COST Action FP1303 meeting

Performance of bio-based building materials

Analysis of dimensional stability of thermally modified wood exposed to several re-wetting cycles (STSM)

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COST FP1303
Performance of bio-based building materials

Mendel University in Brno

TALLINN UNIVERSITY OF TECHNOLOGY

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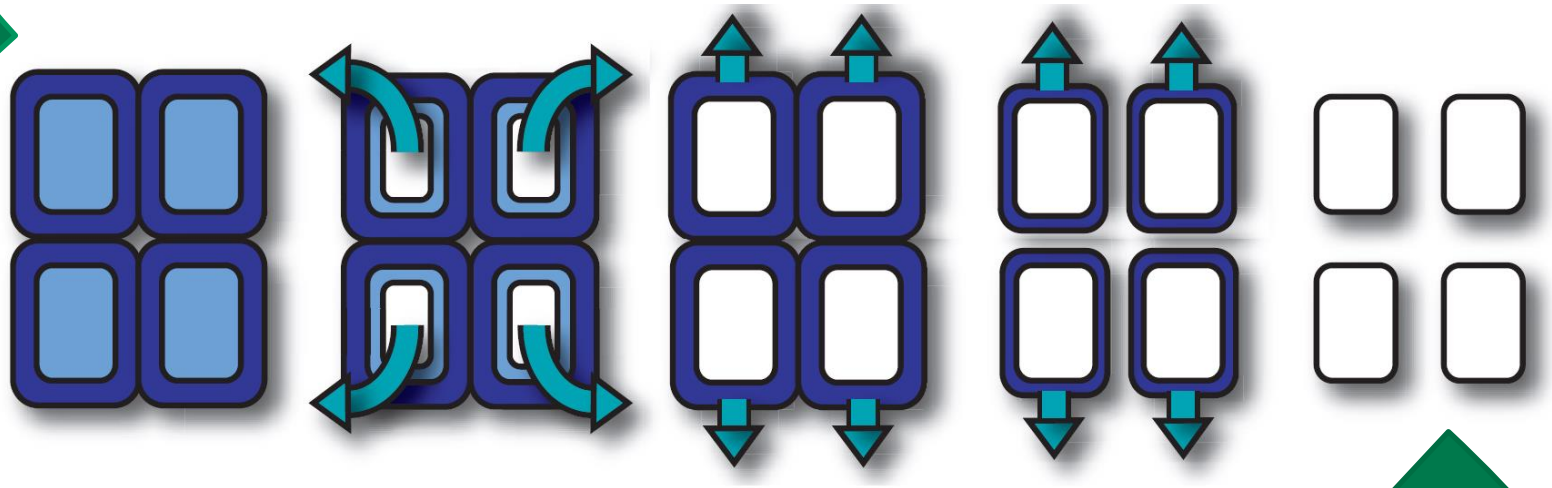
Wood water relationship

