Wood Utilisation Research Centre

DEVELOPING A SOLAR, LOW COST, TIMBER DRYING SYSTEM

T.J.G. McDonald

February 1991
W.U.R.C. Technical Report No. 23
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SUMMARY

A solar, low cost, timber drying system was designed for small sawmillers lacking capital to build conventional kilns. A prototype was built at the Wood Utilisation Research Centre (W.U.R.C.) of the Department of Conservation and Land Management located at Harvey in the south west of Western Australia.

This report discusses the design objectives and financial considerations which were taken into account, and a description of the design is given. The results of a trial in which 30 mm and 40 mm thick jarrah (*Eucalyptus marginata* Donn ex Sm.) boards were dried, and suggested drying schedules and annual drying capacities, are discussed.

INTRODUCTION

The decreasing resource of mature eucalypt forests in Australia means that there is an increasing need for sawmillers to dry more timber products to obtain the benefits of value-adding. In Western Australia, the Timber Strategy of the Department of Conservation and Land Management (1987) has the objective of 50 per cent of production in the state having a value-added component by 1997.

Conventional kilns have high capital and operating costs, and generally only major companies have been involved with drying timber. These drying systems are designed for large volume inputs. There was a perceived need for a drying system suitable for companies involved in sawmilling and drying which do not have the resources to invest in conventional drying equipment. Most small hardwood sawmillers in Australia have a high value resource which they have not exploited to achieve a better return, mainly because conventional equipment is difficult to scale down economically. These smaller operators have been specifically targetted as potential users of a low capital cost, low operating cost drying system which can be custom-designed for individual sawmills to dry a specified volume of timber each year.

A questionnaire was circulated to all small hardwood sawmillers in Western Australia, seeking information on the industry's value adding capacity. A workshop was then arranged at Harvey at the Wood Utilisation Research Centre (W.U.R.C.) of the Department of Conservation and Land Management of Western Australia (CALM), to establish more precisely the needs of this sector of industry. A committee was then selected to advise CALM staff on these needs, while the drying system was being developed.

Conventional drying

When hardwood timber is dried, the drying process can be divided into discrete stages:

(i) curing in a high humidity environment to minimise surface checking

(ii) drying to just below fibre saturation point (f.s.p.), which is the moisture level when free water has been lost from the cell cavities, and loss of bound water in the cell walls commences

(iii) drying to final moisture content (eg. 10 per cent).

Traditionally the timber has been air-dried before final drying in a conventional kiln at temperatures between 60 and 90°C. This has often resulted in substantial degrade due to the uncontrolled environment that the timber is subjected to while air-drying. Air drying is generally a slow process resulting in stockholding losses.

In later years it has become the practice to employ pre-driers for the second stage of drying. These have guaranteed a controlled environment to minimise degrade. Schedules of temperatures, humidities, and velocities (which can change as the timber dries) have and are being developed for optimum drying without degrade. Considerable research on drying schedules for regrowth eucalypts has been done using experimental kilns at the W.U.R.C. (Brennan *et al.* 1990).

DESIGN OBJECTIVES

The objectives of this applied research were to:

- design apparatus to achieve a more economical means of drying hardwood
- test this apparatus to enable further development
- determine the most beneficial means of using this system
- utilise solar energy and energy conservation principles.

Financial considerations

The factors to be considered in minimising drying costs include:

- running costs - fuel
- running costs - labour
- interest on capital
- depreciation - maintenance costs
- depreciation - replacement costs after a given service life
- interest on timber stockholding.

The biggest deterrent to small sawmillers undertaking drying is the capital cost. They do not want the liability of a large interest bill on monies invested in drying apparatus. Drying times were considered to be of lesser importance to the small sawmiller than low capital cost, low running cost, and safe schedules.

Design criteria

Considerations for the conceptual design of a drying system were to:

- produce an efficient dryer for small volumes of timber
- use a low cost structure
- utilise solar energy and other renewable resources
- have control systems which minimise labour costs and are (only) sophisticated enough for the particular drying requirement
- be simple to erect and able to be marketed in kit form
- be versatile in respect to the type of drying required, the degree of drying required, and the volume of timber requiring drying.

DESIGN IMPLEMENTATION

Apparatus - the Mark I prototype dryer

The Mark I prototype dryer, constructed in 1988, was designed to dry 20 to 30 cubic metres of hardwood in each charge. The relevant construction details are shown in Figures 1 and 2, and incorporate the design features discussed in this section.

