Department of Conservation
and Land Management

Date:
Reference: NO. 4

Wood Utilisation Research Centre

HIGH TEMPERATURE DRYING OF GREEN JARRAH BLOCKS PRIOR TO CHARCOAL PRODUCTION

D.J. Donnelly, L.R. Mathews and W.R. Hanks

May 1989
W.U.R.C. Technical Report
Limited Distribution

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SUMMARY

This trial was to determine the drying behaviour of green jarrah (*Eucalyptus marginata* Donn ex Sm.) blocks dried in a kiln at high temperatures (150°C and 120°C) to reduce the moisture content (M.C.%) prior to charcoal production.

The results showed that the average M.C.% can be reduced quickly, but steep moisture gradients are set up within the pieces which cause considerable degrade to the wood structure with internal collapse, surface and end splitting. Average green moisture contents of about 70 per cent were reduced to 22 per cent after 9 hours drying using kiln temperatures of 150°C, and to 9 per cent after 50 hours using 120°C. Air speeds of up to 4m/s were used.

The removal of bark increased the drying rate, and shorter lengths dried faster than longer lengths.

INTRODUCTION

Charcoal production involves pyrolysis of wood to remove volatile gases and tars with a limited oxidation of the carbon. Efficiency of production is increased if moisture of the wood is at least down to 25 to 30 per cent (i.e. about fibre saturation point).

This experiment was set up to assess the drying behaviour of jarrah (*Eucalyptus marginata* Donn ex Sm.) sections in reducing moisture content to a suitable level prior to charcoal production. The aim was to compare drying rates of wood taken from live standing trees direct from the forest, cut into three pre-determined lengths or chunk sizes. The effect of bark removal on drying rate was assessed on half of the pieces in each length. A kiln charge of these lengths or chunks was dried at each of two different maximum temperatures (150°C or 120°C).

METHODS

Logs were taken from poor quality trees growing in jarrah forest east of Harvey, about 140 km south of Perth, and considered unsuitable for the production of sawlogs. The sample included a mature tree with a small end diameter of approx 50 cm, and three regrowth trees with a small end diameter greater than 15 cm. They were healthy vigorous trees selected to ensure a high initial moisture content.

The logs taken from the trees were transported directly to the Wood Utilisation Research Centre in Harvey for docking and splitting where necessary to the size required for drying.

The logs were docked by chain saw into discs of 150, 200 or 250 mm lengths. The discs from the large mature log were further reduced where necessary, by splitting with an axe to produce chunks approx 250 mm^2, equivalent in volume to discs from the smaller regrowth logs.

Sections were taken from each 3 m of log length during the docking to produce sample pieces from which oven-dry moisture contents of the log could be estimated. In addition, pieces were docked from either side of the sample and identified for moisture content determination after drying. The moisture contents of case and core specimens were determined using the standard oven-dry method set out in AS1080 - Part 1 1972 (Standards Association of Australia 1972).

The pieces were allocated randomly into two kiln charges. Each of the completely loaded bins was weighed to determine the overall mass before it was placed in the kiln, and this value was subsequently used to estimate oven-dry mass of the charge. Reweighings were then used to measure the average overall losses in wood moisture content. In addition, temperature probes and Bollman moisture meter probes were fitted to selected pieces to monitor wood temperature and moisture content. Kiln temperatures were monitored and automatically recorded on a "Chino" graph recorder, but moisture content meter readings were recorded manually.

The kiln schedule was set to heat the wood as rapidly as possible using a kiln temperature of 150°C in Charge 1 and 120°C in Charge 2. Air temperature reached 100°C after three hours for Charge 1 and after two hours for Charge 2.

The drying of Charge 1 was stopped after nine hours to assess the condition of the wood and the weight loss, as the Bollman meter readings indicated sufficient drying had taken place. Drying was considered satisfactory when the moisture meter readings indicated a mean moisture content below 25 per cent.