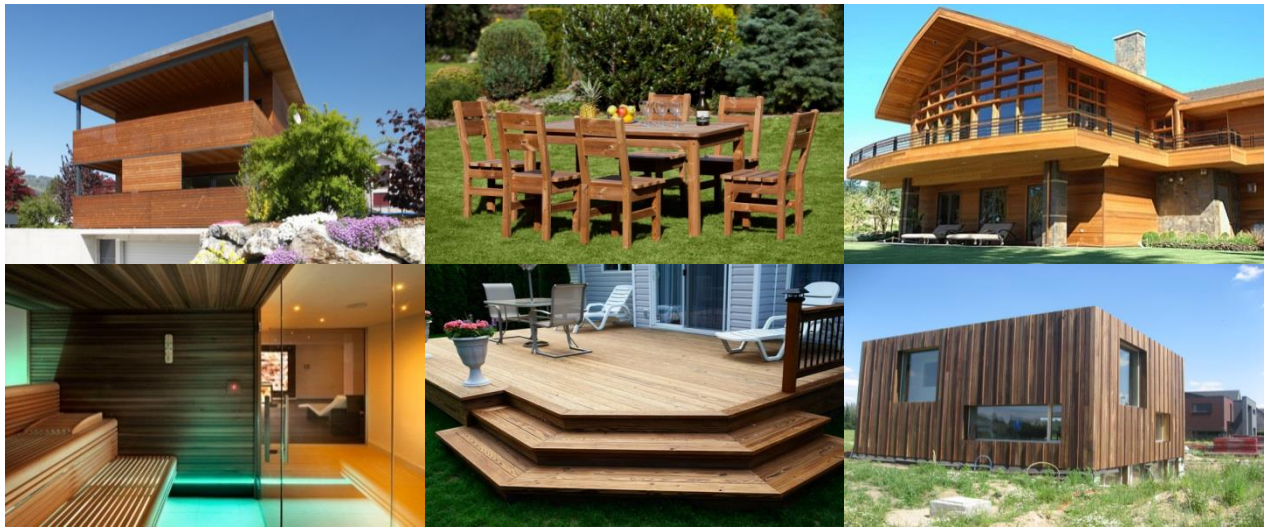
Wood drying → Shrinking



Swelling ← Wood soaking, RH increase

Changes in wood shape due to moisture changes

Wood Modification – Heat Treatment



- Exterior trim
- Cladding
- Decking
- Siding
- Flooring

130 000 m^3
Production in 2013

Exposure to different conditions

During its service life wood is often exposed to different conditions due to seasons changes, rapid changes in the environmental conditions

Material and methods

Specimens A)
15×15×15 mm³

Beech (*Fagus sylvatica* L.) 0.72g/cm³
Spruce (*Picea abies* L. Karst.) 0.41g/cm³
Poplar (*Populus alba*) 0.39g/cm³