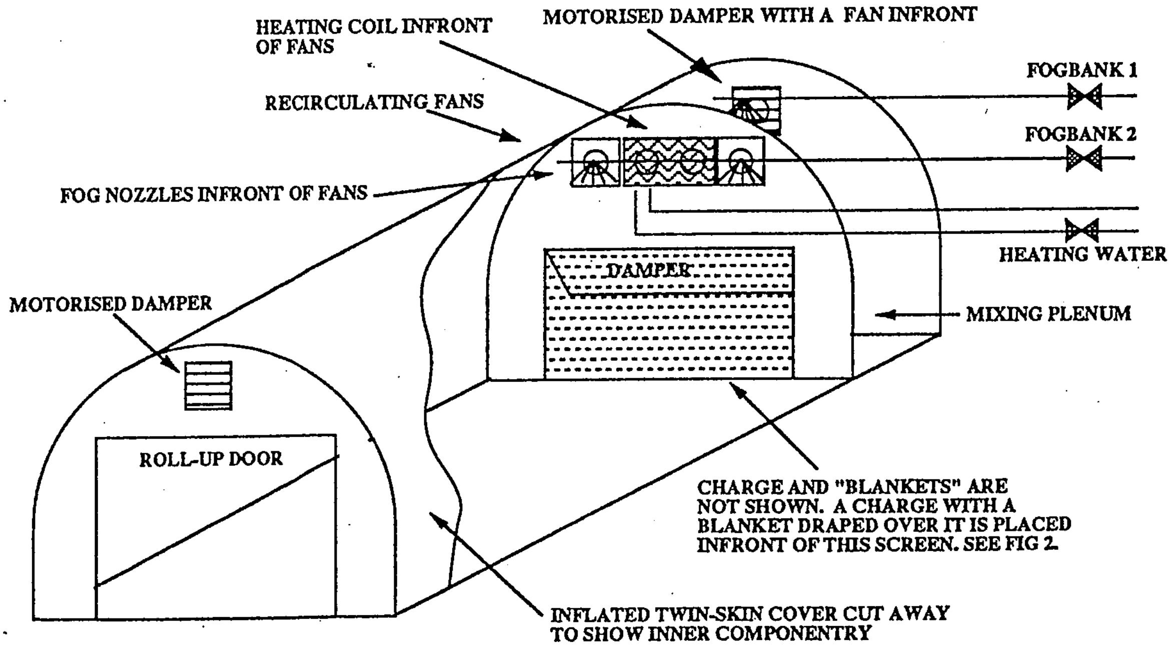
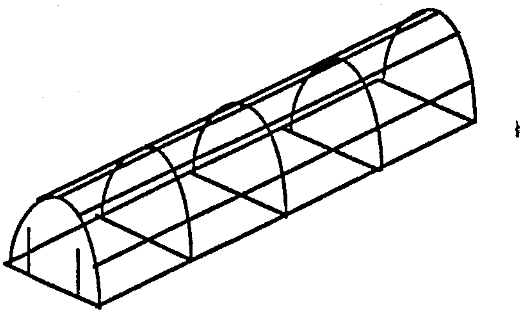
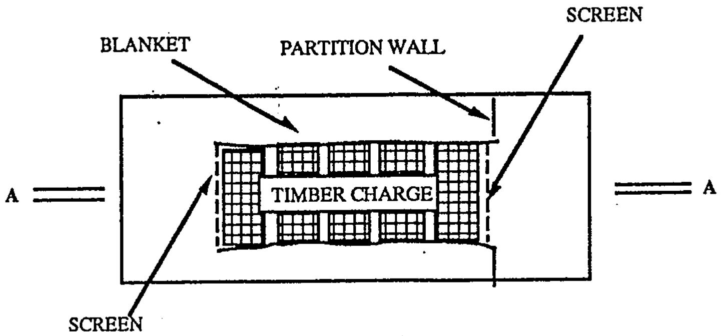


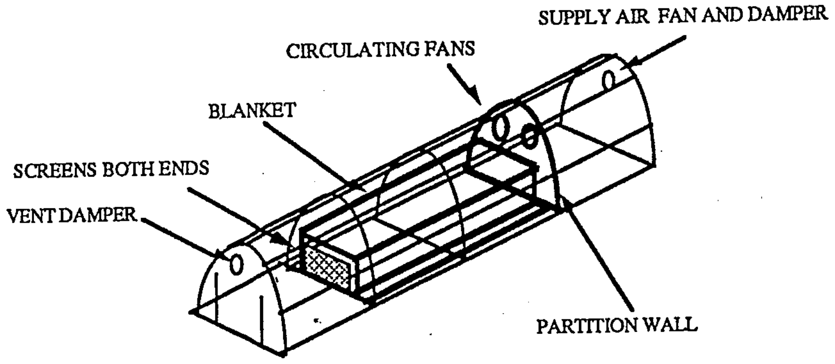
Figure 1. Isometric view of basic CALM dryer



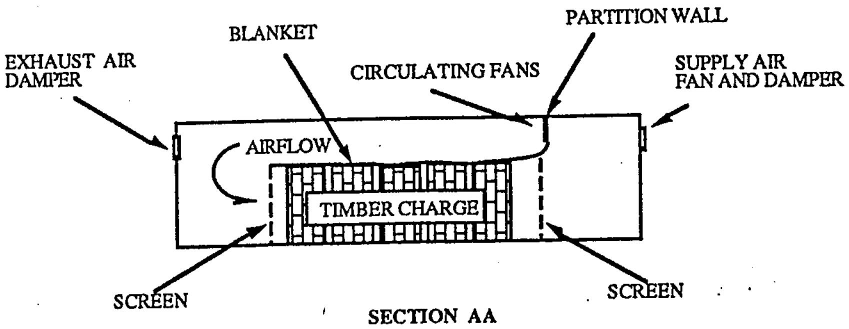
THE BASIC STRUCTURE IS ENVELOPED BY AIRTIGHT EXTERNAL SKIN



SECTIONAL PLAN



INTERNAL PARTITIONING AND BLANKET



SECTION AA

Figure 2. Details of a CALM dryer configuration

Greenhouse Concept

Common to all variations of the dryer developed is a flexible outer enclosure which is transparent to solar radiation and resistant to degradation by ultra-violet radiation. Flexible fabrics are also used on inner walls. This is an economical means of providing structures which can collect considerable amounts of solar energy. The apparatus provides a means of transporting this energy and auxiliary heat (if required) to the material to be dried, and a means of directing and controlling the airflow within the structure without the need for expensive ducting systems or air baffling.

Blanket Concept

A prime innovation of the CALM Drying System relates to its control of air circulation. A blanket forming a tunnel over the timber is pressed against the charge by the pressure differential between the air inside and outside the blanket. This effectively baffles the charge, ensuring uniform air velocities across the charge. This principle has been patented by CALM. Drying air is circulated within the air-tight outer structure, and the need for conventional ducting is eliminated (Fig. 3).

