# Numerical Simulation of Warm-Air Drying of Mexican Softwood (Pinus pseudostrobus)

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**Introduction**: The drying of wood is a very complex phenomenon, since it involves coupled mechanisms that occurring simultaneously. Several publications dealing with wood drying exist in literature. Many oriented to European woods. The aim of this work was to develop and solve a model to simulate drying kinetics and moisture distribution during a warm-air convective drying of Mexican softwood.

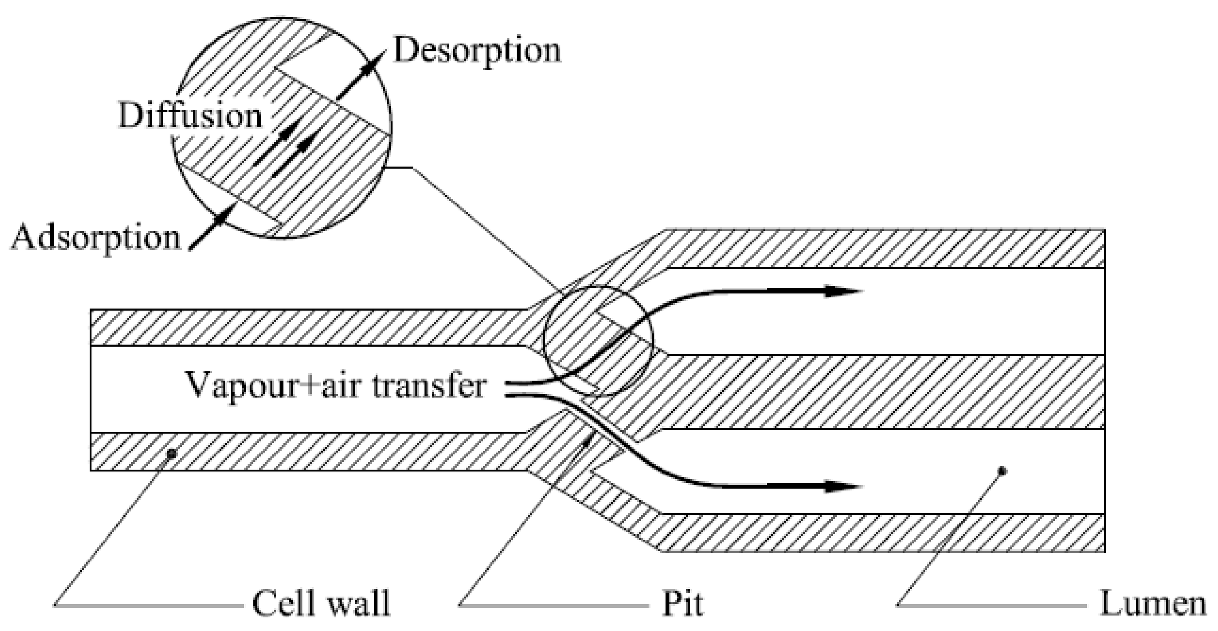



**Figure 1**. Flow paths through softwoods

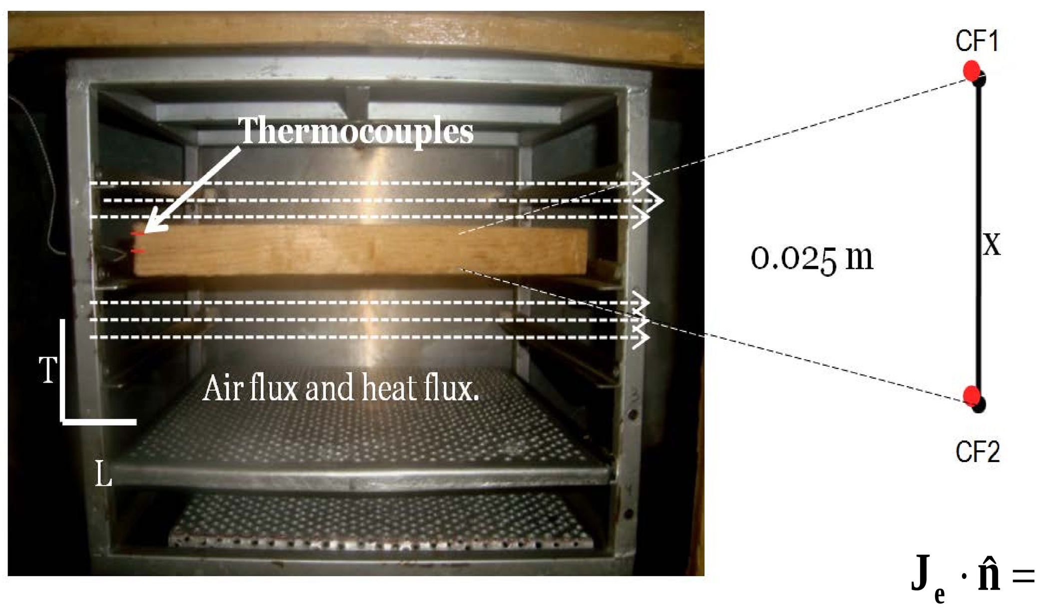
**Computational Methods**: The model was developed by considering the heat and mass transport and the representative elementary volume, which involves the solid, liquid and gas phases. Three primary variables were solved: the moisture content, the temperature, and the dry-air density.

