11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

IMPLEMENTATION OF FULLY COUPLED HEAT AND MASS TRANSPORT MODEL TO DETERMINE TEMPERTATURE AND MOISTURE STATE AT ELEVATED TEMPERATURES

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Key Words: *Wood, mass transfer, heat transfer, elevated temperatures.*

In an open porous hygroscopic material such as wood heat and moisture transport is a complex system of coupled processes. Inside timber, different phases of water can be observed, i.e., free water, bound water and gas phase of water (water vapour and air). Conservation equations for each phase with the exchange of mass between the different phases have to be considered. Different transfer phenomenon's can be applied for each phase. The bound water transfer model is assumed to follow Fick's law. More complex is the transfer of gaseous mixture. Transfer of water vapour and air is combined by the convective and diffusive model of transport. For the convective part Darcy's law is applied and for the diffusive part Fick's law is used. The free water constitutive relation is usually assumed to follow the generalized Darcy's law. All three processes are connected with each other thru the exchange of mass between the different phases, i.e., the conversion of vapour to free water and vice versa (condensation and evaporation), the conversion of vapour to bound water and vice versa (sorption) and the conversion of free water to bound water and vice versa. Thermal coupling is considered in temperature dependent diffusion coefficients where Fick's law is applied and temperature dependent mass velocity where Darcy's law is used. The equations describing the conservation of mass are supplemented with an equation describing the conservation of enthalpy. This equation takes three phenomena into account. Firstly, the usual conduction of heat thru solid, described by Fourier's law. Secondly, the changes in enthalpy resulting from change of phase, i.e. sorption, evaporation and condensation. And finally, the convective transfer of heat, i.e. the effect that heat is carried in the mass flux. These equations with corresponding initial and boundary conditions are generally non-linear and can be rarely solved analytically. Therefore, numerical methods have to be employed. The aim of these article is to present precise numerical formulation to determine temperature and moisture state of timber exposed to elevated temperatures expected in case of fire.