternative was that check-susceptible timber can also be treated with surface coatings while in the green condition. For example, a polyvinyl chloride (P.V.C.) /polyvinyl acetate (P.V.A.) emulsion system was developed by the Tasmanian Timber Promotion Board to reduce surface checking in backsawn Tasmanian oak, using the P.V.A. emulsion to adhere the P.V.C. film onto green timber (Schaffner and Doe 1984).

The aim of the present study was to find a reliable schedule for drying mature and regrowth jarrah and karri during the initial critical stage of drying, referred to as the `curing' period. After determining the curing period, an efficient schedule could be developed for drying 140 mm x 40 mm and 140 mm x 30 mm boards to a final moisture content of 6 to 8 per cent.

MATERIALS AND METHODS

A batch kiln with a capacity of approximately 0.5 m^3 of green timber was designed and constructed to undertake this applied seasoning research at the W.U.R.C. Because accurate monitoring of temperature and humidity was required, resistance temperature devices (R.T.D.s) were installed to measure wet and dry bulb temperatures. Temperature can be measured to an accuracy of $\pm$ 0.2°C (range 0 to 80°C) and relative humidity to an accuracy of $\pm$ 2 per cent (range 20 to 98 per cent). Process control is done with a 'Micro-mac', and data logging with an 'Olivetti' M24 host computer. Fogging, heating and steaming facilities are available to maintain set drying conditions, with variable air speed from 0.2 m/s to 3.0 m/s.

An associated air-conditioned assessment room is used for timber inspections. Every board in the stack is sampled, which enabled the initial runs in the batch kiln to combine regrowth and mature jarrah and karri in the one bundle, with the mature timbers used as controls.

The regrowth jarrah (48 to 58-years-old) used for drying Runs 1 to 8 came from a stand in Arklow Block, Collie District. This stand was heavily cut in the 1930s and the resulting regrowth was subsequently thinned. Regrowth jarrah (60 to 70-years-old) used in Runs 9 and 10 was from a high quality pole stand in Urbrae Block, Dwellingup District. Mature jarrah from Arklow Block estimated to be 300-years-old was used as a control in all runs.

The regrowth karri (52-years-old) and mature karri (approximately 100-years-old) came from a two-tiered stand in Treen Brook Block, Pemberton District. The regrowth trees resulted from natural regeneration in the 1930s.

After the first seven runs only mature jarrah was used as a control because mature and regrowth karri had shown similar drying characteristics. Runs 1 to 8 used 140 x 40 mm boards and Runs 9 and 10 used 140 x 30 mm boards.

Drying schedules developed by Campbell (1980) showed that a period of air-drying down to 60 per cent moisture content was necessary before applying the CSIRO conventional drying schedule for jarrah and karri. To evaluate the need for a critical or `curing' period the conventional CSIRO drying schedule 'AT' recommended for jarrah was tested on green timber (one to two hours after sawing). The schedule used was:-

Dry bulb temperature (DBT)	-	40°C	
Wet bulb depression (WBD)	-	3°C	
Relative humidity	-	82	per cent
Air velocity	-	1	m/s.

This run resulted in severe checking after four days and indicated the need to investigate higher humidity, lower temperature schedules for the initial stages of drying.

Table 1 lists the schedules for the initial drying stage of the first ten runs. Assessment of each run was done by determining the percentage of boards with surface checks i.e. checks occurring only on clear wood and not associated with defects such as knots, gum and epicormic buds. This indicated the percentage of boards checked, but not the volume of timber with checks. When checking became unacceptable the drying run was discontinued.

Even at high humidity and low temperature, the schedule used in Run 6 resulted in unacceptable checking. Research by CSIRO in drying regrowth ash eucalypts had indicated the need for minimal air flow during initial drying, therefore in Runs 7, 8, 9 and 10 the air velocity was reduced from 0.5 m/s to 0.2 m/s. In Run 7 the schedule was changed at day 43 to DBT 30°C, WBD 1.0°C and air velocity 0.2 m/s. After initial curing in Runs 8 and 10, schedules similar to the CSIRO 'AT' schedule were used to dry the boards to a final moisture content of between 6 and 8 per cent.

