

## Improvement of the technological quality of eucalypt wood by thermal treatment in air at 170°C-200°C

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### ABSTRACT

Heat treatments for technological improvement of wood were made in the presence of air using *Eucalyptus globulus*. The heat treatment was made using an oven during 2 to 24 h and temperatures of 170 °C, to 200 °C. Mass losses increased with treatment time and temperature. Anti Shrinking Efficiency (ASE) between treated and untreated samples was calculated at 35%, 65% and 85% relative humidity for radial and tangential directions. Bending strength and MOE were also determined. Equilibrium moisture content of heat-treated wood decreased by 67%. 87% Radial ASE<sub>35%</sub> for Tangential ASE<sub>35%</sub> was usually higher than radial. ASE<sub>65%</sub> and ASE<sub>85%</sub> showed behaviour similar to ASE<sub>35%</sub> but smaller. All ASE values increased with temperature and treatment time. Bending strength and MOE decreased with mass loss.

### INTRODUCTION

The use of thermal treatments to modify properties of wood is not new. The first studies to improve wood dimensional stability have been carried out by Stamm *et al.* (1946). More recently, environmental concerns stimulated the search of methods to preserve wood without the use of chemicals and heat treatment processes have evolved all over Europe, namely Thermowood in Finland, Plato Wood in Holland, Rectification and Bois-Perdure in France and OHT in Germany.

*Pinus pinaster* and *Eucalyptus globulus* are two of the forest species with most planted area in Portugal. Pine wood is used for all kinds of furniture, although for outdoor use it must be treated since it is considered a low durable species by NP EN 350-2. Until last year it was mainly treated with CCA and currently with CCB. *Eucalyptus globulus* is used almost exclusively for pulp production. Old eucalypts with very high extractives content are not adequate for pulp and are used as firewood or for some less demanding pieces of furniture. Eucalypt wood is considered to be non durable by NP EN 350-2, with high dimensional instability and very difficult to treat, even with the use of pressure, since it is almost impossible to impregnate. The impregnation is only possible for small diameters without heartwood and there is a considerable leaching of preservative solution because of the large diameter of vessels. Even treated eucalypt wood is susceptible to soft-rot fungus attack (Reimão and Nunes 1989). Heat treatment can improve dimensional stability and rot resistance so that wood can be used outdoors without chemicals and compete with tropical wood of higher cost.

## EXPERIMENTAL

Eucalypt (*Eucalyptus globulus* L.) wood came from the Portuguese region of Águeda. Samples for heat treatment were cubic with around 40 mm edge size with clear radial, tangential and transversal faces. Samples were kept in a conditioned room with 50 % humidity and 20 °C for three weeks. Equilibrium moisture and mass of all the samples were determined. Oven heat treatment was made in the presence of air during 2, 4, 6, 8, 12 and 24 hours at 170 °C, 180 °C, 190 °C and 200°C. After treatment the samples were cooled in a dry environment and weighted. Mass loss was determined in relation to dry wood. The treated and untreated samples were kept in an oven at 20°C and 35 % relative humidity. After stabilization, the samples were weighted and measured in radial, tangential and transversal directions. The same procedure was done using 65 % and 85 % relative humidity. Dimensional stability was determined by the ASE (Anti Shrinking Efficiency) method used by Stamm (1946), which gives the shrinking difference between treated and untreated samples. ASE 35%, ASE 65% and ASE 85% correspond to shrinking differences between the corresponding relative moisture and the dry state, determined in radial or tangential directions. Total ASE corresponds to volume difference at 35 %, 65 % and 85 % relative humidity. MOE and bending strength of treated and untreated wood were measured using a three point bending device. Measurements were made using a constant velocity of 0.3 mm/min for MOE. The velocity for bending strength was estimated as the velocity so that the sample brakes after 3 min.

## RESULTS AND DISCUSSION

### *Mass loss*

### *Equilibrium moisture content*

Equilibrium moisture content decreased for all treated samples even at 170 °C and during only two hours. Equilibrium moisture content decreased with heat treatment especially for 35% relative humidity. At the same temperature and time of treatment, the decrease was higher for eucalypt wood. Equilibrium moisture content of pine wood at 35% relative humidity, treated for 24 h, decreased 46%, 53%, 57% and 56% of initial equilibrium moisture content, for 170°C, 180°C, 190°C and 200 °C. For 65% and 85% relative humidity the decrease was smaller, e.g. the maximum decrease was 48% and 46% respectively. For eucalypt wood treated for 24 h, the equilibrium moisture content at 35% relative humidity decreased 61%, 69%, 67% and 67% of initial equilibrium moisture content, for 170°C, 180°C, 190°C and 200 °C, while for 65% and 85% relative humidity, the equilibrium moisture content decreased only 59% and 48% respectively (Figure 1).

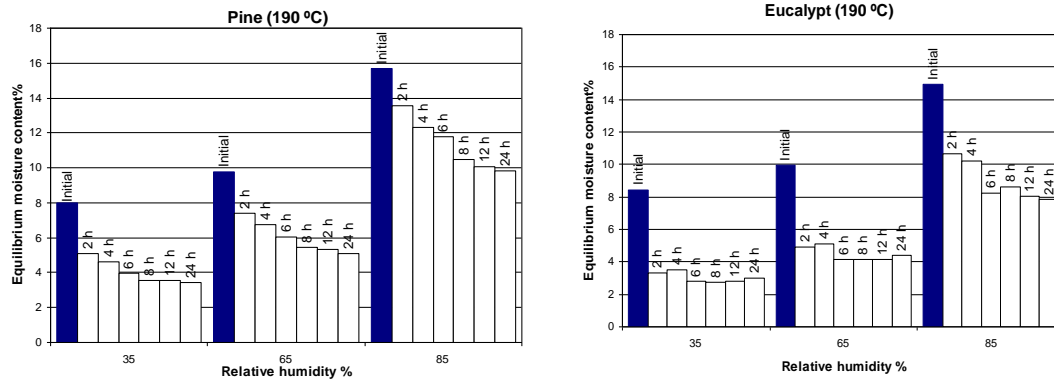


Figure 1. Equilibrium moisture content for heat treated pine and eucalypt wood for 35%, 65% and 85% relative humidity (Example for 190 °C)