Treatment at 180°C and 200°C, 3 h

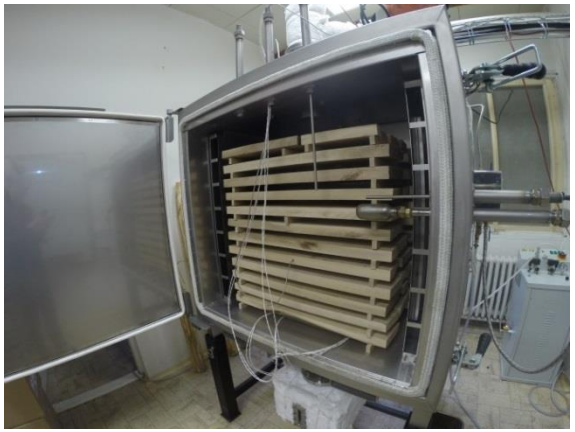
Specimens B)
15×15×5 mm³

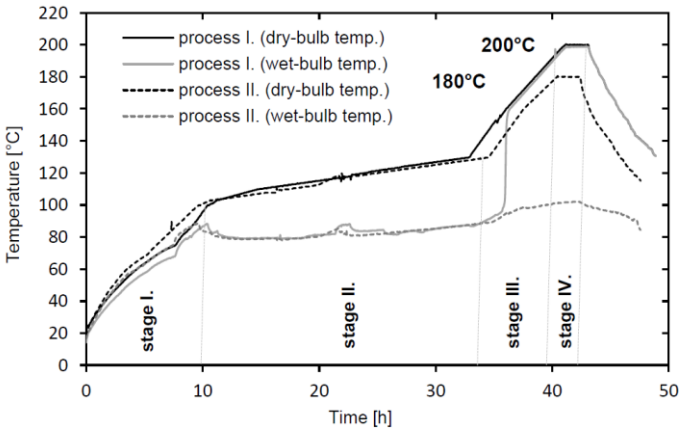
Pine (*Pinus sylvestris* L.) 0.47g/cm³

Treatment at 160°C and 220°C, 3 h

Thermal modification process

Small scale laboratory chamber for thermal modification, steam environment

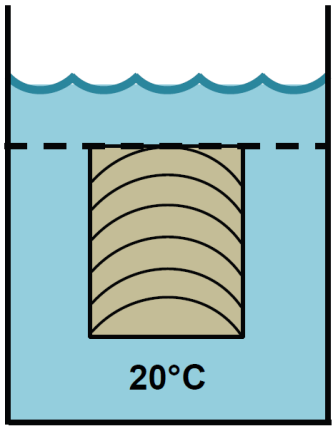


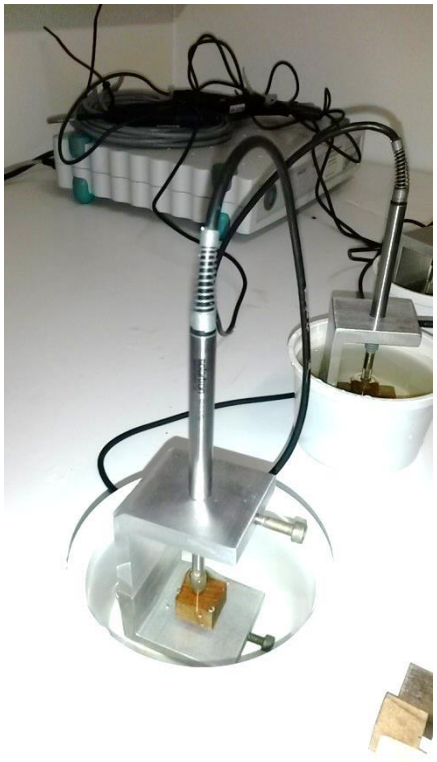


Dimensional stability (cycling) tests

Test A)
15×15×15 mm³

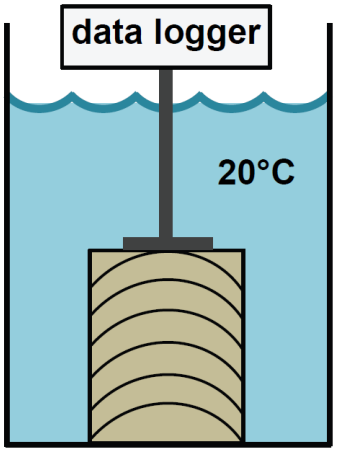
SPECIMENS SOAKING
MAX. SWELLING





Test B)
15×15×5 mm³

DYNAMIC SWELLING – SWELLING CURVES