Haslett and Kininmonth (1986) had found that pre-steaming red beech increased the drying rate. Run 9 was pre-steamed for 2 hours at 95°C WBT before the bundle was placed in the kiln. This bundle was initially dried at DBT 30°C, 3°C WBD and 0.2 m/s air velocity for two days.

To assess the efficiency of the drying schedules for Runs 8 and 10, the timber was graded into Clear, Feature, Processing and Merchantable grades, using the W.U.R.C. grading rules for boards milled from regrowth eucalypts (Appendix 1). The number of boards or pieces downgraded through surface checking was also recorded.

RESULTS AND DISCUSSION

Results from using the CSIRO's Schedule 'AT' on green timber indicated that a high humidity, low temperature schedule needed to be developed.

Tables 1 and 2 show drying schedules and the level of degrade at various time periods. Starting with a DBT of 30°C, WBD of 1.6 ± 0.6°C and air velocity of 0.5 m/s, boards were surface checking after several days of drying. Slight modifications were made in each successive run, but each of Runs 1 to 6 was discontinued because of unacceptable checking.

For Run 7 the air velocity was reduced to 0.2 m/s to assess the affect on the amount of surface checking. After 36 days only 10 per cent of jarrah, but 19 per cent of mature karri and 29 per cent of regrowth karri had checked. To increase the drying rate, the schedule was changed at day 43 to DBT 30°C, WBD 1.0°C and air velocity 0.2 m/s. After 67 days the percentage of checking was still acceptable.

Table 1
Batch kiln schedules for jarrah and karri in the initial curing period

Run No	DBT (°C)	WBD (°C)	RH (%)	Air Velocity (m/s)
140 x 40 mm				
1	30	1.6 ± 0.6(a)	89 ± 8 (a)	0.5
2	30	2.0 ± 0.5	86 ± 3	0.5
3	32	1.7 ± 0.2	89 ± 3	0.5
4	25	1.5 ± 0.2	88 ± 3	0.5
5	20	0.8 ± 0.2	93 ± 3	0.5
6	20	1.0 ± 0.2	91 ± 2	0.5
7	20	1.0 ± 0.2	91 ± 2	0.2
8	20	1.0 ± 0.2	91 + 2	0.2
140 x 30 mm				
9 (b)	30	3.0 ± 0.2	79 ± 2	0.2
10	30	1.5 ± 0.1	89 ± 1	0.2

DBT - Dry bulb temperature
WBD - Wet bulb depression
RH - Relative humidity

(a) Allowable range
(b) 2 hours pre-steaming before drying

Table 2
Drying schedules used for Runs 8 and 10 following initial drying

	Time (days)	DBT (°C)	WBD (°C)	Air Vel (m/s)	Ave MC Change (%)
Run 8	Initial schedule	20	1.0	0.2	77 - 45
	92	Air dried in an enclosed shed under winter ambient conditions for 30 days			
	124	40	8	0.5	45 - 15
	126	50	10 - 12	0.5	
	128	80	18 - 20	0.5	15 - 7
Run 10	Initial schedule	30	1.5	0.2	85 - 35
	58	45	4	0.5	35 - 30
	64	50	5	0.5	30 - 25
	68	50	8	0.5	25 - 20
	71	60	12	0.5	20 - 8

Note:

1. This sequence of changes follow the CSIRO Schedule 'AT' (Campbell 1980).
2. For Run 8 the average MC is for mature and regrowth jarrah.
3. For Run 10 the average MC change is for mature and regrowth jarrah and regrowth karri.

Using the same schedule as Run 7, Run 8 used an increased sample size of regrowth jarrah (56 boards) with mature jarrah used as the control. Karri was excluded to accommodate this increase in sample size.

