Properties of thermally modified wood of

Eucalyptus globulus from Spanish plantations

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Content

- Introduction
- Mechanical properties, density and bending strength
- Durability
- Dimensional stability
- Conclusions

Why this specie?

- Specie: *Eucalyptus globulus* L
- Main specie planted in Spain
- Area approximately 700 000 ha.
- Possibilities more than 35 millions m^3 incl. bark
- Main current use: pulp and paper
- Potential for use as solid wood – very attractive
- Solutions for use: own weight, dimensional stability and durability

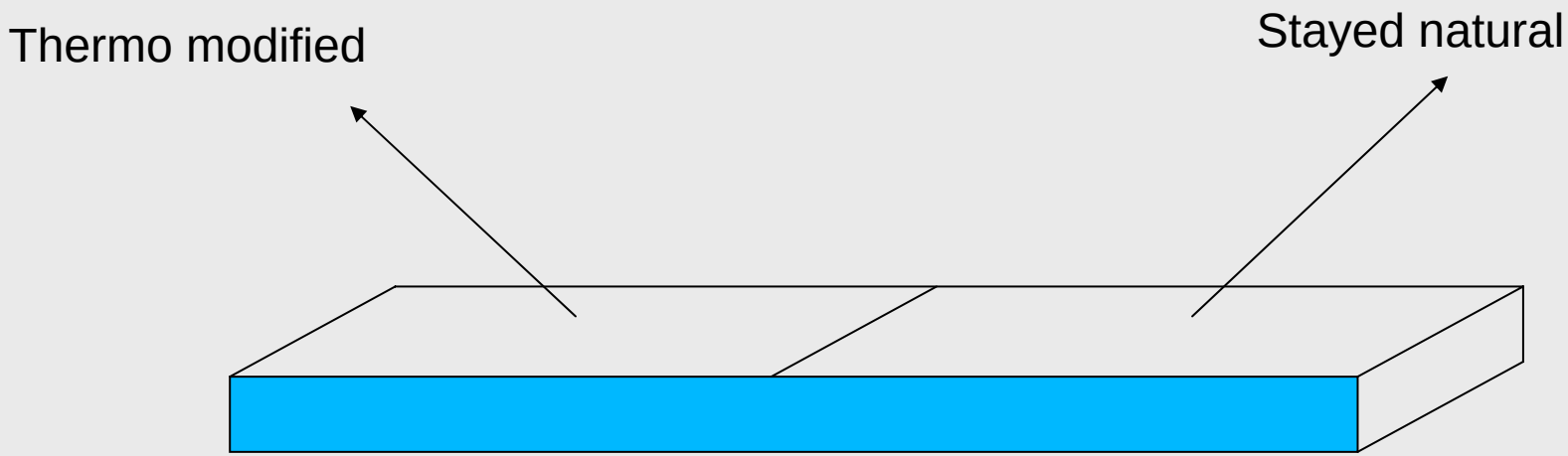
Why thermally modified wood?

Natural wood

Thermally modified wood

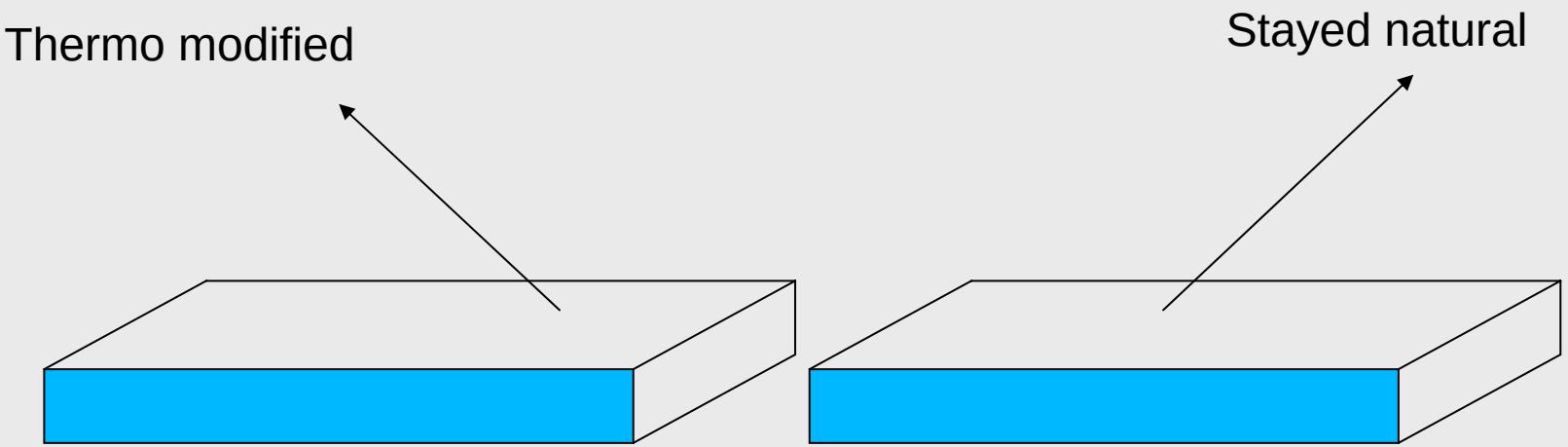
- Wood modification processes are constantly in development
- Improved properties such as dimensional stability and durability
- No use of chemical products: advantages for environment
- Normally use of softwood, but what happened with hardwoods?
- Hardwood has high initial mechanical properties !
- Test of the behavior of wood specie, but not of the modification process
- Thermal treatment with 180 ºC