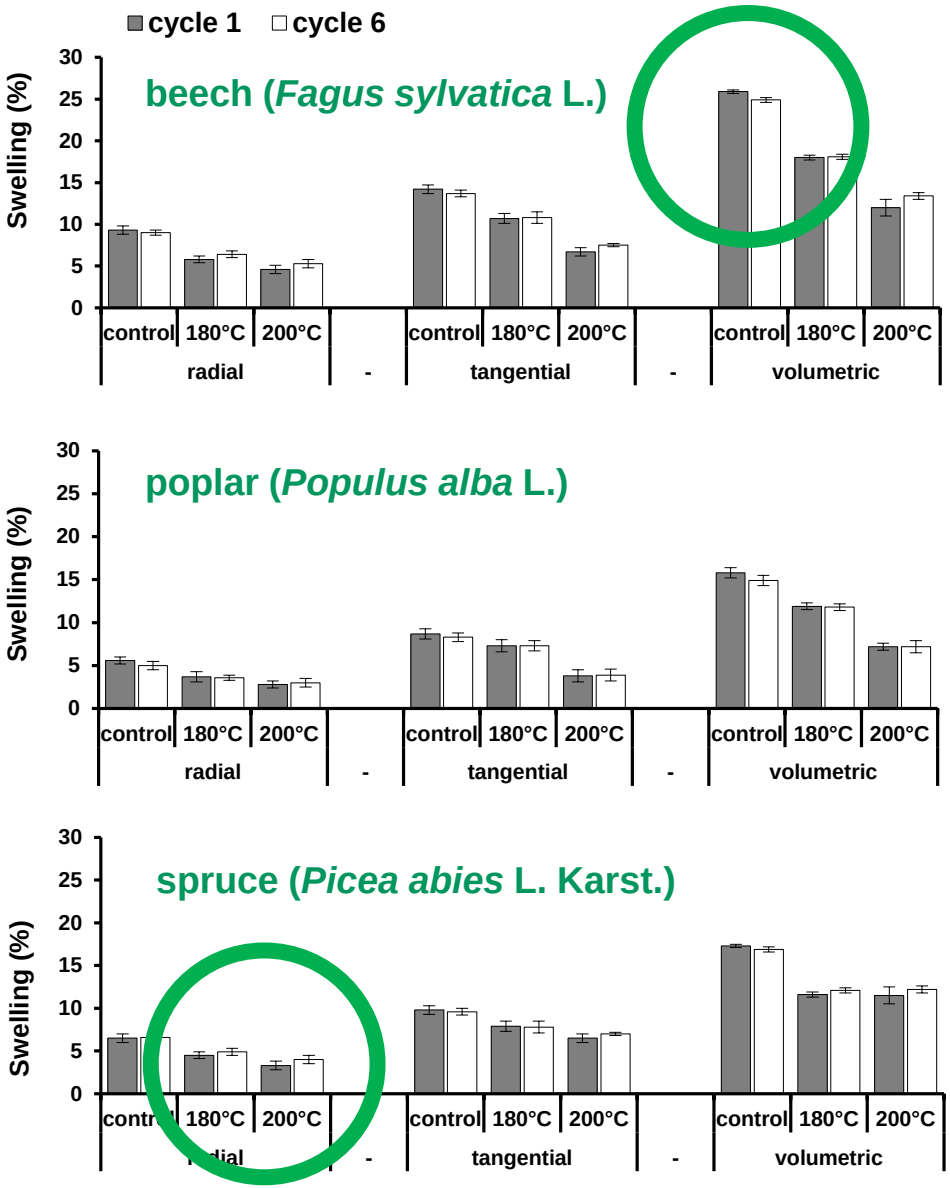
Dimensional stability (cycling) tests

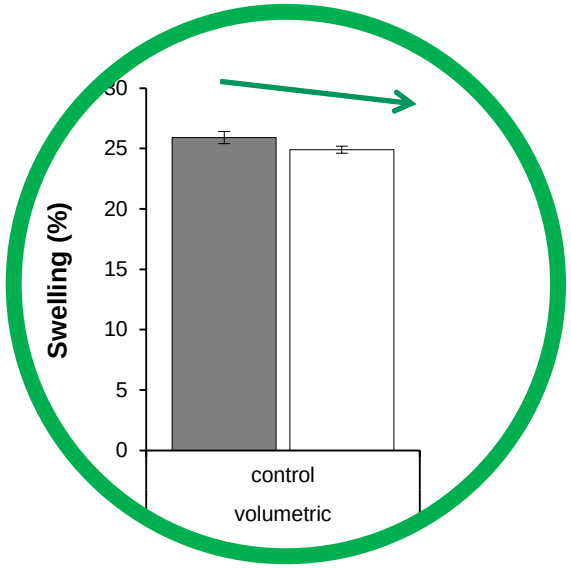
	TEST A)	TEST B)
CYCLE 1	Soaking in the water (20°C) for 24 h	Soaking in the water (20°C) for 24 h, displacement probe recording (1min)
	Radial, tangential and longitudinal dimensions and weight	
	Three stage oven drying to 0% MC - 24 h at 40°C, 12 h at 60°C and 12 h at 103°C	
	Radial, tangential and longitudinal dimensions and weight → Vs, Ts, Rs	
	6 CYCLE REPETITION	
	Calculation of volumetric, radial and tangential swelling, anti-swelling efficiency (ASE)	