Charge 2 was stopped for an assessment which took two hours, after 28.5 hours drying. The kiln was then restarted and drying continued to reduce moisture contents to about 10 per cent to obtain additional data. This took a further 21.5 hours, to give a total drying time for this charge of 50 hours.

Actual moisture contents were established from samples at the end of the drying by the oven-dry method. The wood mass of each charge was measured after 4, 8 and 12 weeks following kiln drying to assess any moisture content variations.

RESULTS AND DISCUSSION

The moisture contents before and after kiln drying for Charges 1 and 2 are given in Table 1, which shows the advantages of removing bark on the round timber. Bark-on split specimens had the advantage of a comparatively large surface area. The trend of increasing moisture loss during drying with decreasing length was confirmed. The lower moisture contents in Charge 2 specimens were due to longer kiln times.

The drying behaviour in both charges was observed by using Bollman moisture meter probes and wood temperature probes in each charge (Figure 1). In Charge 1 the initial mean Bollman reading of 60 per cent moisture content decreased to 25 per cent after 7 hours, and to 20 per cent after 9 hours. In comparison, Charge 2 data showed a mean initial Bollman reading of about 80 per cent, which decreased to 25 per cent after 27 hours. Following the two hours assessment after 28.5 hours drying, the charge was dried for a further 21.5 hours to a final moisture content of 9 per cent. The trends in wood temperature in both charges were reasonably similar.

Data on moisture gradients from case to core of four randomly selected pieces before and after drying of Charge 2, are given in Table 2. The data indicate the considerable variations in mean case and core moisture content, although the sample size was small. The amount of internal checking with the moisture gradients set up would be acceptable only in residue uses such as charcoal production. Photographs in the Appendix illustrate the amount of checking, particularly in the samples with bark-off. However, the product should be acceptable for charcoal production (R. Leupen, personal communication).

Mr R. Leupen, Agnew Clough Ltd, Perth.

Table 1: Moisture contents of jarrah sections before and after drying (%)

Treatment	Charge 1		Charge 2	
	Before %	**After** %	**Before** %	**After** %
Bark-on rounds. 250mm length	69.1	26.1	65.3	16.4
200mm	69.1	22.8	68.4	11.6
100mm	69.1	19.3	67.8	9.7
Bark-off rounds. 250mm	69.1	-	65.3	10.9
200mm	69.1	18.3	68.4	7.0
100mm	69.1	-	67.8	1.4
Bark-on split. 250mm	65.8	19.4	-	-
200mm	65.8	15.3	-	-
100mm	65.8	15.7	-	-

Table 2. Moisture gradients from case to core before and after drying (%).

Treatment	Before drying		After drying	
	Case %	Core %	Case %	Core %
250mm round bark-on	65.6	82.3	16.9	25.0
200mm round bark-off	25.4	64.1	13.8	17.2
100mm round bark-on	58.4	70.2	8.9	8.7
250mm chunks bark-on	49.8	68.6	0.5	7.4
200mm chunks bark-on	47.9	69.8	2.2	8.2

Table 3. Variation in mass with kiln drying and subsequent storage (kg)

	Charge 1		Charge 2	
	Mass (kg)	Estim. MC %	Mass (kg)	Estim. MC%
Initial	1384.4	68.2*	1374.2	67.6*
After drying	1006.0	22.2	891.0	8.7
4 weeks	943.0	14.6	913.5	11.4
8 weeks	940.0	14.2	926.5	13.0
12 weeks	N/A	N/A	915.0	11.6

* From Table 1.