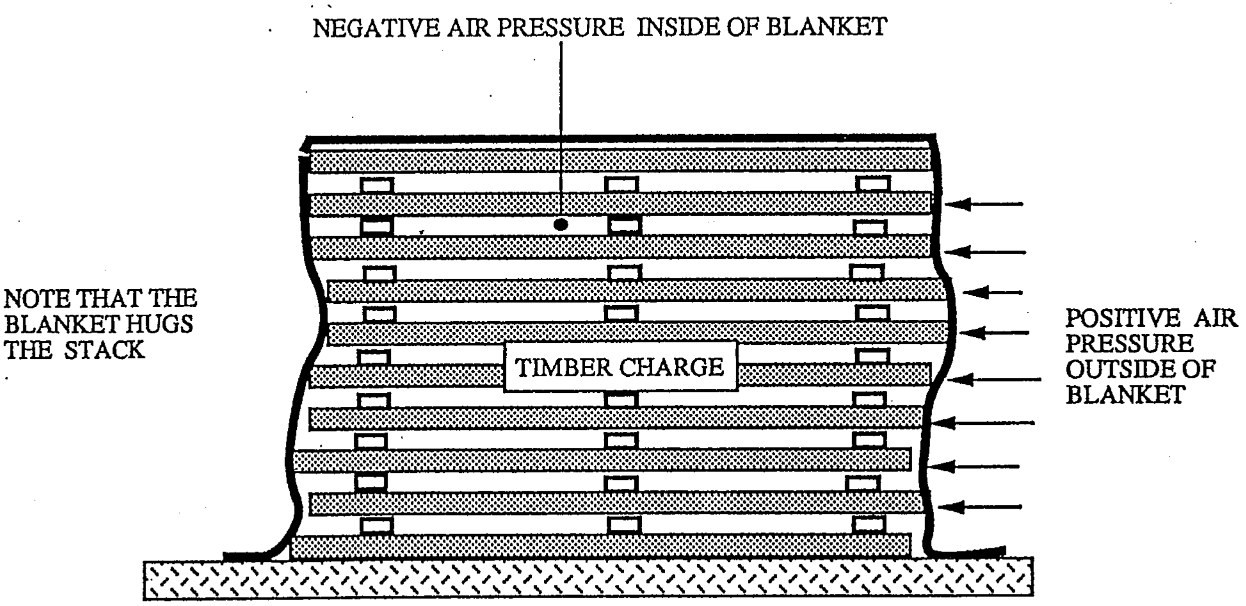


Figure 3. Section through the charge and blanket

Framework

Tubular steel framework is used. It is inexpensive and can be bought off the shelf or custom-made to suit stack heights required and/or the materials handling methods to be utilised. Because small sawmillers will have access to a small loader or forklift, sophisticated materials handling equipment is not employed.

Slab
A concrete slab was poured with the footings for the steel structure. The pad contributes to a cleaner environment in the dryer and makes loading easier. It should be graded and drained.

Outer covers
High quality horticultural PVC membrane has been used as an outer cover on the dryer. The particular fabric used is especially resistant to ultraviolet radiation, and has a long life (approximately 5 years) compared to most horticultural plastics (1 to 2 years). This plastic can be successfully glued using off-the-shelf PVC adhesives. When these units are sold in kit form replacement outer covers can also be offered.

When drying to f.s.p., `twin-skin' is utilised. Two layers of plastic have the space between them inflated by pressurised air to create a 100 mm air-gap. This serves to insulate the inner chamber as well as making the structure more rigid. This insulation, with an overall heat transfer coefficient of about 3, is inexpensive. As the timber may be 10 - 20°C above night time ambient conditions, the insulation is beneficial in reducing radiation and conduction losses, thus conserving energy. It is still advantageous to dampen temperature fluctuations, especially in colder climates.

Humidity control
Setting of upper and lower set points for relative humidity (RH) is critical in developing schedules for particular drying applications.

A fogging system was employed to maintain high humidities. High pressure (700 kPa) water is forced through laser cut nozzles to produce a dry fogged environment, and the fog produced is superior to any misting system on the market. The humidification produced is equivalent to the more conventional steam humidification systems, but is produced from water at ambient temperature, creating substantial energy savings. This system was first installed at the W.U.R.C. in 1986, and apparently this was the first time it had been applied in timber drying in Australia.

Conversely, heat or dehumidification may be required to reduce the humidity to the upper setpoint of the schedule of air conditions needed for a particular drying application i.e. when venting alone will not achieve this reduction in humidity because the ambient humidity is too high. It is not used to produce high temperatures.

Auxiliary heating
Although solar energy contributes to the heating requirements, another heat source will be desirable at times to reduce the fluctuations in solar radiation. The need for supplying auxiliary heat to the dryers will depend on the timber species being dried. The method will depend on the quantities of heat required, whether residue is available in the quantities required, what other fuels are currently used on site, and available capital. Auxiliary heat generated by natural gas, LPG or solid fuel can be

transferred to the dryers directly or by heated water or oil.

A 16 kW gas heating system was installed in the prototype dryer at Harvey to permit automatically controlled heating at a fairly low capital cost. The heater incorporated an air to air heat exchanger so that the dryer's air could be recirculated through the heater when heat was required. An automatically-fed solid fuel heating unit would have reduce the fuel component of the operating costs, but they are costly to install and have high maintenance costs.

Control and monitoring

The degree of sophistication of controls should depend on the species and thickness of the material to be dried, its vulnerability to degrade, and the quality of product needed.

The prototype installed for research and development at the W.U.R.C. used a fairly sophisticated system to enable temperature as well as humidity to be controlled within precise setpoints. Safety procedures are incorporated in case of system failure or part failure. Such control was achieved by using a Programmable Logic Controller (PLC). Relatively complex logic is used to switch various dampers, heaters, solenoids and fans. This controller served a multiple purpose by functioning also as a data logger.

For some specific drying applications a more basic system can be considered such as a 'straight through' system employing 100 per cent outside air where only fog or mist is controlled (from a simple humidistat). The alternative simple control system may comprise only a humidistat controlling the ventilation (by opening and shutting motorised dampers) and the fog. Monitoring of conditions would be by thermohydrograph chart recorders.

METHOD OF TESTING

Tests were carried out to establish the dryer's performance both with and without auxiliary heat, and to determine the optimum schedules for its use.