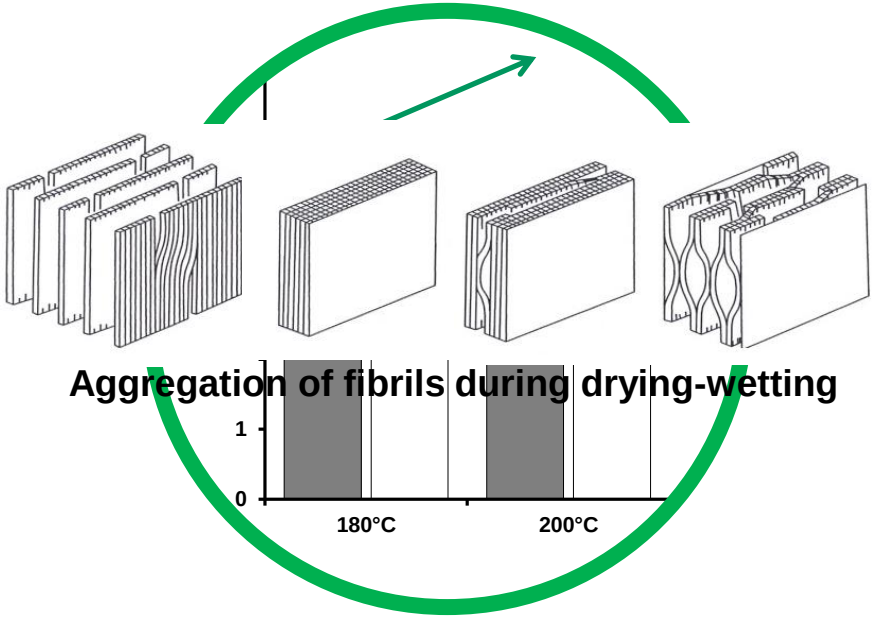
$$S_{R,T,V}\,(\%) = (V_1 - V_0)/V_0 \cdot 100$$

$$ASE_V\,(\%) = (S_u - S_m)/S_u \cdot 100$$

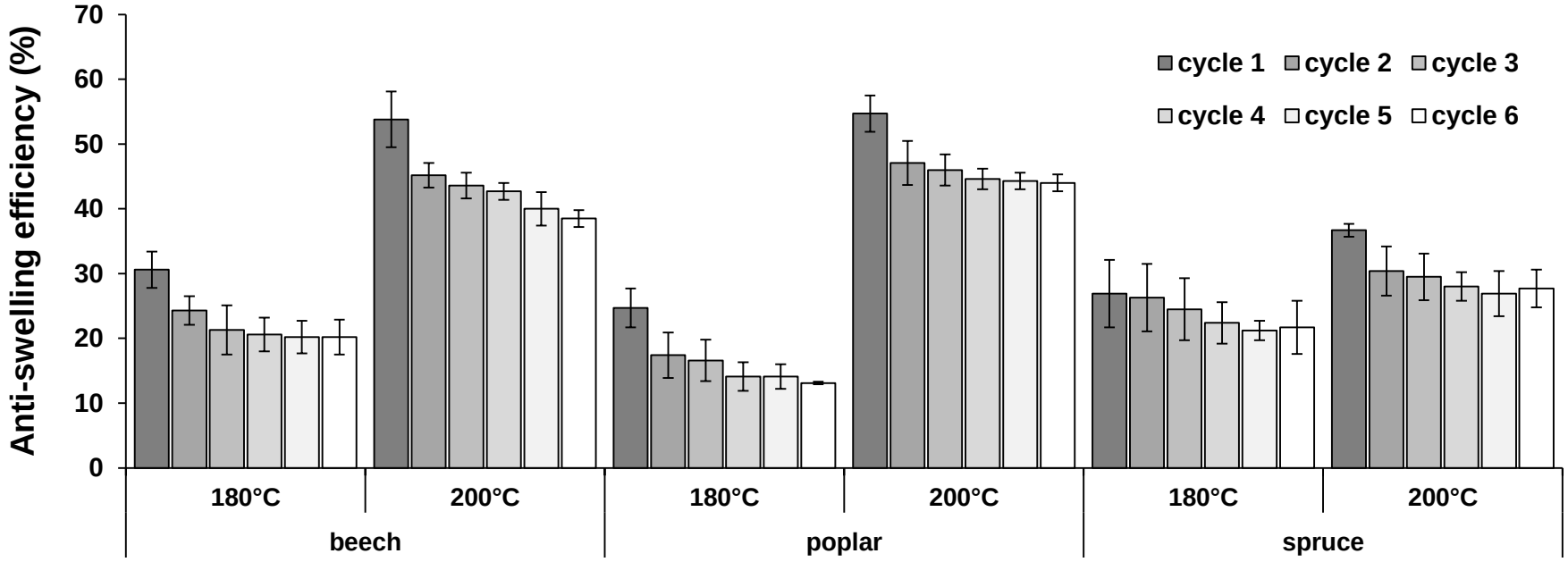
Results – swelling (R_{ad}, T_{an}, V_{ol})