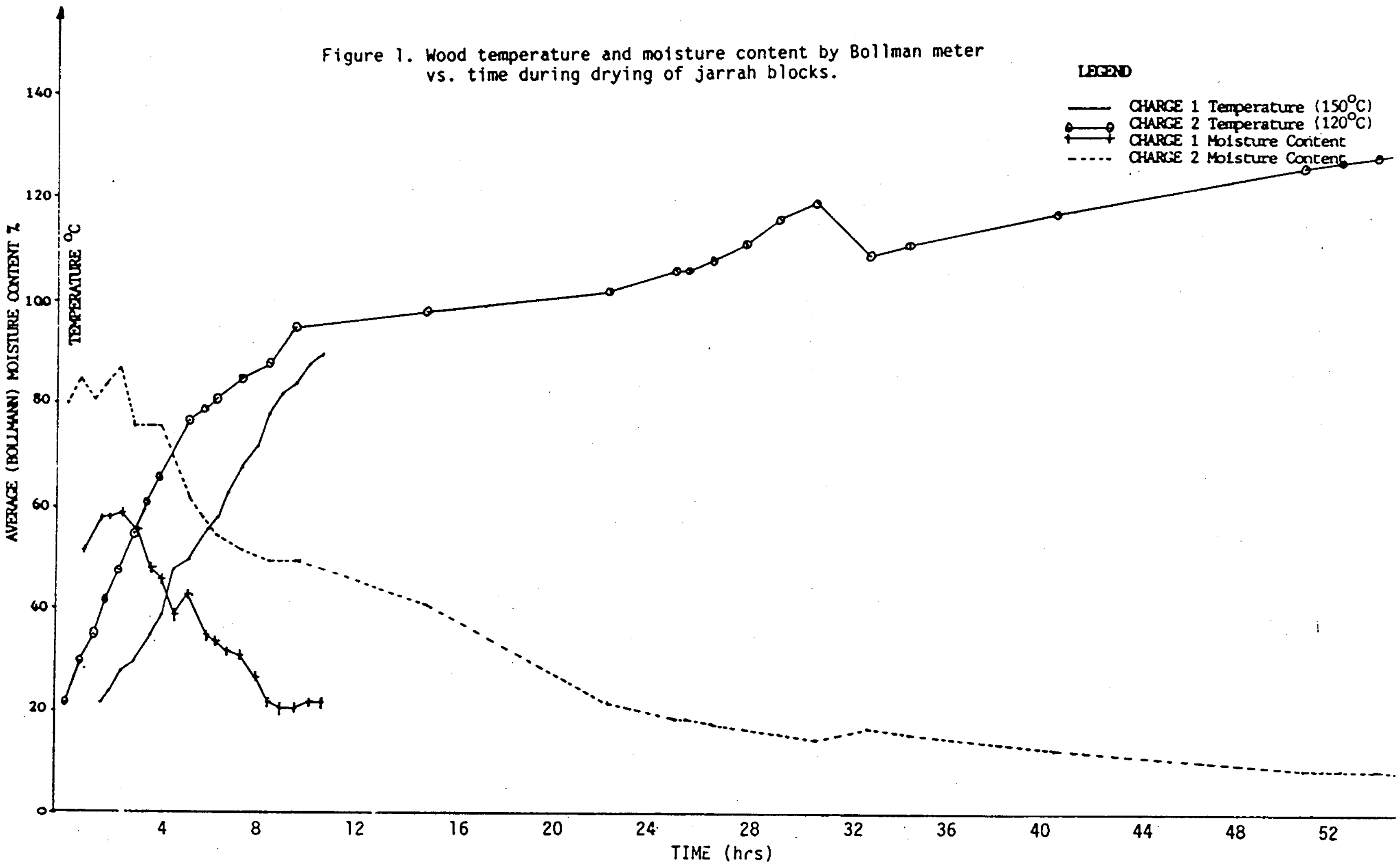


Figure 1. Wood temperature and moisture content by Bollman meter vs. time during drying of jarrah blocks.