After 72 days only 5 per cent of mature jarrah but 32 per cent of regrowth jarrah had surface checked. After 128 days in the kiln (30 days of air drying in an enclosed shed during winter ambient conditions occurred during this period), 19 per cent of mature jarrah and 45 per cent of regrowth jarrah surface had checked.

Grading results using the W.U.R.C. grading rules (Table 3), showed that 61 per cent of regrowth jarrah made Clear and Feature grades, provided that timber was docked and lengths as short as 0.6 m were used. An assessment of surface checks and end splits (Table 4) indicated that only 7 per cent was downgraded because of surface checking and end splits, and 15 per cent because of checks and end splits combined with other defects. This indicated that seasoning defects alone do not influence grading recoveries, that short length pieces must be used, and that any major surface checking should be docked out. Similar results can be seen for Run 10 (Tables 5, 6 and 7), when 140 x 30 mm boards were dried.

Table 3
Grading results for regrowth jarrah from Run 8

Grade	Graded recovery %	Lengths (m) distribution by grade							
		2.4	2.1	1.8	1.5	1.2	0.9	0.6	0.3
Clear	13.5		1	2	1	3	5	5	
Feature	47.8	11	1	7	8	6	2	5	
Processing	20.7	3		2	4	3	6	4	
Merchantable	14.5	1		3	1	3	3	7	
Reject	3.5								8

Table 4
Effect of surface checks and end splits on grade in different lengths of regrowth jarrah from Run 8

	% Downgraded	Length (m)							
		2.4	2.1	1.8	1.5	1.2	0.9	0.6	0.3
Downgraded by checks and end splits	7.0	1			3	1	1	1	
Rejected due to checks and end splits	0.5								2
Downgraded by checks and end splits combined with other defects	15.0	3		3	3	1	2	1	
Rejected due to checks and end splits combined with other defects	0								

Table 5
Grading results from Run 10

Grade	Graded recovery %		
	Mature jarrah	Regrowth jarrah	Regrowth karri
Clear	35	16	11
Feature	33	63	45
Processing	12	10	29
Merchantable	15	8	11
Reject	5	3	4

Table 6
Effects of surface checks and end splits on grade in mature and regrowth jarrah and regrowth karri from Run 10

	% Downgraded		
	Mature jarrah	Regrowth jarrah	Regrowth karri
Downgraded by checks and end splits	3	5.5	5
Rejected due to checks and end splits	0	0	0
Downgraded by checks and end splits combined with other defects	9	11.5	11
Rejected due to checks and end splits combined with other defects	0	0	0

Table 7
Relationship between graded recovery and length of regrowth jarrah and karri from Run 10

Grade	Graded recovery %	Length (m) distribution by grade							
		2.4	2.1	1.8	1.5	1.2	0.9	0.6	0.3
Jarrah									
Clear	15.5	1		1		5		9	
Feature	45.0	12	1	6	7	7	5	4	
Processing	29.0		1	2			1	3	
Merchantable	11.0	1						5	
Reject	3.0								8
Karri									
Clear	11.0				1		4	9	
Feature	45.0	4	3	2	7	4	9	3	
Processing	29.0	4	1		5	2	4	2	
Merchantable	11.0			1	1	3	4		
Reject	4.0							2	9

Following work by Haslett and Kininmonth (1986) on red beech, in Run 9 140 x 30 mm regrowth jarrah and karri (mature jarrah control) were pre-steamed for 2 hours at 95°C before kiln drying under a mild schedule (Table 1). This resulted in surface checking in 90 per cent of jarrah boards and 100 per cent of regrowth karri boards after 2 days. Consequently no further pre-steaming was tried at that stage.