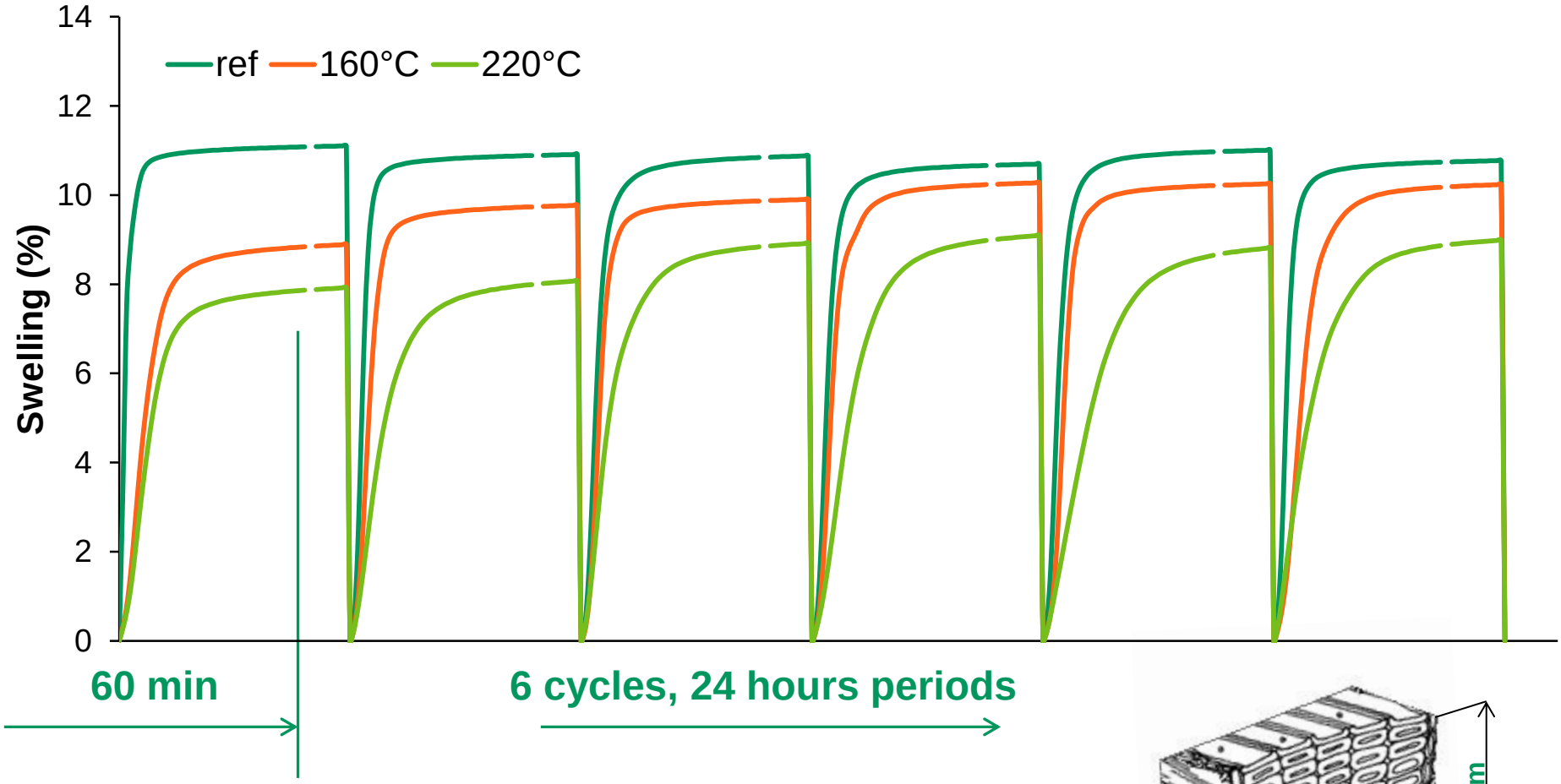


Results – Anti-swelling efficiency (ASE)

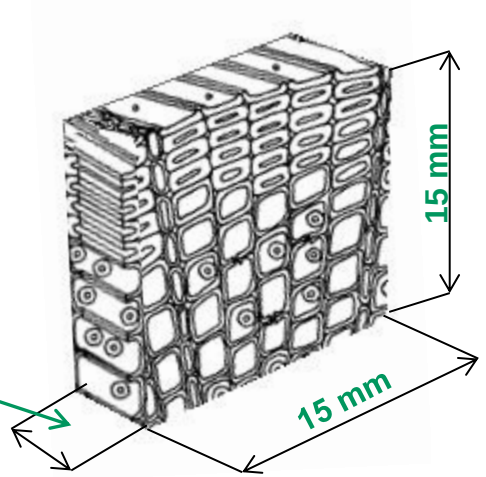


Initial ASE	30.60	53.80	24.70	54.70	26.90	36.70
ASE after 6 cycles	20,20	38,50	13,10	44,00	21,70	27,70
Mass loss	3.8	6.9	3.2	10.4	2.8	4.5