Introduction



Board cut in the middle; half treated and half stayed natural

Introduction

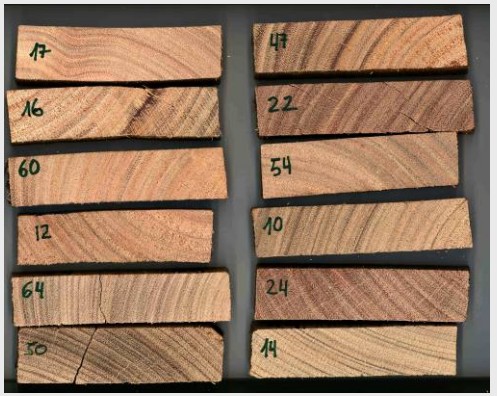


Board cut in the middle; half treated and half stayed natural

Mechanical properties

Density
Bending strength
Resistance to indentation (Brinell)
Strength dynamic flexion
Axial compression strength
Withdrawal capacity of fasteners (screw)

Mechanical properties

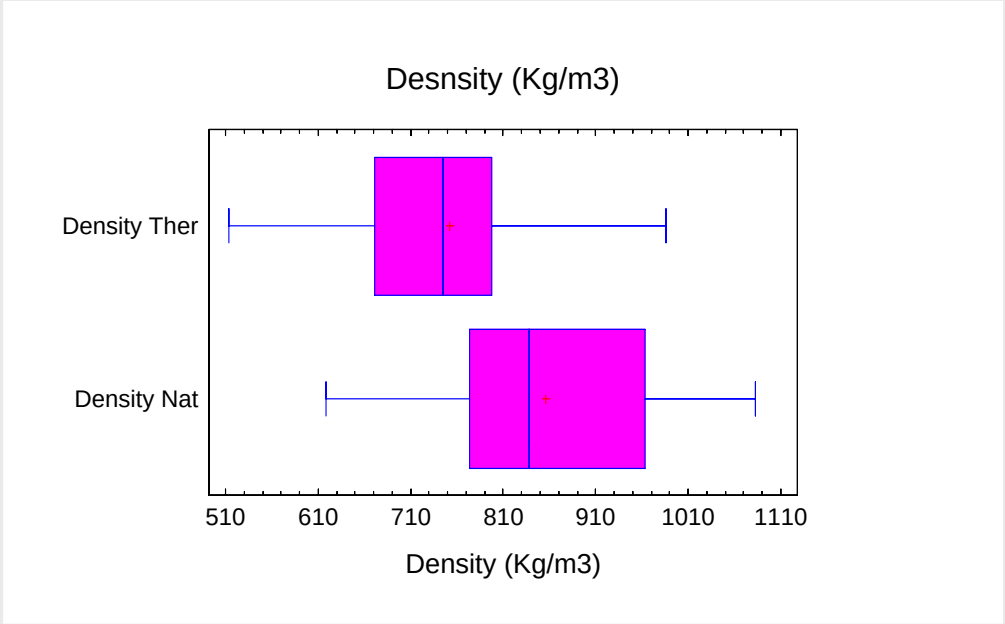


- For this meeting: evaluation of density and bending strength
- 84 test specimens for density and 84 test specimens for bending strength
- Reference norms: UNE 56 531-77 and UNE 56 537-79
- Density: 20 x 20 x 40 mm; Bending strength: 20 x 20 x 300 mm