### Dimensional stability

Radial ASE35% increased with time and temperature of treatment. Maximum ASE35% values were 65%, 63%, 64% and 73% for pine wood and 76%, 85%, 89% and 88 % for eucalypt wood at 170°C, 180°C, 190°C and 200 °C respectively. Radial ASE65% and ASE85% also increased with time and temperature of treatment but with smaller values. Maximum values for Radial ASE65% were 37%, 52%, 61%, 55% for pine wood, and 59%, 73%, 69%, 71% for eucalypt wood and for ASE85% they were 31%, 40%, 36%, 39% for pine wood and 39%, 45%, 53% 50% for eucalypt wood at 170°C, 180°C, 190°C and 200 °C respectively. Tangential ASE showed an identical behaviour with higher values than radial ASE (Table 1). Total ASE had intermediate values between radial and tangential ASE, since there was almost no difference in axial length. Although untreated eucalypt samples had higher swelling than pine, treated samples showed smaller swelling.

Table 1: ASE for heat treated pine and eucalypt wood at 190 °C conditioned at 35% relative humidity

Temp. [°C]	Time [h]	ASE <sub>35%</sub> [%]					
		Pine			Eucalypt		
		Radial	Tangential	Total	Radial	Tangential	Total
190	2	56.7	61.5	60.0	77.0	72.6	74.4
	4	45.9	67.6	59.5	83.6	83.3	83.6
	6	63.7	73.2	70.0	78.5	85.7	83.2
	8	63.6	73.3	69.1	81.6	90.6	87.5
	12	63.5	74.3	70.7	81.1	87.6	85.4
	24	64.4	74.7	70.0	88.7	95.7	93.2

Radial, tangential and total ASE at 35%, 65% and 85% relative humidity increased with mass loss, the increase being higher for smaller mass losses. Results were better for eucalypt wood than for pine wood treated at the same time and temperature. When comparing results, at the same mass loss, eucalypt ASE values were better than pine's. For example with 3% mass loss Radial ASE65% was 80% for eucalypt and 52 % for pine wood.

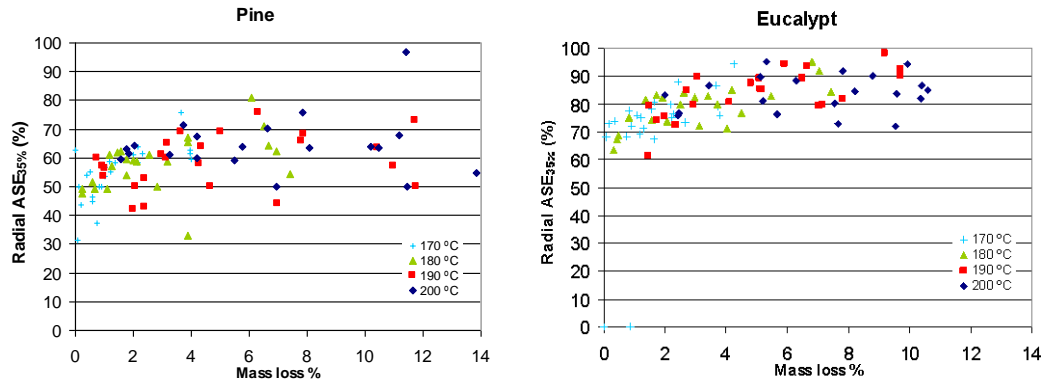


Figure 2. Variation of Radial ASE35% with mass loss for heat-treated pine and eucalypt wood.

### ***Mechanical resistance***

MOE of heat-treated pine wood decreased with mass loss. The decrease was under 5% for mass losses until 4%, reaching 20% for a 12% mass loss. MOE of heat-treated eucalypt wood showed a similar behaviour although some values contradicted this tendency, i.e. it seemed to decrease less until 7%, decreasing more after this point and reaching 25% at 10% mass loss. Bending strength of heat-treated eucalypt and pine wood showed a high variability. Despite this, bending strength of heat-treated pine wood seemed to decrease about 30% for 4% mass loss reaching 60% for mass losses higher than 6%. Bending strength of heat-treated eucalypt wood decreased about 30% for 4% mass loss and about 60% for 10% mass loss.

## **CONCLUSIONS**

Heat treatment decreased the equilibrium moisture content of wood and increased its dimensional stability but decreased MOE and bending strength. Stability improvements were better for the tangential direction and for low relative humidity. Improvements were better for eucalypt wood than for pine wood. Heat treatment seems to be a viable process for eucalypt wood now used almost exclusively for the production of pulp for paper.

## **REFERENCES**

- NP EN 350-2 (2001).- Durabilidade da Madeira e de produtos derivados. Durabilidade natural de madeira maciça. Parte 2: Guia da durabilidade natural da madeira e da impregnabilidade de espécies de madeira seleccionadas pela sua importância na Europa.
- Reimão, D. and L. Nunes (1989). Um estudo sobre a impregnabilidade de madeiras redondas de eucalipto comum Laboratório Nacional de Engenharia Civil.
- Stamm, A., Burr, H. and A. Kline (1946). Staby-wood- A Heat stabilized wood, Ind. Eng. Chem, 38 (6), 630-634.