On March 14 1989 the dryer was loaded with jarrah (*Eucalyptus marginata* Donn ex Sm.) regrowth, cut 30 mm and 40 mm thick. Moisture contents were initially measured using an 'oven-dry' test (Standards Association of Australia 1972). The average moisture content at different stages of drying was then estimated by reweighing the sample boards. Moisture contents of samples from each stack in the charge were also recorded.

The air velocity profiles were measured to assess the efficiency of the patented blanket. A 'hot-wire' anemometer was used at 20 locations across the face of the stack (a 4 x 5 grid). This was done both upstream and downstream of the charge, at various velocities, and both with and without the fabric damper.

By using the Programmable Logic Controller (PLC) controlling the dryer as a data logger, the condition (temperature and humidity) of the air entering the charge was logged regularly at 2 hour intervals or less. A 'Vaisala' sensor was used to monitor the temperature and humidity. This sensor is rated fairly accurate in the high humidity range (plus or minus 2 per cent).

Periodically the conditions down the length of the charge were monitored to assess the changing conditions due to moisture absorption by the air.

Drying schedule

The following setpoints were set to achieve a desired schedule of conditions considered safe for the timber charge discussed. It was a schedule that was used mainly for testing the drying apparatus for further development, rather than a schedule to achieve maximum throughput.

Day	Lower set point (RH %)	Upper set point (RH %)
0	85	93
7	88	90
11	85	93
14	73	77
18	77	85
(the following setpoints were set to achieve RH's as low as possible)		
109	20	-
112	20	-
119	20	-

Generally temperature was allowed to vary between broadly spaced set points. It was considered that the temperature should not go above 40°C. Minimum temperatures were only applicable when the heating unit was operational.

RH was the prime factor controlling drying although the air velocity through the charge was used to some extent. Until day 59 only one fan was used and the air velocity ranged from 0.7 m/s initially to 1.0 m/s. (The fan could be wired on low speed or high speed.) Until day 112 two fans were then used, resulting in a velocity approaching 2.0 m/s. After day 112 three fans were turned on and the air velocity approached 3.0 m/s.

It should be noted that the upper RH setpoints were exceeded for much of the trial period. When ambient conditions began to approach or exceed the desired RH, then maintaining the RH below the upper setpoint was not possible without auxiliary heat or adequate solar contribution.

RESULTS AND DISCUSSION

Velocity profiles

The velocity profiles indicated that there was good uniformity of airflow. The stacks were covered with the blanket which ensured that airflow was directly through the stack. Without fabric dampers at the rear of the charge, the air velocity profiles measured upstream through the stack showed a variation from 0.5 m/s near the top corners, to a maximum of 0.9 m/s in the centre. The mean air velocity was 0.74 m/s (S.D. 0.15 m/s). The corresponding velocities downstream ranged from one reading of 0.5 m/s at the top right to 0.9 m/s, but the mean velocity increased to 0.82 m/s (S.D. 0.09 m/s). The differences between gridpoints were most likely attributed to poor placement of gluts or baffling between the gluts. These velocities were higher than those used in normal drying, but were used to test the systems.

Large fabric dampers at the rear of the charge are most useful as a means of air restriction for finer control of velocity and do not have much effect on the uniformity of air distribution. Using these dampers, upstream velocities ranged from 0.9 to 1.6 m/s, with mean 1.36 m/s (S.D. 0 .21 m/s) and the downstream velocities from 0.6 m/s to 1.0 m/s, with a mean 0.89 m/s (S.D. 0.10 m/s).

These velocity profiles at each end of the charge indicated that there was more turbulence at the upstream end which was corrected using the shadecloth screens and a plenum area in front of the timber. The resistance of the screens also serves to enhance the pressure differential which permits the blanket principle to work.

A subsequent test showed mean upstream velocities of 0.48 m/s (S.D. 0.06 m/s), and mean downstream velocities of 0.42 m/s (S.D. 0.04 m/s), indicating a reduction in turbulence upstream, and overall more uniform air velocities.