Results – Dynamic swelling test



Early wood tracheid's length – 2-6 mm
Late wood tracheid's length – 10% > EW



Next steps? DVS measurements and OH-group accessibility

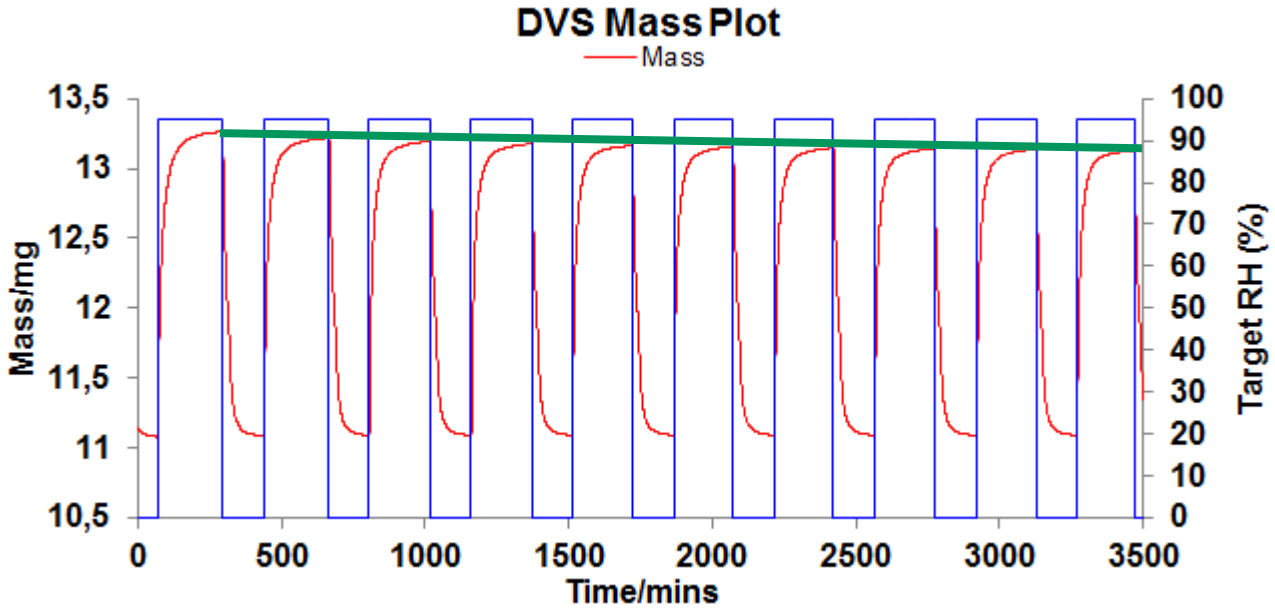
5 mg specimens

Relative humidity cycles 0% to 95% (5% steps)

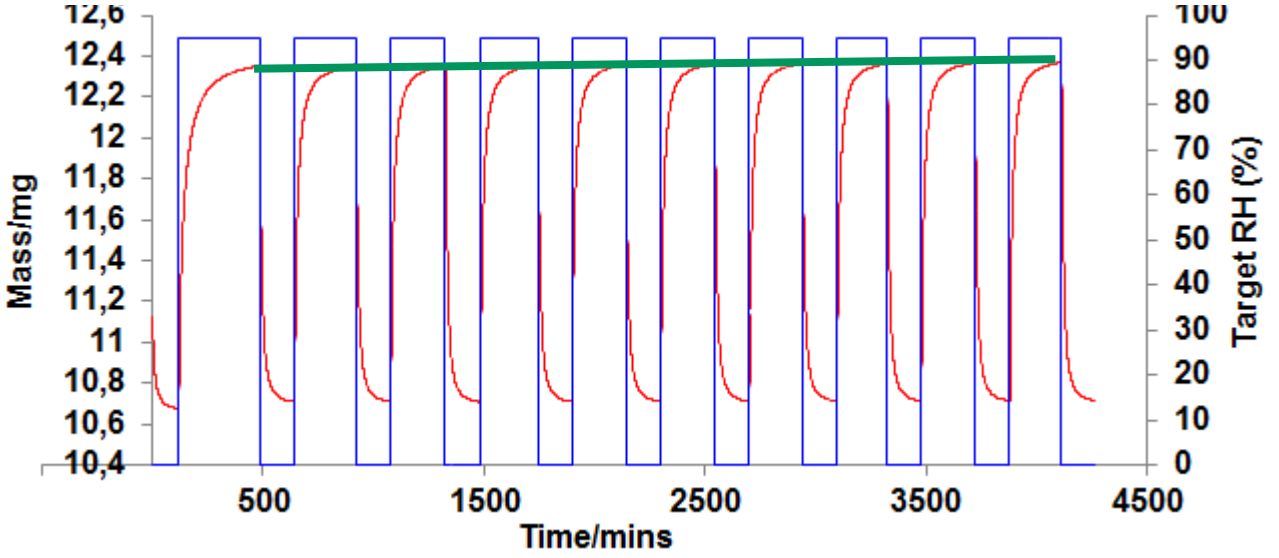
The highly accurate balance (+0,1 µm)

Next steps? DVS measurements and OH-group accessibility

Reference



Thermally modified



Conclusions

1) Thermal modification significantly improved the dimensional stability of the wood. The R, T and V swelling of modified wood decreased, resulting in 24 to 30% ASE for mild treatment (180°C) and 36 to 54% for severe (200°C).

2) When specimens were exposed to several rewetting cycles, the initial dimensional stability of the thermally modified wood was reduced by 34 and 28.4% for beech, 47 and 19.6% for poplar, and 19.3 and 24.5% for spruce.

3) Dimensional stability reduction following numerous soaking cycles can be partly attributed to the formation of leachable extractives within the thermally modified wood as a result of thermal degradation. This leaching made new areas accessible to water molecules.

4) The control specimens underwent lesser swelling during rewetting cycles, likely due to hornification, which resulted in a reduction of -OH group accessibility after repeated soaking cycles.

5) Additional measurements of DVS