Results of mechanical properties

Density

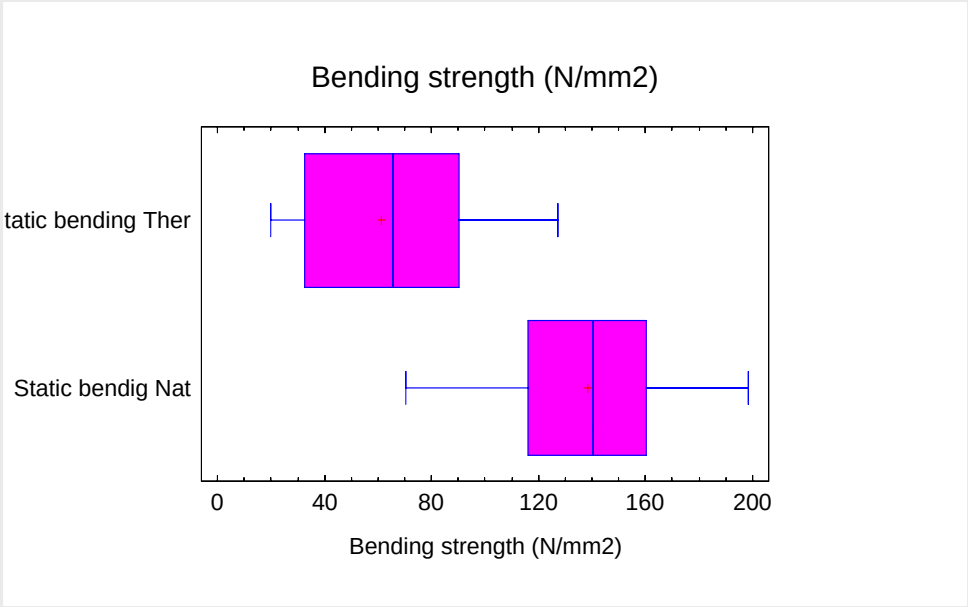
- Decrease 13 %
- 860 kg/m^3 to 748 kg/m^3



