Optimisation of steam reconditioning for regrowth-ash and plantation-grown eucalypt species

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by

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Abstract

Steam reconditioning to recover collapse, in mid to low density eucalypt species, has been known for over ninety years. The current industrial practices for steam reconditioning have largely been based on a few older studies, which were often poorly documented and based on very small sample sizes. On top of this, many local practices and ‘rules of thumb’ have developed over time, many of which have a questionable scientific basis. This thesis was undertaken to more rigorously investigate and fundamentally understand collapse recovery, and try to optimise its application.

The most obvious variable that kiln operators have control over is the moisture content of the timber prior to steam reconditioning. Experiments were undertaken to generate a range of moisture gradients (ranging from minimal to more industrially realistic) to evaluate the effect of moisture content on collapse recovery. An optimal moisture content for the core of the boards was found to be between about 18–20%, although there was no statistical difference in recoveries between about 17–25% moisture content. Below 15% moisture content recovery dropped off severely and intra-ring internal checking closure was incomplete, while at 25% moisture content an increased level of normal shrinkage, due to the early removal of drying stresses, was the main drawback. Above a core moisture content of about 35% incomplete closure of intra-ring internal checks was again observed. There was little evidence of re-collapse occurring in these high moisture content samples.

Previously established relationships between density and collapse and drying rate were again generally observed in these experiments. However, for the first time an effect of collapse in reducing the fitted drying diffusion coefficients was also observed.
It was also observed that, provided the moisture content of the board was in the critical range, most of the collapse recovery was achieved in the time it took to get the core of the board up to the steaming temperature of close to 100°C. This suggests that for most thicknesses a conservative reconditioning period of two hours at temperature is all that is required. This recommended shortening of the reconditioning cycle could dramatically increase the throughput of timber through the steam reconditioning chambers. Alternatively, it could mean that where modern final drying kilns are being used, the reconditioning treatment could be carried out within the final drying kiln.

A finite element model was developed to demonstrate the mechanism by which collapse recovery occurs. The theory tested was that the elastic component that stores the energy to restore the shape of the deformed cell is primarily found in the S\textsubscript{1} and S\textsubscript{3} layers. In contrast, the inelastic component is primarily found in the S\textsubscript{2} layer. The model generated here provided limited support for this theory.
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\(^1\) The joint forces of CSIRO and Scion (www.ensisjv.com)
List of Publications

The following papers were either published or are in submission as a result of the work presented at the time of submission of this thesis:


**List of Abbreviations**

- **CML** — Compound Middle Lamella
- **CSIRO** — Commonwealth Scientific and Industrial Research Organisation
- **DBT** — Dry Bulb Temperature
- **MC** — Moisture Content
- **ML** — Middle Lamellae
- **P** — Primary cell wall
- **RH** — Relative Humidity
- **S$_{1, 2~or~3}$** — Secondary cell wall (1, 2 or 3 indicates layer in secondary cell wall)
- **S$_{r, t, l~or~v}$** — Shrinkage (r – radial, t – tangential, l – longitudinal and v – volumetric)
- **US** — Unit Shrinkage
- **WBD** — Wet Bulb Depression
- **WBT** — Wet Bulb Temperature
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