MODELING CONVENTIONAL ONE-DIMENSIONAL DRYING OF RADIATA PINE BASED ON THE EFFECTIVE DIFFUSION COEFFICIENT

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***Abstract*— We modeled conventional one-dimensional drying of radiata pine (*Pinus radiata*) wood using the concept of effective diffusion. The experimentally determined effective diffusion coefficients for the radial and tangential directions were related exponentially to the moisture content. These coefficients were characterized by two parameters that were determined through optimization within the context of an inverse problem. One-dimensional drying experiments were carried out under constant drying 44/36 (ºC/ºC) in order to determine transitory spatial distributions of moisture and drying curves, which were used then to determine the model parameters and validate the model. The mathematical model consisted of a partial, non-linear, differential equation of the second order and was characterized by coefficients that varied exponentially with moisture content; this later was integrated numerically through the finite volume method. Simulations of the transitory distribution of moisture gradients gave satisfactory results, and the drying curves were correlated with experimental data as well as the values of the parameters required by the proposed model.**

***Keywords*— drying, wood, radiata pine, diffusion.**

I. INTRODUCTION

The process of drying wood is particularly interesting due to the complexity of this material's porous matrix and the different form in which water can be found within it (free water in cavities of the porous matrix, water contained within cell walls). This complexity leads to diverse physical mechanisms of moisture transport (capillary flow, convection, diffusion) and is heightened by the high variability among species as well as differences resulting from the tree age, height of the cut, growing conditions, etc.

The modeling of moisture transport in wood can be viewed from a phenomenological point of view or in terms of the physics of the transport phenomena (Ananias *et al.*, 2005; Salinas *et al.*, 2008). The latter approach includes classical diffusion models such as those presented by Stamm (1964) or Siau (1984), models based on the thermodynamics of irreversible processes (Luikov, 1966), and those developed using Whittaker's multiphase approach (Whittaker, 1977).

This study focuses on diffusion models, which are advantageous given their simplicity in terms of the number of physical parameters required and numerical calculations. Wood drying simulations of conifers below the fiber saturation point (FSP) traditionally rely on these methods due to the dominance of diffusive transport in this range (Smith and Langrish, 2008; Hukka, 1999; Pang, 1997). When wood exceeds the FSP, diffusion models are limited by other dominant phenomena such as capillarity and permeability (Keey *et al.*, 2000). By the way, the researchers have formulated models that made difference above and below FSP like the one proposed by Davis *et al.* (2002). Nonetheless, diffusion models have also been used beyond the hygroscopic range; these use an effective water diffusion coefficient obtained as suggested for porous materials in general by Chen (2007) and employed to simulate the drying kinetics across the entire moisture range of conifer woods by Rozas *et al.* (2009). In this matter, we followed the suggestion of Hukka (1999), who simulated moisture transport in the transversal plane of Scots pine (*Pinus sylvestris*) based on the concept of an effective diffusion coefficient and proposed extending this simulation to moisture contents above the FSP.

In numerical terms, the finite volume method (Patankar, 1980) was implemented in order to integrate the diffusive transport equation, using a central difference for the second order derivatives and an implicit Euler scheme for the transitory term.

The parameters that ultimately determined the relationship between moisture content and moisture flow were calculated by solving the following inverse problem: Given a known drying curve and known moisture distributions in certain sections, we determined the effective diffusion coefficient in order to simulate the drying process using a diffusive transport equation. Moreover, it was necessary to calculate the mass convection coefficient required as a boundary condition at the wood/drying environment interface.

The objective of this work was to simulate the one-dimensional drying process of radiata pine over the entire moisture range using the concept of effective diffusion coefficient, which is dependent on the moisture content as proposed by Comstock (1963). This was used for one-dimensional modeling in the radial and tangen-