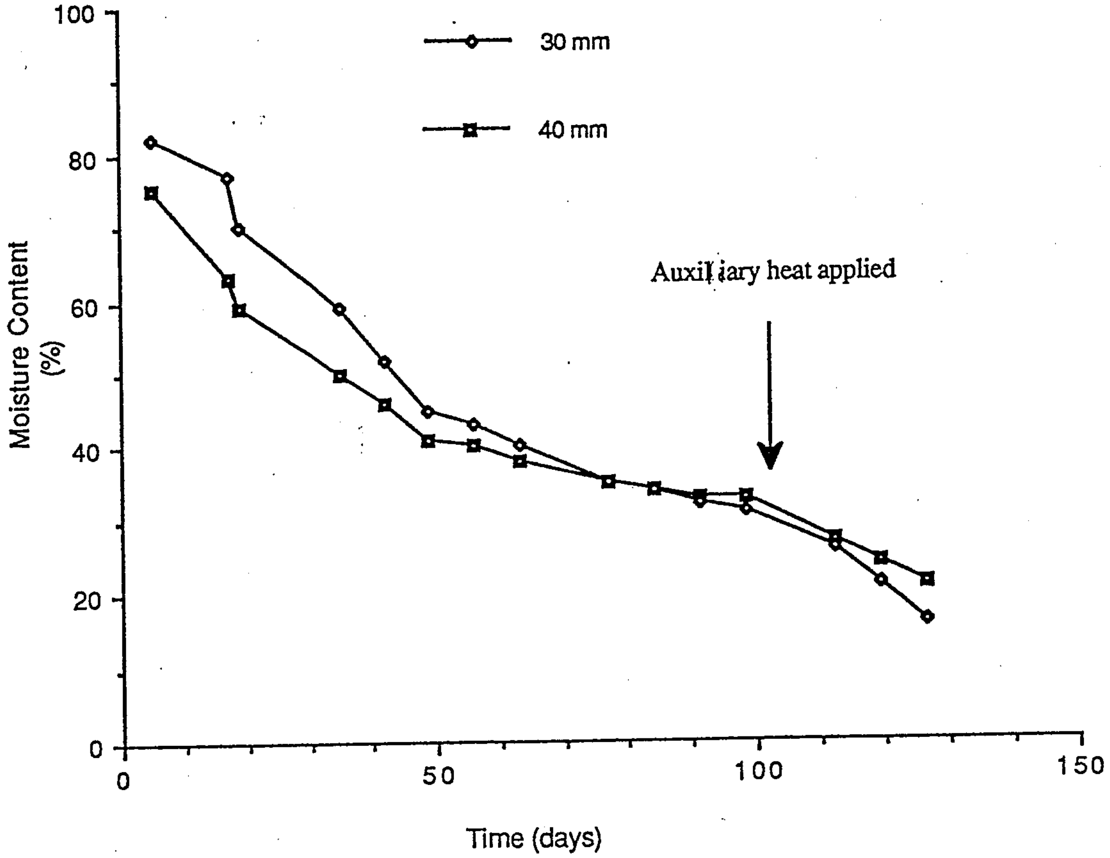
Fogging system

The controls on the drying system were such that upper and lower set points for both temperature and humidity to be set. The fog ensured that the RH never fell below the lower setpoint, but a backup misting system was installed in case of fog system failure.

Drying results

The drying curves for 30 mm and 40 mm thick regrowth jarrah boards (Fig. 4) showed that the drying patterns were similar, although as expected the 30 mm material dried faster. The drying rates decreased from about 0.75 per cent moisture loss per day to about 0.25 per cent moisture loss per day when the average moisture content reached about 45 per cent. When auxiliary heat was added the drying rate increased substantially. This data suggest that there are advantages in adding auxiliary heat and changing the drying schedules at about 45 per cent moisture content to maintain the drying rate.

Figure 4. Drying curve for 30 mm and 40 mm thick regrowth jarrah boards



Auxiliary heating

The heating unit was not installed at the commencement of these trials, but the need of heating became apparent as winter approached. The humidity was controlled above the lower RH set point using the fog system, however, when the ambient RH was high and venting could not be used to decrease the RH, heating was required to keep the RH below the upper limit. Without auxiliary heat or adequate solar heating the RH could not be contained below the desired value (the upper set point).

Auxiliary heat is essential if schedule conditions are to be achieved to attain the maximum drying rate possible. Drying rates would have increased substantially if auxiliary heat had been available to control the RH below the upper set point for RH. However, the drying rates achieved were considered acceptable for much of the initial drying cycle without auxiliary heating.

The effect of having auxiliary heat was shown when the heater was initially run for 2 days, from day 92 to day 94 (Fig. 5). The conditions were kept within the prescribed set points of RH for these 2 days. This was during mid-winter with high RH ambient conditions. Dryer conditions before and after this period showed that the RH could not be controlled without this additional heat.

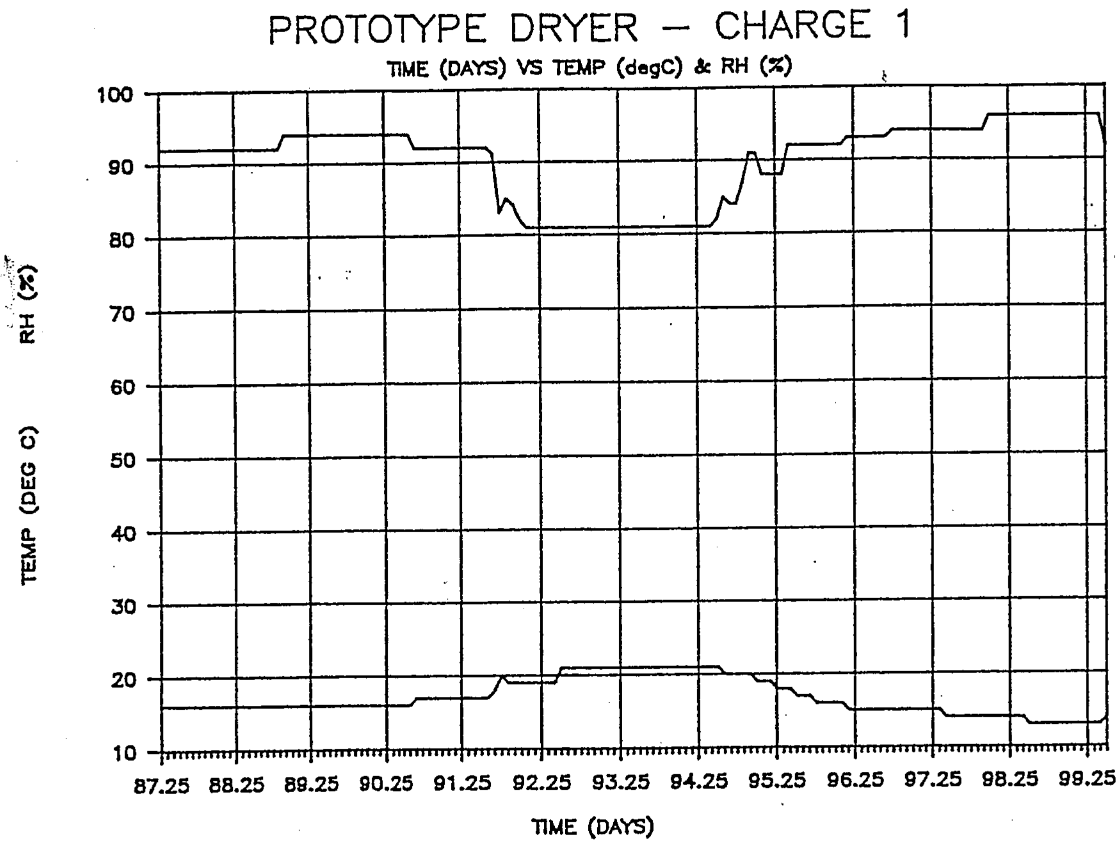


Figure 5. Effect of auxiliary heat on temperature and relative humidity

The heater unit selected for this system was deliberately undersized, even considering that this dryer was designed basically to be used as a pre-dryer. This would limit the cost of fuel consumed and the capital cost, but reduce the drying rates during the coldest months of the year.