$$\frac{\partial W}{\partial t} = -\nabla \cdot \left\{ \frac{1}{\rho_s} \left( \rho_l \mathbf{v}_l^l + \rho_v \mathbf{v}_v^g + J_b \right) \right\} \quad (1)$$

$$\frac{\partial}{\partial t}(\rho_a) + \nabla \cdot \left( \rho_a^g \mathbf{v}_a \right) = 0 \quad (2)$$

$$\rho C_p \frac{\partial T}{\partial t} + \Delta h_{vap}\, \overline{m}_{lv} + \Delta h_{sorp}\, \overline{m}_{bv} + \left( C_{pl}\rho_l \mathbf{v}_l + C_{pb}\rho_b \mathbf{v}_b + C_{pv}\rho_v \mathbf{v}_v + C_{pa}\rho_a \mathbf{v}_a \right) \cdot \nabla T = \nabla(\lambda \nabla T) \quad (3)$$

We assumed the moisture transport is done mainly in the thickness direction (1D), and then the model's geometry is represented by a straight line. There are two boundary conditions CF1 and CF2.




$$\mathbf{J_w} \cdot \hat{\mathbf{n}} = k_m c M_v \ln\left( \frac{1 - x_{v_\infty}}{1 - x_v} \right)$$

$$P_g^g = P_{atm}$$

$$\mathbf{J_e} \cdot \hat{\mathbf{n}} = h\,(T - T_\infty) + \Delta h_v\, k_m\, c\, M_v \ln\left( \frac{1 - x_{v_\infty}}{1 - x_v} \right)$$

**Figure 2**. Experimental setup in the drying tunnel, geometry and boundary conditions.

**Results**: We considered constant air-flow temperature at 60°C, an initial drying temperature of 25°C and an initial moisture content of wood of 96%. The drying kinetics were compared versus both the drying characteristic curve method and experimental data.

