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Curves Characteristic of Natural Drying of Five Species of Wood

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Abstract

One hand, we will study the processes linked to evaporation and, on the other hand, the mechanisms governing the interactions of liquid water with the porous medium, which determines the mobility and distribution of water during a evaporation. First, we briefly recall some definitions concerning the structure of wood. Wood is industrially defined as an anisotropic and heterogeneous material formed over many years of a tree's life. And a study of the constituent elements of wood being oriented in several directions, it follows that its mechanical and physical properties differ in the longitudinal, radial or tangential direction. Wood is also a porous and hygroscopic material that exchanges moisture with the surrounding air before reaching its equilibrium moisture after a certain time. And since wood is a porous medium one gives the definition and some characteristics of porous media. In a second step, the results of the isothermal drying experiments carried out on the five wood samples of the same size but different types. Finally, we specify that this study carried out in the laboratory, under controlled conditions of relative humidity, temperature and agitation of air, and with distilled water as wetting fluid.

Keywords: evaporation, anisotropic, wood, humidity

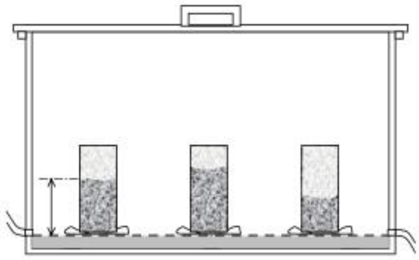
1. Introduction

Two phenomena allow the drying of wood: The diffusion of moisture in the material, the conditions of the ambient air. A fresh wood from a tree has a degree of moisture that varies between 40 and 100% water. The moisture is diffused by the evaporation of the water contained in the wood, which flows gradually from the internal parts to the drier outer parts. and this until reaching the hygroscopic equilibrium. Like all hygroscopic porous bodies, wood loses some of its water as soon as it is exposed to air when it is not too moist. The degree of moisture in the wood decreases until it becomes in equilibrium with that of the atmosphere. It is hygroscopic equilibrium, which is practically independent of gasoline. Our studies show where the balance lies. The purpose of drying is to partially or totally remove water from a wet body by evaporation. From a physical point of view, evaporation is a change of state corresponding to the passage of a body from the liquid phase to the vapor phase. This relatively simple concept, when it is at a free water surface for example, depends on various external parameters such as temperature, partial pressure of water vapor (relative humidity), agitation of air (speed of wind). In this case they are processes of diffusion and convection, which ensures the transport of water in vapor form. For the drying of a porous material (wood, rock, stone, etc.), that is to say for the evaporation of water in a porous network, it is also necessary to take account of the internal property which determines the displacement of the liquid water in the material.

2. Experimental Study

Conduct of the experiment

Cubic wood specimens have a surface area of 6.25 cm^2 and a height of 5 cm. The test pieces are first dried in an oven at 60°C. until the weight is stabilized. The imbibitions are carried out on these naked samples, placed vertically on a grid, in a basin at the bottom of which the level of distilled water is maintained constant throughout the duration of the experiment. Water and the base of the sample is ensured by a very porous disk soaked in water, the capillary feed is then provided by a film of approximately 1 mm



Experimental device for capillary imbibition

The samples

There are five samples which present in cubic form of 5 cm in height and of 6.26 cm^2 has the surface. These samples are of different types:

Sample1: Aleppo Pine

The Aleppo pine is one of the most typical and important forest species of the Mediterranean south. It belongs to the coniferous family it can reach 20 meters of height.
Its average density at 12%: 660 (Kg / m^3).

Sample 2: Maritime Pine

The maritime pine is a tree belonging to the coniferous family has large size, it can reach 30 meters tall. It has a rapid growth and longevity is about 200 years.
Its average density at 12%: 550 (Kg / m^3).

Sample 3: Sapin Rocaria

The fir Rocaria is a large tree, with a straight trunk and low branches spread out, can reach more than 60 m high in the natural state. The diameter of the trunk can reach 2 meters
Its average density at 12%: 490 (Kg / m^3).

Sample4: Eucalyptus grandis

Eucalyptuses, the genus Eucalyptus, are trees of the family Feuillus it can reach up to 60 m
Its average density at 12%: 650 (Kg / m^3).

Sample5: Pin Radiata

The pine Radiata is a large tree, it belongs to the family of conifers, its height between 30 to 40 m. It has a rapid growth and its longevity is of 200 years approximately.

Its average density at 12%: 504 (Kg / m^3).

The study of Sample 1 (Aleppo Pine)

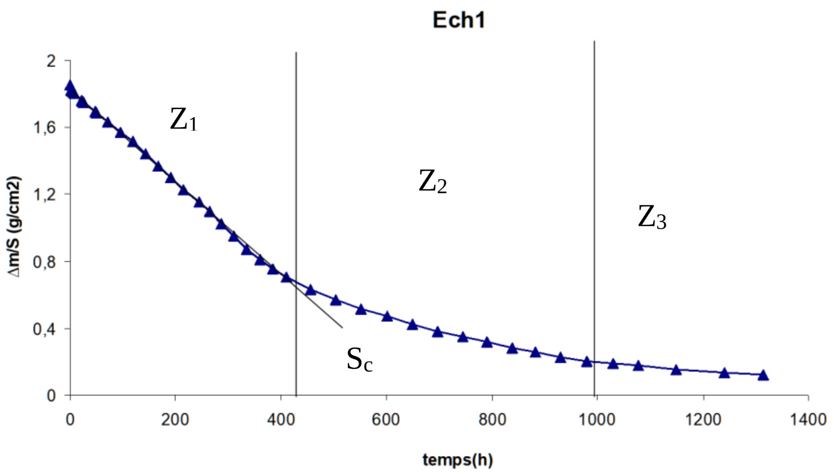


Figure1: Curve of evaporation kinetics of sample 1 at 75% relative humidity, test piece 5 cm high and 6.25 cm^2 surface area.