It would be desirable to fit a solid fuel heating system to the drying unit to enable optimum schedules to be followed without dependence on ambient conditions. It would enable low RH conditions to be produced which relate to EMC of 6 per cent. (A 40 kW unit would suffice for drying slow drying species). This would mean that timber could be dried to 8 per cent moisture content .

Heat load calculations
Calculations of heat loads for specific ambient and dryer conditions, both for predrying and final drying are shown on the following table (Table 1). Heat loading is calculated for winter and summer conditions based on the average conditions at 6 am (night) and 3 pm (day) for Perth, W.A. January figures are used for summer conditions, July figures are used for winter conditions (Roy and Miller 1982). These heat loads suggest that higher temperatures are undesirable when using this apparatus. Final drying is feasible but it is recommended that dryer temperature should be kept as low as possible to reduce heat losses, although high enough to achieve an appropriate RH (and EMC).

The table shows that the heat losses through the structure are typically less than 25 per cent of the total heat required when pre-drying schedules are used. For final drying these losses may constitute up to 90 per cent of the total heat required (during winter ambient conditions). However, these seemingly high heat losses do not rule out that these dryers be used for final drying. Firstly, because the total heatload during final drying would typically be much less than that required for pre-drying (when large amounts of moisture are evaporated). Secondly, the cost of energy to run the dryer as a final dryer maybe low compared to the capital cost of installing a high temperature kiln or an insulated chamber more suited to final drying. This would often be the case with the small sawmiller, particularly if he uses wood waste to fire a solid fuel system.

Table 1

Examples of heat load analysis used in designing dryers

Pre-drying in winter

Assume desired dryer conditions of 25°C and 50% RH

Ambient temp. (°C)	Ambient RH %	Heat loss through the structure (kW)	Total heat load (kW)
11.5 (night)	81	9.72	39.4
17.7 (day)	57	5.26	26.48

Final drying in winter

Assume desired dryer conditions of 35°C and 30% RH

Ambient temp. (°C)	Ambient RH %	Heat loss through the structure (kW)	Total heat load (kW)
11.5 (night)	81	16.9	19.38
17.7 (day)	57	12.46	14.46

Pre-drying in summer

Assume desired dryer conditions of 25°C and 50% RH

Ambient temp. (°C)	Ambient RH %	Heat loss through the structure (kW)	Total heat load (kW)
19.3 (night)	63	4.1	21.7
28.4 (day)	40	2.45 gain	0.27

Final drying in summer

Assume desired dryer conditions of 35°C and 30% RH

Ambient temp. (°C)	Ambient RH %	Heat loss through the structure (kW)	Total heat load (kW)
19.3 (night)	63	10.94	12.96
28.4 (day)	40	4.75	6.28

These heat loads assume a properly inflated 'twin-skin' cover. If only a single skin cover is used, then the heat loss through the structure can be considered doubled.

Control accuracy

The proportion of tiem that RH was within the prescribed set points was affected by the solar energy contribution available and the ambient conditions.

The failure of this dryer to restrict the RH conditions to less than the upper set point of humidity without auxiliary heat has been discussed. However, for much of the early part of the drying this control was achieved. When ambient conditions have a low RH then the dryer conditions were generally controlled between the RH set points (Fig. 6).

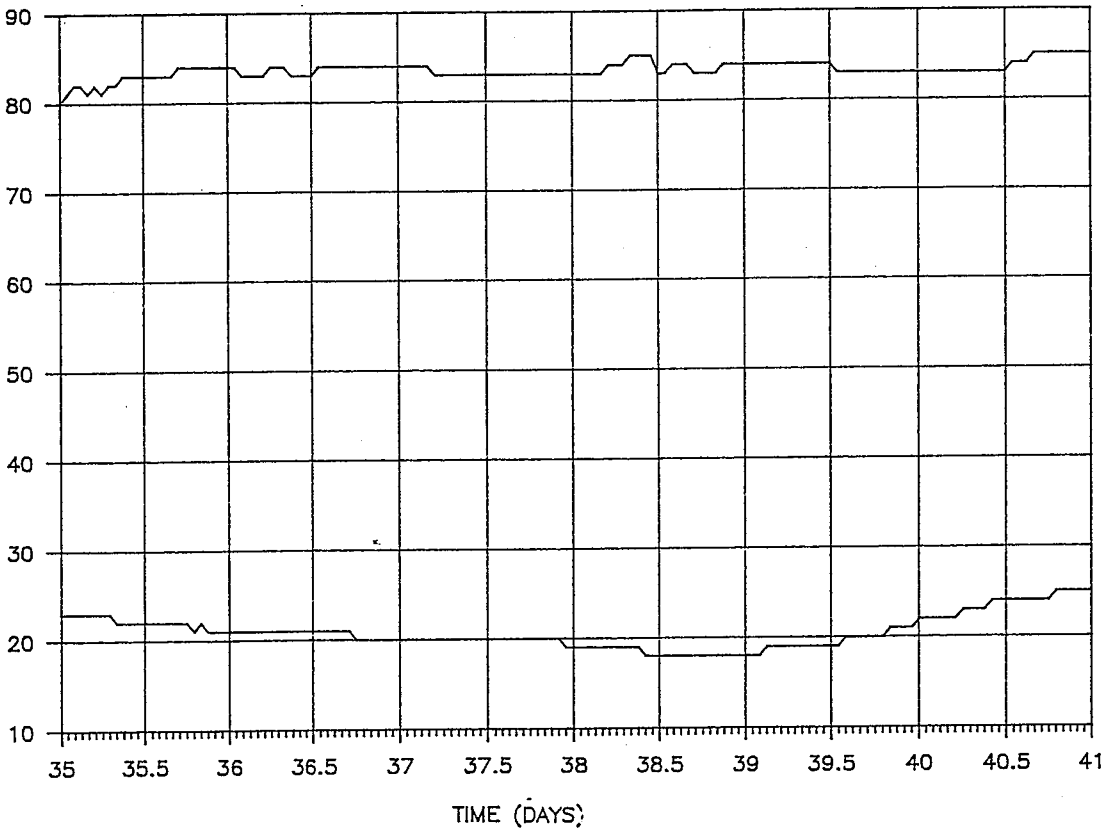


Figure 6. Dryer conditions from day 35 to day 41 in the trial.