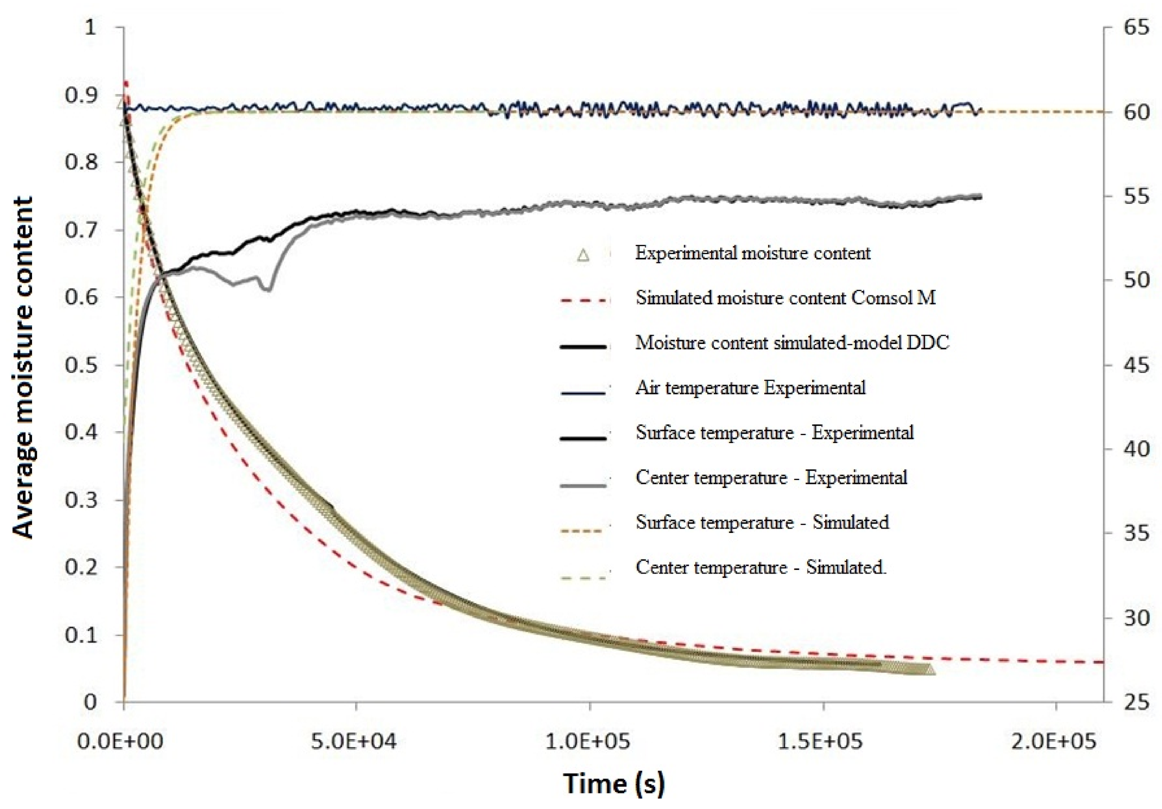



**Figure 3**. Drying kinetics and average temperature evolution.

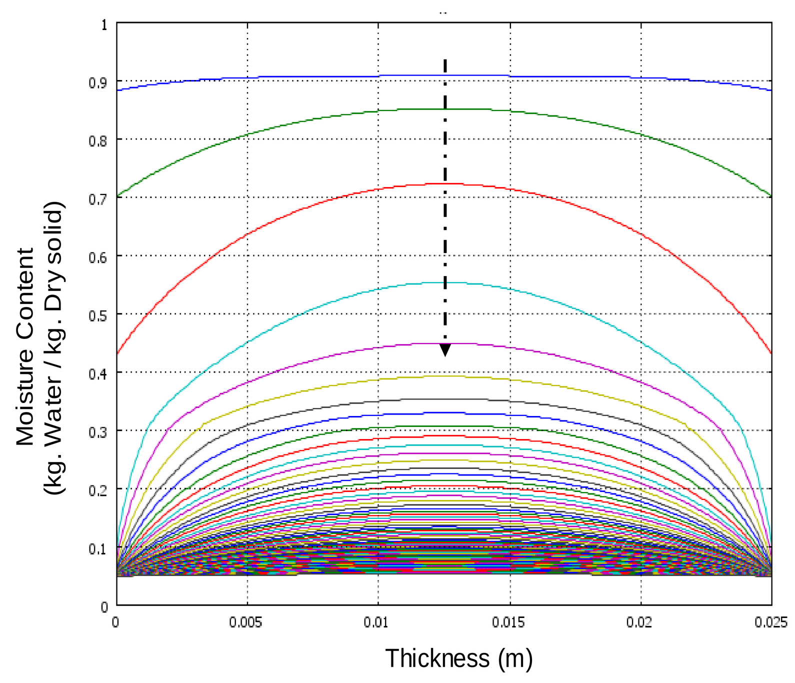



**Figure 4.** Moisture distribution through the thickness of wood every 1e3 secs.

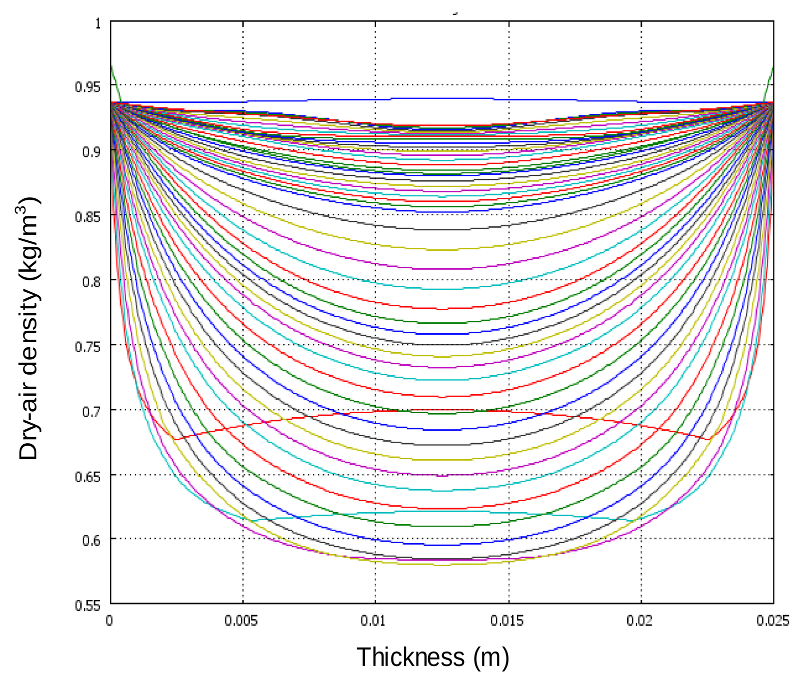



**Figure 5**. Dry-air density distributions through the thickness of wood every 4e3 secs.

**Conclusions**: Drying kinetics, moisture distribution inside wood and gas transport was correctly simulated. Many of the transport properties required by the model correspond to similar softwood species, so the variations in the theoretical kinetics could be diminished if their thermo-physical properties were experimentally obtained

**References**:

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