Results of mechanical properties

Static bending strength

- Decrease 66 %
- 138 N/mm^2 to 62 N/mm^2



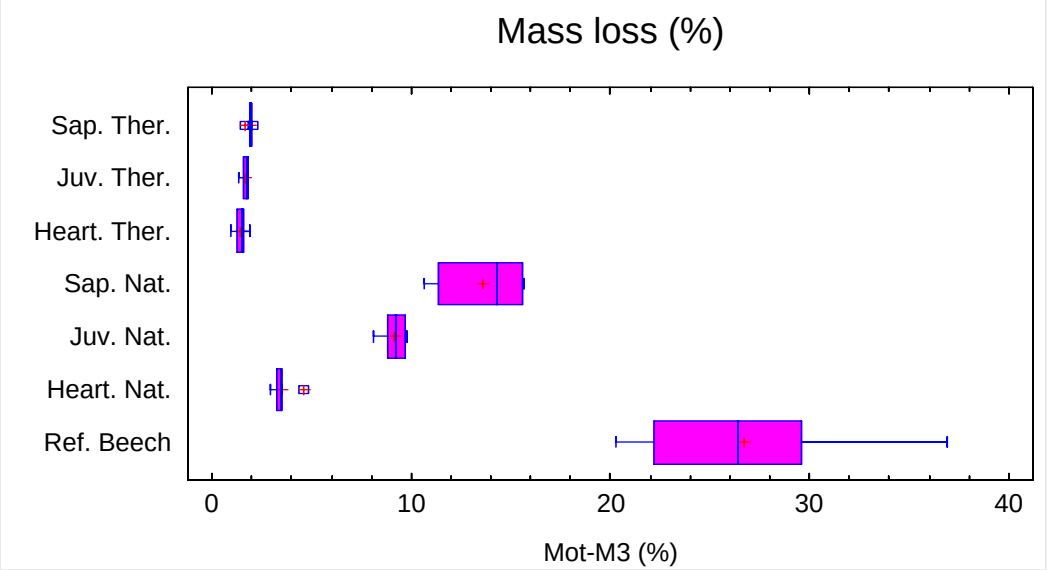
Durability

- Three boards were tested: codes 55, 58 and 64
- Exposure period: 36 weeks (16 weeks per sample)
- Three types of wood: juvenile wood (j), heartwood (d) and sapwood (a)
- Reference norm: EN 113 “Wood preservatives. Test method for determining the protective effectiveness against wood destroying basidiomycetes. Determination of the toxic values”
- Fungus*: Gloeophyllum trabeum* (brown rot)
- 18 test specimens with dimensions 25 x 15 x 50 mm of natural wood, 18 of thermally modified wood and 18 test pieces of reference wood (*F. sylvatica* L.)
- In the labor of INIA-Madrid

EN 113: Wood preservatives. Test method for determining the protective effectiveness against wood destroying basidiomycetes. Determination of the toxic values

- Mass loss criteria
- Initial mass: m_{12}
- Theoretic initial dry mass: $m_{0t} = 100 \times m_{12} / 100 + u$
- Dry mass, after fungus exposure: m_3
- Loss mass in each specimen: $m_{0t}-m_3$
- Loss mass as a percentage of the initial dry mass: $m_{0t} = (m_{0t}-m_3) \times 100 / m_{0t}$
- X = mass loss of thermal modified specimens / mass loss of reference specimens

Durability



- The results for the three types of wood are very close together

- Very similar to the original heartwood

- Reference beech wood samples lost over 20 %

Durability

EN 350-1: Durability of wood and wood based products. Natural durability of solid wood. Part 1: guide to the principles of testing and classification of the natural durability of wood.

DURABILITY CLASS	DESCRIPTION	X VALUE
1	Very durable	X ≤ 0,15
2	Durable	X > 0,15 and ≤ 0,30
3	Moderately durable	X > 0,30 and ≤ 0,60
4	Slightly durable	X > 0,60 and ≤ 0,90
5	Not durable	X > 0,90

Results of durability

Sample 58				
Sample nr.	X (Natural wood)	X (Modified wood)	Durability (according to EN 350-1)	
			Natural wood	Modified wood
58 a1 (N) 58 a1 (T) 58 a2 (N) 58 a2 (T)	0,42	0,07	MODERATELY DURABLE	VERY DURABLE
58 d1 (N) 58 d1 (T) 58 d2 (N) 58 d2 (T)	0,12	0,05	VERY DURABLE	VERY DURABLE
58 j1 (N) 58 j1 (T) 58 j2 (N) 58 j2 (T)	0,33	0,06	MODERATELY DURABLE	VERY DURABLE

Results of durability

Sample 55				
Sample nr.	X (Natural wood)	X (Modified wood)	Durability (according to EN 350-1)	
			Natural wood	Modified wood
55 a1 (N) 55 a1 (T) 55 a2 (N) 55 a2 (T)	0,45	0,07	MODERATELY DURABLE	VERY DURABLE
55 d1 (N) 55 d1 (T) 55 d2 (N) 55 d2 (T)	0,11	0,06	VERY DURABLE	VERY DURABLE
55 j1 (N) 55 j1 (T) 55 j2 (N) 55 j3 (T)	0,31	0,06	MODERATELY DURABLE	VERY DURABLE

Results of durability

Sample 64				
Sample nr.	X (Natural wood)	X (Modified wood)	Durability (according to EN 350-1)	
			Natural wood	Modified wood
64 a1 (N) 64 a1 (T) 64 a2 (N) 64 a2 (T)	0,63	0,08	SLIGHTLY DURABLE	VERY DURABLE
64 d1 (N) 64 d1 (T) 64 d2 (N) 64 d4 (T)	0,16	0,06	DURABLE	VERY DURABLE
64 j1 (N) 64 j1 (T) 64 j2 (N) 64 j2 (T)	0,39	0,08	MODERATELY DURABLE	VERY DURABLE

Dimensional stability

- All boards were tested
- Samples of radial and tangential sides
- 10 test pieces of natural and 20 of thermally modified wood
- Dimensions: 25 x 20 x 50 mm
- 105 days of exposition under different conditions

Dimensional stability

Cycles

- SATURATED with 15 ºC and 98%

- CICLE I with 23ºC and 80%
- CICLE II with 23ºC and 65%
- CILCE III with 23ºC and 30%