This shows typical conditions while the dryer was able to maintain control of the RH within the set points (up until about day 50). This is consistent with the drying curves on Fig. 4. Because day 50 corresponds to early May it is likely that the ambient conditions alone were the prime influence on the dryer's ability to maintain control of RH without auxiliary heating.

The conditions obtained using the 16 kW gas heating system are shown for days 120 to 130 (Fig. 7). RH was maintained generally between 60 per cent and 70 per cent and the temperature was elevated about 10 to 15°C above ambient, an EMC of about 12 per cent. Typical ambient conditions of 10°C and 90 per cent RH resulted in dryer conditions of 25°C and 65 per cent RH.

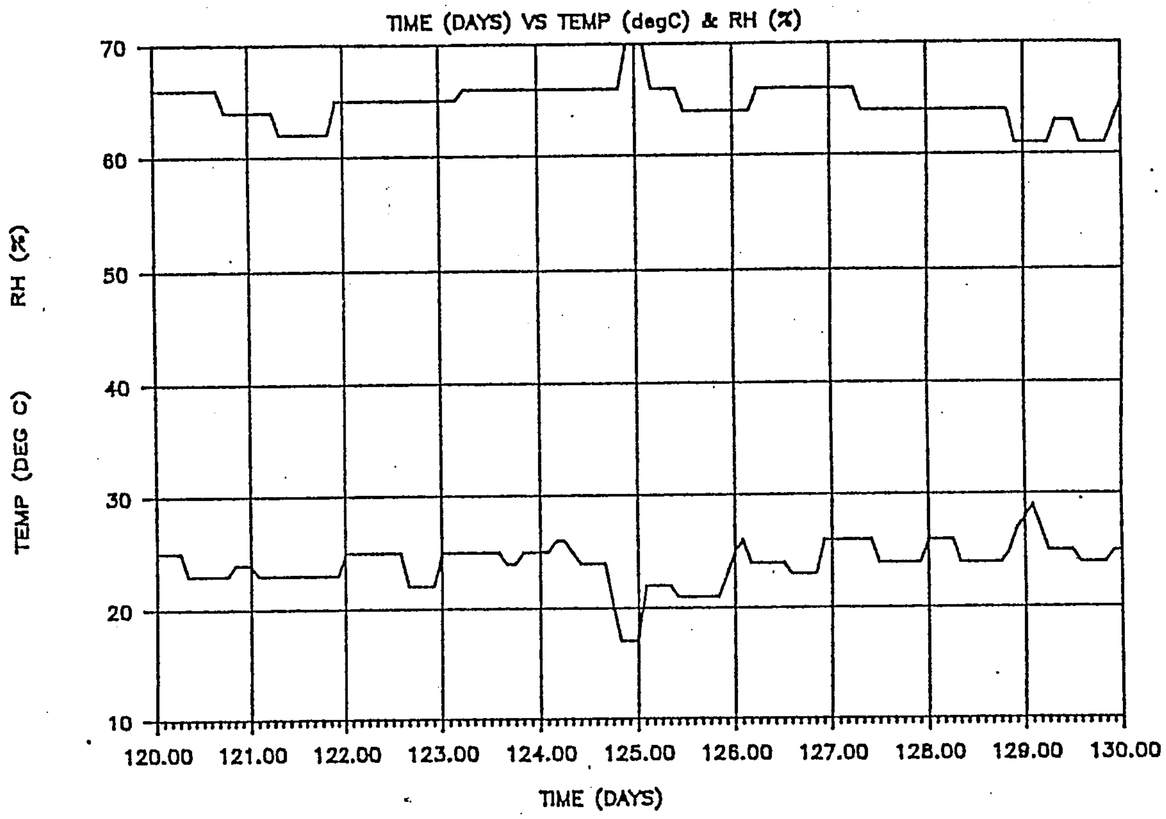


Figure 7. Examples of using auxiliary heat to increase temperature and reduce relative humidity.

Schedules specifically for this apparatus

This apparatus is best suited to low temperature drying. It has been established that low temperatures, very high humidities and very low air speeds are desirable when the timber comes off the saw. This is referred to as the curing period and it should be at least a week.

It has been demonstrated by CALM that drying to about 45 per cent moisture content can be achieved simply by substituting ambient air for vented air, even during the humid winter months. (This of course will vary with climate.) During the drier months this process will dry the timber down to f.s.p. within a reasonable time without auxiliary heating. This is particularly pertinent for energy conservation.

Below about 45 per cent moisture content it is apparent that heating is desirable if schedule humidities are to be achieved when the ambient humidity is high. Heat or dehumidification is required, not to produce high temperatures but to control the humidity to the upper set point of the schedule. That is, when auxiliary heat energy is required to attain the precise humidity requirements, not necessarily to maintain a specific temperature.

Hardware

This dryer utilised hardware which resulted in a low capital cost dryer, relying only partially on solar contribution for heating.

The existing configuration of hardware resulted in acceptable drying rates. It enabled a safe schedule of conditions to be achieved, with an efficient humidification system (fog) to ensure that the humidity never drops below the lower RH set points of a schedule.

Although it would be advantageous to replace the undersized LPG heating unit with a solid fuel system with considerably more heat output (refer to heat load calculations), the existing system would satisfy users who did not require rapid rapid drying during the winter months.

