

Density-property relationships in thermally modified wood

Martin Arnold
Empa, Swiss Federal Laboratories for Materials Testing and Research, Wood Laboratory, CH-8600 Dübendorf, Switzerland

INTRODUCTION

- For appropriate and successful applications of thermally modified timber (TMT) a detailed knowledge of its distinct properties is essential.
- A thermal modification leads to structural and chemical changes in the wood constituents, which may significantly alter the material properties. This concerns not only the absolute property values, but can also affect the relationships between the different material properties as known from untreated solid wood.
- Of particular importance in this context is the dependence of numerous technological properties on the wood density.
- Research question: **Are the density-property relationships of wood altered by a thermal modification?**

EXPERIMENTAL

- 3 wood species: Beech (*Fagus sylvatica*), Ash (*Fraxinus excelsior*), Spruce (*Picea abies*)
- 2 thermal modification levels+ untreated controls
- Density + 5 material properties

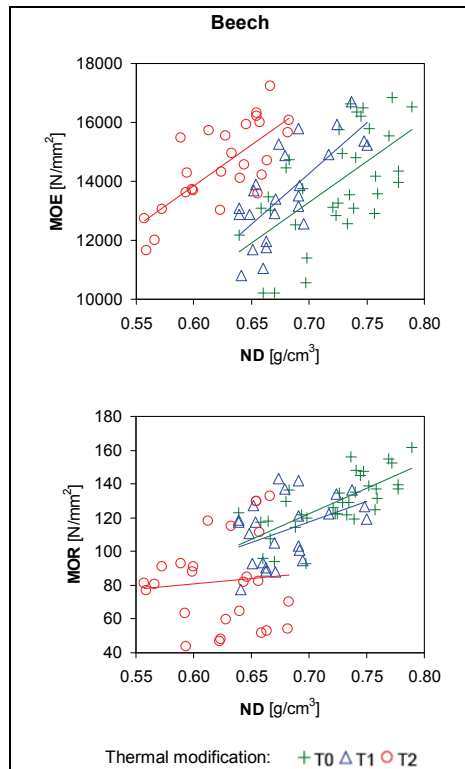
Label	Modification (industrial process)
T0	untreated controls
T1	'mild' heat treatment, max. temperature 180°C
T2	'intense' heat treatment, max. temperature 220°C

Property	Label	Unit	Test method	Specimen size (L x T x R)	Details
Density:					
Normal density	ND	[g/cm ³]	DIN 52182	(bulk density of whole specimens from property tests)	mass and volume at 20°C / 65% RH where not measured
Oven-dry density	OD				calculated from ND
Static bending:					
Modulus of elasticity	MOE	[N/mm ²]	DIN 52186	360 x 20 x 20 mm ³	3-point bending test
Modulus of rupture	MOR				
Impact bending work	IBW	[kJ/m ²]	DIN 52189	300 x 20 x 20 mm ³	
Compression strength	CSL	[N/mm ²]	DIN 52185	100 x 20 x 20 mm ³	parallel to grain
Volumetric swelling	VSW	[%]	DIN 52184	10 x 30 x 30 mm ³	sum of max. radial and tangential swelling

Abbreviations: L: longitudinal, T: tangential, R: radial, RH: relative humidity

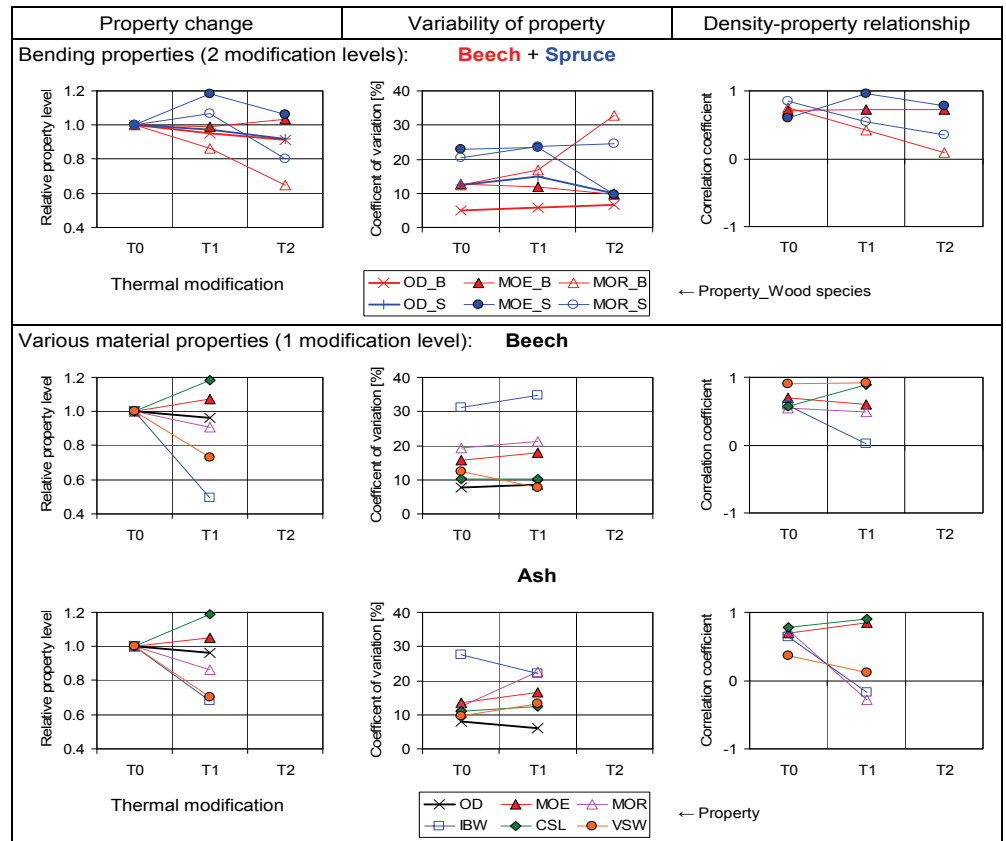
RESULTS

Example of density-property relationship:
Density versus bending MOE / MOR



Data points show values of individual specimens

Effect of thermal modification on property level, variability and correlation with density



CONCLUSIONS

- Property changes: Density is decreasing slightly. Individual properties may improve or degrade depending on sensitivity to material changes. Variability generally remains constant.
- Density-property relationships: For TMT with small to moderate property changes, density-property correlations similar to the controls were observed. For TMT with major property changes, correlations are frequently less specific and may even change sign. Thus, relationships present in untreated solid wood may not apply any more.
- Practical consequences: Where density is used as an indicator for unknown material properties, the density-property relationships have to be established by tests for the specific wood species - thermal modification combinations in question.