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(*PhD student working on hygromechanics of panel paintings)

Effect of hygrothermal treatments on the physical properties of wood

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For many applications, such as the conservation of wooden cultural heritage, wooden construction, understanding and modelling the behaviour of ancient wood is important. During the 1950s, Kohara has shown that aged wood had not the same physical, mechanical and chemical properties as recent wood [2]; the models currently developed are based on non-aged wood and do not fit for our studies. Thus, the aim of our study, to both implement our model and work on a mimic of ancient wood, is to reproduce the properties of this “aged” material by accelerating aging process of recent wood.

Thermal treatments are often used to improve wood durability thanks to a reduction of hygroscopicity. They are usually performed at high temperature (>180°C) and are accompanied by a degradation of post-linear properties: the material becomes more brittle, its transverse strength lowers. Matsuo and al. [3] have validated a procedure to reproduce the wood colour property of aged wood by thermal treatments. However Obataya [2] has shown that thermal treatments in oven-dry state fail to reproduce some important mechanical properties or behaviour such as anisotropy or viscoelasticity. Some recent results [1] suggest that mild temperature levels (<150°C) are preferable to reproduce the chemical changes observed in ancient wood.

The treatments were applied on poplar wood using a closed system. Almost 130 specimens were observed: 1/3 from heartwood and radially oriented (LxRxT = 3x40x5 mm³), the rest were tangentially oriented (LxRxT = 3x5x40 mm³), 1/3 heartwood and 1/3 sapwood (Figure 1). Before treatments, mass and dimensions of specimens were measured at oven-dry state. Then, two types of pre-conditioning protocols were compared: a short ‘dry’ storage at low relative humidity (RH) in a closed box with silicagel, and few days ‘wet’ storage at the same RH as the one applied. The samples were heated 24 hours at 120°C. The same amount of water was introduced inside the reactor to reach the desired RH: 0%, 50%, 75% and 100% for both pre-conditionings. Because of the moisture initially present in the specimen, the applied conditions were respectively: 8%, 62%, 79%, 89% RH for the dry and 19%, 68%, 82%, 91% RH for the wet pre-conditioning. These amounts were evaluated during the test using the pressure measured in the device. Mass and dimensions of samples were measured at different steps of sorption isotherms to evaluate the effect of both pre-conditioning and treatment on hygroscopicity and swelling/shrinkage rate.

The results show some physical modifications due to these mild hygro-thermal treatments: on sorption isotherm, points at high RH present a reduced hygroscopicity and a reduced swelling/shrinkage rate, whatever the preconditioning protocol (Figure 2); nevertheless the introduction of moisture in the sample has an effect on this phenomenon (Figure 3). Figure 4 shows the equilibrium moisture content (EMC) and weight loss (WL) calculated based on the weight at 60%RH, 25°C:

$$WL = \frac{M_{\text{before treatment at 60\%RH}} - M_{\text{after treatment at 60\%RH}}}{M_{\text{before treatment at 60\%RH}}}$$

$$EMC = \frac{M_{\text{after treatment at 60\%RH}} - M_{\text{oven-dry after treatment}}}{M_{\text{oven-dry after treatment}}}$$

Based on these results, the range of hygro-thermal treatments able to mimic aged wood can be discussed.



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Thermo-Hydro-Mechanical Wood Behaviour and Processing

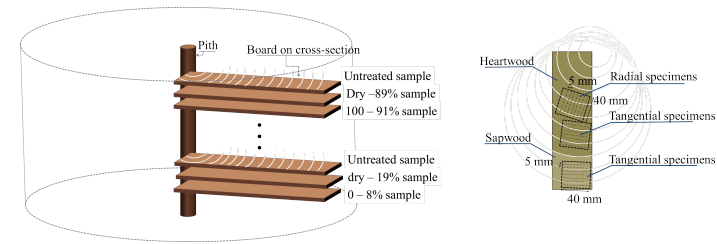


Figure 1. Sample position and treatments.

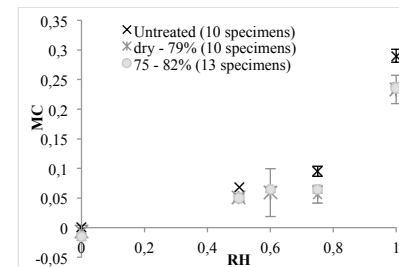


Figure 2. Adsorption isotherm curve for the set treated at dry - 79%RH (star point), at 75 - 82%RH (closed circle), and for the not treated set (cross point)

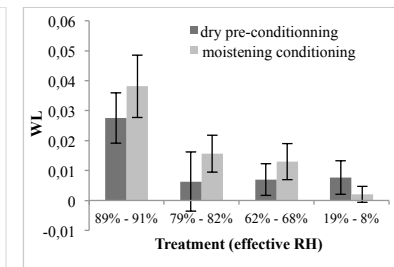


Figure 3. Effect on the pre-conditioning of weight loss of the specimens at oven-dry state

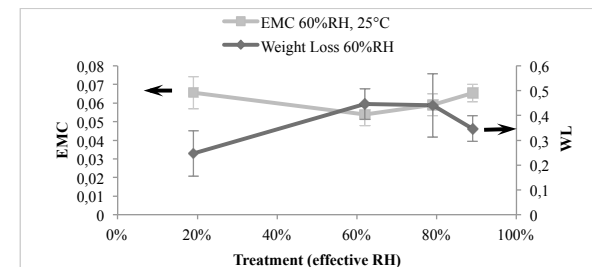


Figure 4. Effect of treatment condition on equilibrium moisture content at 60%RH, 25°C (square, left-side scale) and on weight loss at 60%RH, 25°C (diamond, right-side scale) for the ‘dry’ pre-conditioning

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Thermo-Hydro-Mechanical Wood Behaviour and Processing

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