Haslett and Kininmonth (1986) also found that hot water soaking timber reduced drying time without further degrade in red beech. A separate study, Glossop (unpublished) compared the drying rate and degrade of mature and regrowth jarrah, regrowth karri and Tasmanian blue gum (*Eucalyptus globulus* Labill. subsp. *globulus*), after receiving a hot water soaking treatment of 70°C for one hour, 90°C for 2.5 hours or 95°C for 8 hours. Preliminary results showed no difference in the drying rates, but surface checking was evident for all treatments. The initial drying schedule used was:-

DBT - 30.0°C
WBD - 2.5°C
Air vel - 0.2m/s

The aim of Run 10 was to dry 140 x 30 mm regrowth jarrah and karri without any pre-treatments, using an initial schedule of DBT 30°C, WBD 1.5°C and air velocity 0.2 m/s. At day 58 the average moisture content of mature and regrowth jarrah was 36 per cent (even though the regrowth karri was 47 per cent), and consequently the drying schedule was changed to conform with the CSIRO 'AT ' schedule (Table 2). Regrowth karri had the highest number of boards with surface checks (66 per cent), but the grading results showed that 56 per cent of boards made Clear or Feature grade (Table 5). Results for jarrah were 68 per cent (mature) and 79 per cent (regrowth) making Clear or Feature grade, provided that short length boards were used.

The 30 mm thick timber (e.g. Run 10) can be dried with a more severe schedule than 40 mm thick. The moisture contents and drying times for Runs 6, 8 and 10 are shown in Figures 1 to 3.

Waugh and Rozsa (1990) did drying studies on 25 mm, 40 mm or 50 mm thick backsawn regrowth mountain ash (*Eucalyptus regnans* F. Muell) using commercial drying systems i.e. pre-drying, dehumidification drying and the use of a progressive kiln. These methods resulted in very high levels of drying degrade in boards assessed. They found after analysing various drying regimes and handling methods that the following parameters were necessary for optimum drying of young regrowth ash boards:

(i) careful handling of backsawn material was required from the time of sawing, by use of plastic wrapping of exposed bundles. Water sprays or enclosed storage sheds reduce the amount of drying degrade owing to surface checking from over 70 per cent in material handled conventionally by air/kiln drying, to below 30 per cent for material carefully kiln dried from green.

(ii) preliminary air drying in an enclosed shed reduced surface checks to below 20 per cent, and a pre-storage period (3-5 weeks) of a block-stacked bundle wrapped in plastic further reduced surface checking. Drying times for 40 mm material have been reduced to approximately 12 to 18 weeks for air drying in a shed, and to 10 weeks if dried in the pre-drier. All samples were reconditioned then finally dried to a nominal moisture content of 12 per cent.

(iii) incidence of both surface checks and internal checks decreased as the board thickness was reduced from 50 mm to 40 mm or 25 mm.

When drying under these revised conditions, non-recoverable collapse and the incidence of internal checking was a minor problem, affecting less than 10 per cent of boards.

In summary, the present drying study showed that if sawmillers are aiming for a high quality product by drying jarrah and karri, an initial curing period is essential. The schedule of 20°C (Run 8) is recommended for 140 x 40 mm regrowth jarrah, and the schedule of 30°C DBT with 1.5°C WBD and air velocity 0.2 m/s (Run 10) is recommended for 140 x 30 mm regrowth jarrah and karri. Mature jarrah can be dried successfully using either schedule. An air velocity of 0.2 m/s may not be achievable in some commercial kilns, but kiln operators must reduce the air flow to the lowest air velocity possible in their particular kiln.

Figure 1. Progressive moisture contents when drying 140 x 40 mm boards of mature and regrowth jarrah and karri, in batch kiln Run 6.