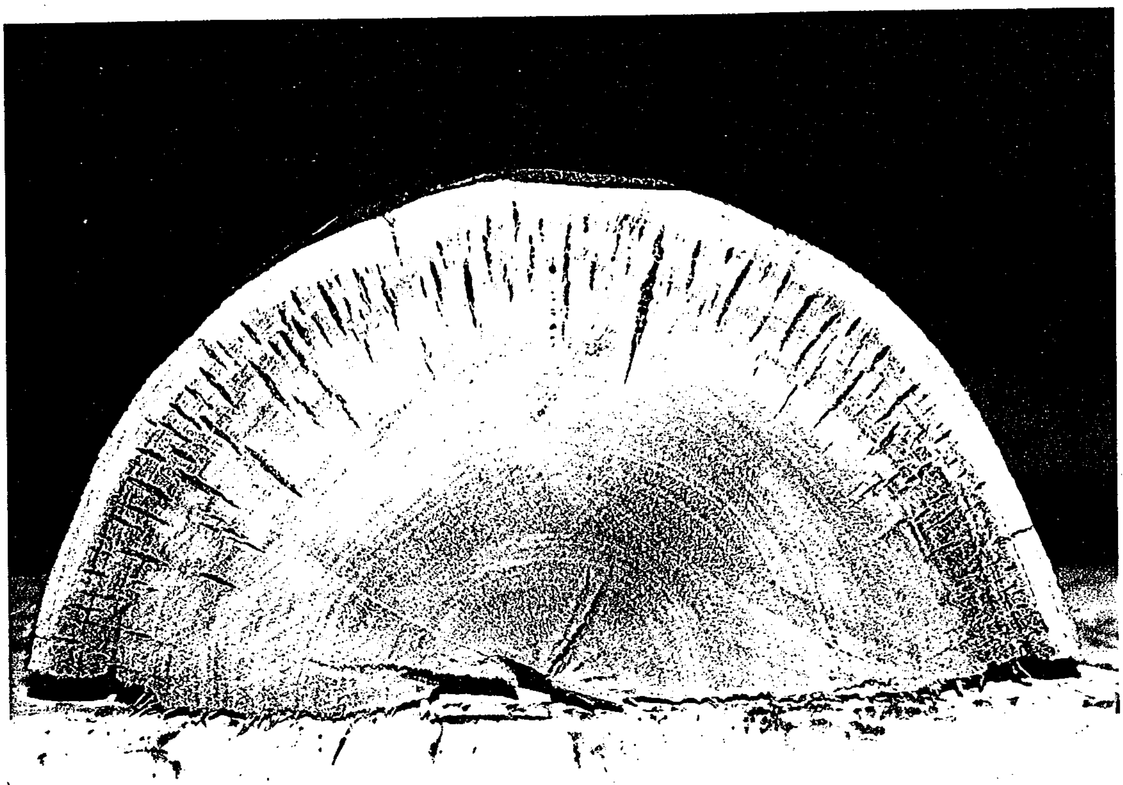
The actual moisture loss in each charge was calculated by weighing before and after kiln drying (Table 3). The oven-dry mass of each charge was estimated from the total green wood mass using the data on mass and moisture content from the samples. The mean moisture contents after drying were 22.2 per cent and 8.7 per cent for Charge 1 and Charge 2 respectively.

The bins were left to stand and reweighed after 4, 8 and 12 weeks. Charge 1 continued to dry towards the expected equilibrium moisture content (e.m.c.) of about 12 per cent, while Charge 2 absorbed moisture which increased its moisture content to just below the expected e.m.c.

In summary, the study showed that high temperatures can be used for fast removal of moisture to dry wood to about 25 per cent moisture content before using the wood for charcoal production. Bark removal leads to faster drying rates, and length of the pieces is inversely proportional to drying rates, as might be anticipated. The data indicated that seven to eight hours drying at 150°C could be adequate to bring the moisture content to acceptable levels. The damage to the wood caused by the high moisture gradients must be acceptable to the charcoal producer. In addition, the producer would need to assess the comparative value of fast drying times, and energy and handling costs.

APPENDIX

Before (above) and after kilning (below) showing degrade due to kilning.



Comparative effects on degrade of bark-off (above) and bark-on (below).