- FINAL Oven-dried

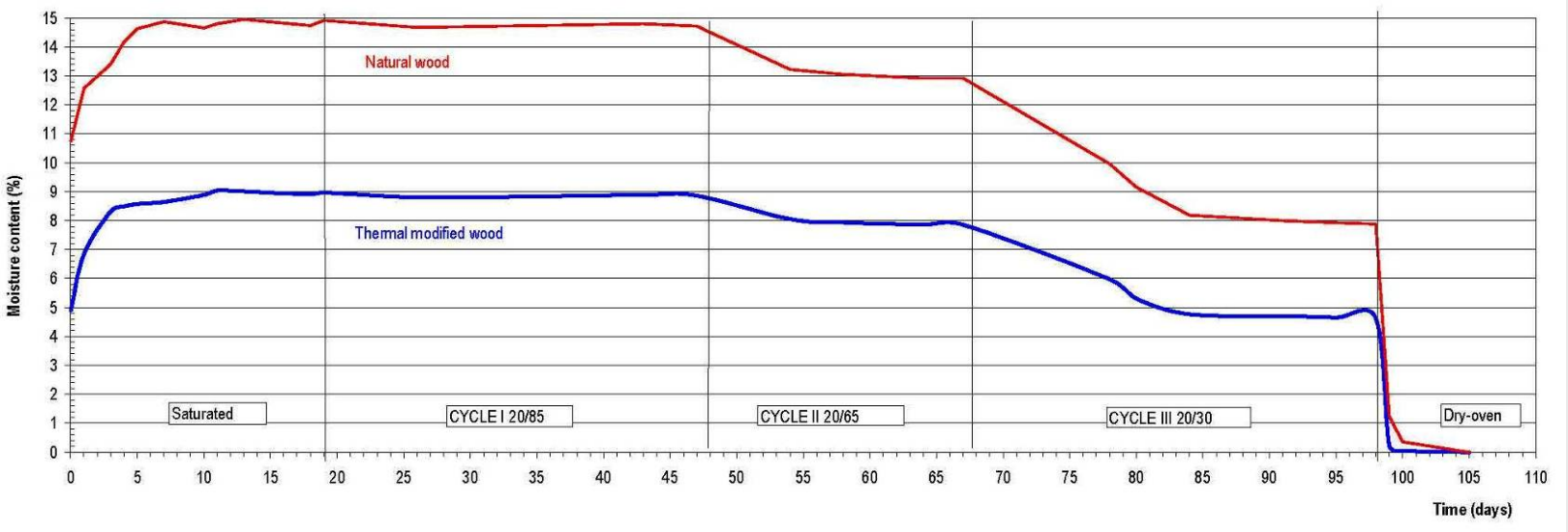
Differences between two consecutive mass value below 0,1 %

Dimensional stability

	Initial conditions	Saturated conditions	CICLO I 23ºC / 80%	CICLO II 23ºC / 65%	CICLO III 23ºC / 30%	Oven-Dried
Natural wood equilibrium moisture content (%)	10,75	14,95	14,72	12,92	7,88	0
Modified wood equilibrium moisture content (%)	4,90	9,02	8,87	7,86	4,63	0
Time	0	13	47	67	98	105

- Measurement every 24 h: weight and all dimensions

Dimensional stability



- Very symmetrical curves between natural and modified wood
- 40% low EMC for modified wood

Dimensional stability

Unit shrinkage	RADIAL	TANGENTIAL
Natural wood	0,3	0,54
Thermally modified wood	0,3	0,43

- Natural and modified wood similar in radial shrinkage
- Significant improvement for nervous wood in tangential direction: 20%

Conclusions

- Density decreases slightly: 13 %
- The own weight is reduced, but this has no negative influence on other products
- Bending strength decreases: 66 %
- This decrease is less important compared to other species of wood (specially softwood)

Conclusions

- Sapwood and juvenile wood pass from the low durability class to a very durable class against *Basidiomycetes*. The hardwood keeps being very durable.
- May be an important market opportunity for products exposed to class 3 (wood exposed directly to the weather, but not in contact with the ground).
- Equilibrium moisture content reduces about 40%. It can support better wet conditions.
- Dimensional stability, special influence in tangential shrinkage about 20%
- Need for further improvement of the process: different temperatures, durations, etc.

Thank you for your attention !