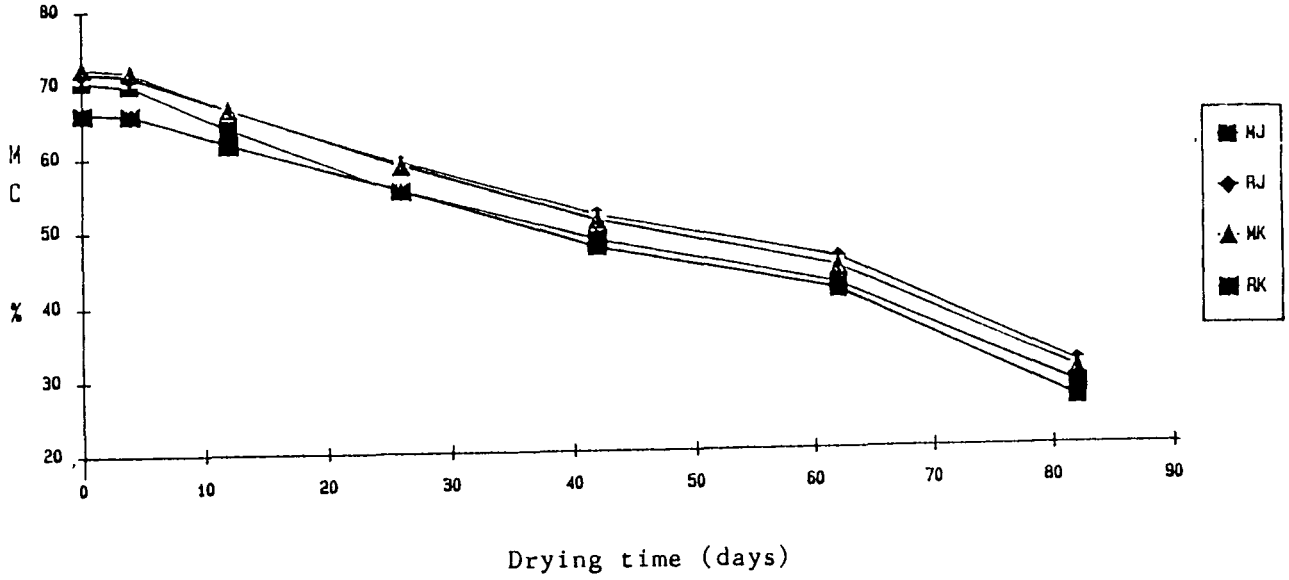


Figure 2. Progressive moisture contents when drying 140 x 40 mm boards of mature and regrowth jarrah in batch kiln Run 8.