The system used supply air and exhaust air fans with integral solenoid dampers. These caused some mechanical problems and limited the rate of venting. It would be better to use motorised opposed blade air conditioning dampers. As the ambient conditions approached the dryer's upper set point, it would be preferable to have a greater airflow rate through these dampers.

The control system comprised a PLC which was deliberately oversized. This gave the potential to monitor various parameters and store data using unused registers within the PLC. These were downloaded to a printer every 2 weeks. A second reason was to choose a unit which could be used in future developments at the sawmill after the prototype had been tested.

Length of charge

A characteristic of this dryer is the long length of the airway through the charge. The charge comprised a row of 5 stacks each 1 m wide and the drying air had to pass through about 5 m of timber. As the air passed through the charge it was expected to pick up moisture. Having monitored the conditions down the charge it appeared that there was no great variation in RH down the charge when the RH was over 90 per cent in the initial stage of drying. This was also the case in the final stages of drying when the moisture loss per day dropped off and RH was desirably low, so that even though the air picks up some moisture, the final RH was still fairly low. It appeared that the greatest gradient of moisture conditions through the charge occurred during the middle stages of drying. The drying rate on the downstream end of the charge became the limiting drying rate, however, this reduction in the overall drying rate of the charge is tolerable considering the increased dryer capacity. This greatly affected the overall economies of drying.

The data used in Figure 4 were based on two readings for the 40 mm material and four readings for the 30 mm material. The standard deviations for the latter readings decreased from 11 per cent to 2 per cent, indicating that the moisture contents were becoming more uniform.

Economic considerations

Green jarrah scantling timbers may be sold for approximately $350/m^3. This same resource when dried may be worth in excess of $850/m^3. If only 80 m^3 of marketable final dried timber (allowing shrinkage, degrade and dressing waste) is produced in one year, the gross increase in the value of the resource is greater than the capital cost of the apparatus used to dry it. (The cost of the installed and commissioned Drying System complete with control and monitoring equipment, and a gas furnace was less than $30 000 in 1987). Costs would be reduced if the driers are sold as kits for erection and sub-contracting by the sawmiller. Additionally the drier capacities could be doubled to lessen the capital cost per cubic metre capacity.

Running costs are minimised due to the solar contribution. The heater system used was only about 16 kW capacity; it was deliberately undersized. If extra LPG was consumed drying rates would obviously increase, but it is believed that the drying rates obtained in this trial are sufficiently fast to satisfy many small sawmillers. When heating was required during the months of winter, the cost of the LPG consumed was about $200 per week in 1987 (based on a consumption of 24 kW of LPG consumed continually).

Solar contribution

Accurate determination of the solar contribution to this system is a complex calculation, and is dependent upon a large number of variables.

An approximate figure was determined using the calculated figures for radiation received in Perth, Western Australia. It was calculated as a flat plate collector, based on the floor area of the dryer; the actual collector area will be larger and dependent upon the drier orientation. Radiation losses are not considered in these calculations.

It is presumed that the dryer temperature is not appreciably different from ambient temperature and the dryer will not experience high radiation losses. The twin skin covers reduce radiation losses.

The following calculations used data for Perth, Western Australia (Roy and Miller

(1982). The total annual radiation received on a surface 0° slope is 6902 MJ/m^2. This equates to about 436 W/m^2 for a nominal 12 hour period of sunlight, over the whole year. The total monthly radiation for the month of June is 296 MJ/m^2 and for December is 887 MJ/m^2.

Assuming that 50 per cent of the radiation available is collected and can be utilised; this equates to an annual power saving of:

218 W/m^2 x 70 m^2 floor area x 50 % x 365 days x 24 hours = 66 838 kWh.

This would relate to an annual saving of about $5 000 in fuel costs if an 80 per cent efficient lag heating unit is used. The LPG is costed at 6 cents per kWhr.

Drying rates

Using conservative winter drying schedules the following drying rates were obtained for drying 40 mm boards to below f.s.p. during the winter months at Harvey. Final drying, however, was not taken to 8 per cent moisture content in these trials. Using an undersized heating unit, it would be unlikely to accomplish this rate during the winter months when the timber approached its dry state.

Moisture content %	Auxiliary Heat	Drying rate (%/day)	No. days
80 - 40	No	0.7	57
40 - 20	No	0.3	67
40 - 20	Yes	0.7	29
20 - 8	Yes	0.2	60

According to the drying rates in the above table, drying to FSP will take about 124 days without auxiliary heat, 86 days using auxiliary heat. If adequate auxiliary heat is available the material can be dried to final moisture content in another 60 days. Drying to below f.s.p. in this dryer is sufficient where high temperature kiln facilities are available. When they are not, it may be desirable to final dry the timber in this dryer. With sufficient auxiliary heat, this could be achieved from its green state in 146 days.

However, given sufficient auxiliary heat it would be feasible to produce drier conditions which would enable optimum drying rates to be achieved. A drying rate of 1 per cent per day down to f.s.p. could be achieved without causing degrade to the charge, and a drying rate of 0.5 per cent per day could be expected when final drying.

Even without auxiliary heat, in summer it is expected that these rates would increase considerably owing to the greater proportion of each day that the desired drier conditions can be achieved due to the solar contribution.

Yearly capacity

The green volume capacity of the prototype dryer is calculated based on a green volume of 1.7 m^3 per bundle and 24 bundles per charge, for a total volume of 40.8 m^3.

Thus in one year, drying to FSP without any auxiliary heating, the apparatus could dry about 120 m^3. With auxiliary heating it would be expected to dry about 170 m^3 .

Using the dryer (with auxiliary heating) to final dry to 8 per cent moisture content, the apparatus would be expected to process at least 100 m^3 from green off the saw.

CONCLUSION

A comparatively low cost prototype solar dryer, capable of efficiently drying hardwoods from green, was successfully constructed at the Wood Utilisation Research Centre at Harvey and research trials were undertaken. Aspects of this design, and the results and principles derived from the experimental data, formed the basis of the subsequent development of CALM Drying Systems. Details of these Drying Systems will be given in a later report.

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