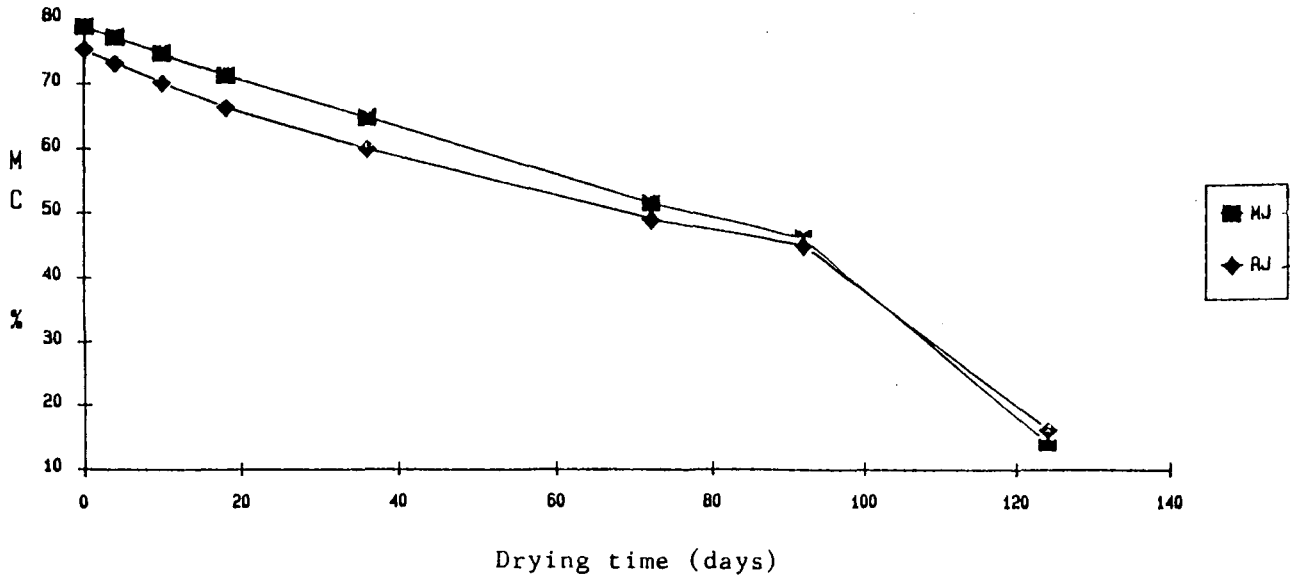
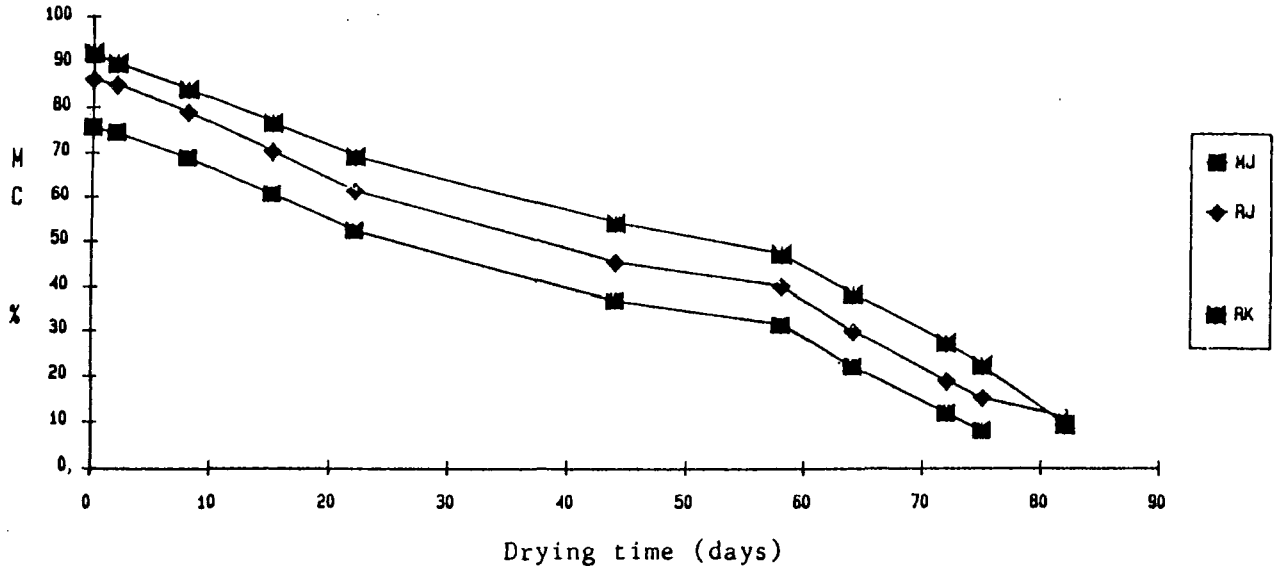


Figure 3. Progressive moisture contents when drying 140 x 40 mm boards of mature and regrowth jarrah and regrowth karri, in batch kiln Run 10.



REFERENCES

BRENNAN, G.K. and GLOSSOP, B.R. (1989). Seasoning 25 mm mature jarrah boards using a progressive tunnel kiln. Department of Conservation and Land Management, W.U.R.C. Technical Report. No. 1.

CAMPBELL, G.S. (1964). The control of surface checking during drying. Part I. CSIRO Division of Forest Products. Forest Products Newsletter No. 313.

CAMPBELL, G.S. (1978). The drying of ash type eucalypts. Australian Forest Industries Journal 44(7):29-36.

CAMPBELL, G.S. (1980). Index of kiln drying schedules for timber dried in Australia. CSIRO Division of Building Research. Unpublished report.

CAMPBELL, G.S. and HARTLEY, J. (1978). Drying and dried wood. In Eucalypts for Wood Production. Chapter 16 (Eds: Hillis, W.E. and Brown, A.G.). CSIRO, Griffin Press Limited, Adelaide, South Australia.

HASLETT, A.R. and KININMONTH, J.A. (1986). Pretreatments to hasten the drying of *Nothofagus fusca*. New Zealand Journal of Forestry Science 16(2):237-246.

MACKAY, J.F.G. (1970). Current practice in seasoning Western Australian jarrah. CSIRO Division of Forest Products. Forest Products Newsletter No. 377.

SCHAFFNER, R.D. and DOE, P.E. (1984). Surface check reduction in eucalypt timbers using semi-permeable coatings. Paper presented at the 21st Forest Products Research Conference, Melbourne, November 1984.

WAUGH, G. and ROZSA A.N. (1990). Sawn timber. CSIRO, Draft report for the Young Eucalypt Project. February 1990.

APPENDIX 1
W.U.R.C. grading rules for boards milled from regrowth eucalypts

These grade rules are intended for regrowth eucalypts, particularly jarrah.

The intention is to produce dry pre-dressed boards in one of four grades.

The sizes are based on the optimum metric size taking account of moisture content, shrinkage, section and length requirements of the appearance grade markets.

The grades are:

- Feature,
- Clear,
- Processing,
- Merchantable.

These grades will apply to sections dressed 2 mm over the finished metric sizes of 10, 20, 30, 40, 60, 80, 100, 120, 150 or 180 mm.

Lengths range from 0.6 m to 3.6 m, increasing in increments of 0.3 m.

Timber must be seasoned to between 6 and 8 per cent M.C.

Feature Grade
Acceptable features:

Sapwood: No limit on 1 face or 2 edges providing one face is clear of sapwood.

Branch occlusions or birds eye: Sound intergrown with seasoning checks up to 1 mm wide and confined within the area of the feature.

Surface checks: Length of individual checks not exceeding 200 mm and width 1 mm. Only one check is allowed in every 50 mm across the face of the board.

Knots: Ingrown and sound knots not to exceed half the width of the face or 50 mm (measured at right angles to arris), whichever is the larger. They need to be separated by at least twice the width of the face.

Knot occlusions or holes: Holes are to be free of bark and decay, with any associated voids not to exceed more than 0.5 cm^2. The same limits for knots apply to holes.

Gum Veins: Gum veins must be tight and to the same limits as surface checks.

Pin holes: Clear of stain around the edges and less than 1 mm in diameter. Limit on the number of holes is 10 holes per 10 cm^2.

Bow and spring: Maximum of 2 mm in any length less than 1.8 m.

Skip and machine damage: Less than 1 mm deep on any face or edge.

Clear Grade
Clear grade will be clear of all imperfections excepting sapwood which will be accepted for the full length of the piece.

Processing grade
Acceptable features:-

Sapwood: Unlimited.

Birds eye: Unlimited.

Surface checks: Length of individual checks not to exceed 300 mm long and 1 mm wide. Only one check is allowed in every 50 mm across the face of a board.

Knots: Knots must be ingrown and free from bark and decay, but may contain fractures or voids up to 1 cm^2.

Knot occlusions or holes: This feature must be free from bark and decay and not exceed 1 cm^2.

Gum Veins: 3 mm in width, maximum of 50 cm in length.

Gum pockets: As for knots and holes.

Bow: 5 mm in any length less than 1.8 m.

Spring: 5 mm in any length less than 1.8 m.

Skip or machine damage: If on one face, then not to exceed 2 mm deep. If on two faces, then not to exceed 1 mm deep.

Pin holes: Up to 2 mm in diameter, no more than 20 in any 10 cm^2.

Merchantable Grade
May contain features in excess of the above grades.

0863-0191-600