H.R 75%	Flux F1 ($g.cm^{-2}.h^{-1}$)	Sc (%)	T_{Sc} (h)
Ech 1	$-2{,}56.10^{-3}$	38	420

Table 1: Drying kinetics measured on sample 1 after capillary saturation at 75% relative humidity, temperature 22 °C. and without agitation of the air.

The curve of Sample 1 is characterized by three phases, the first is linear of constant high flux F1 = - $2.56.10^{-3}$ ($g.cm^{-2}.h^{-1}$) with tSC = 420h, and the critical saturation point is sc = 38%. Phase 2 is started just after the point of Sc that is nonlinear and its flux decreases with time. The last phase is linear with a very low flux which vanishes over time.

The study of Sample 2 (Maritime Pine)

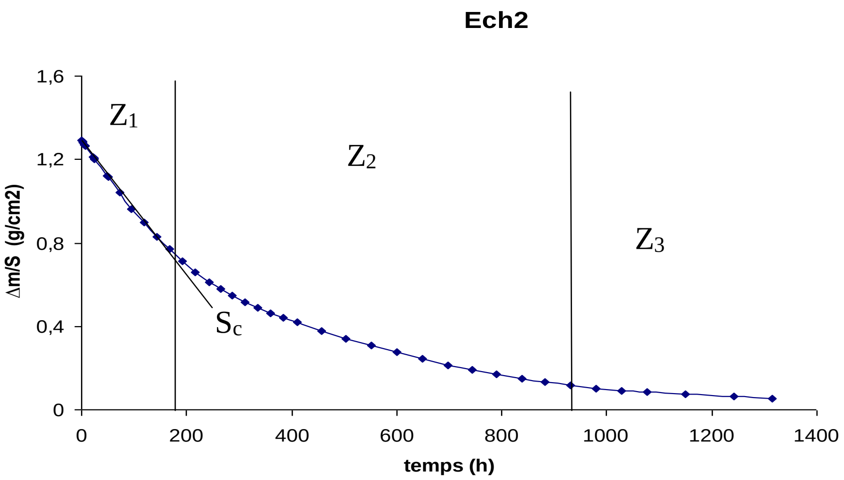


Figure 2: curve of evaporation kinetics of sample 2 at 75% relative humidity, test piece 5 cm in height and 6.25 cm^2 in area.

H.R 75%	Flux F1 ($g.cm^{-2}.h^{-1}$)	Sc(%)	t_{Sc}(h)
Ech 2	$-3,45.10^{-3}$	55,1	180

Table 2: Drying kinetics measured on sample 3 after capillary saturation at 75% relative humidity, temperature 22 °C. and without agitation of the air.

It can be seen that the evaporation kinetics curve of the sample 2 divides by three parts the first part is linear characterized by a high evaporation, ie a large flux which is constant F1 = -3.45×10^{-3} ($g.cm^{-2}.h^{-1}$), and a saturation time equal to 180 h, the critical saturation of E2 is 55.1%. The second phase begins at Sc is a nonlinear part its flux is decreasing with time. The last phase is linear and has a very low flux is constant vanishes over time.

The study of Sample 3 (Sapin Araucaria)

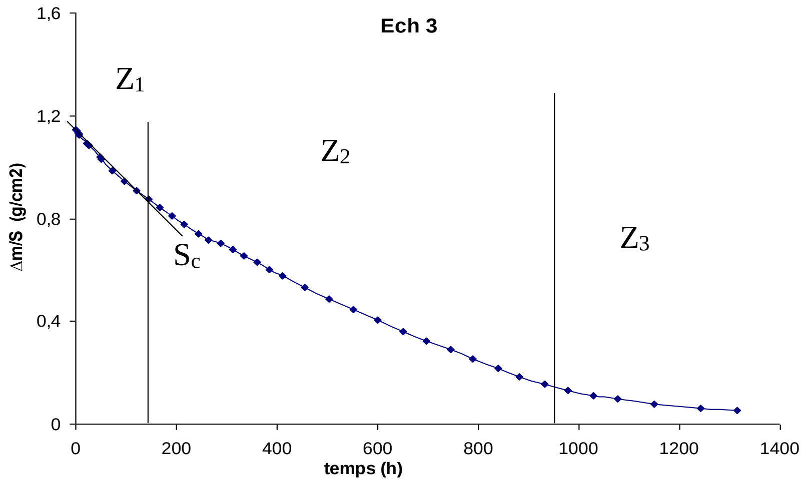


Figure 3: curve of evaporation kinetics of sample 2 at 75% relative humidity, test piece 5 cm high and 6.25 cm^2 of surface area.

H.R 75%	Flux F1 ($g.cm^{-2}.h^{-1}$)	Sc(%)	t_{Sc}(h)
Ech 3	$-2,2.10^{-3}$	76,4	140

Table 3: Drying kinetics measured on sample 3 after capillary saturation at 75% relative humidity, temperature 22 °C. and without agitation of the air.

It is possible to distinguish in the evaporation kinetics curve of the sample 3 three phases the first one which is linear has a constant flux F1 = - 2.2.10-3 ($g.cm^{-2}.h^{-1}$) and has a time of Critical saturation 140 h, the critical saturation in this sample is 76.4%, starting from the point Sc start the phase 2 which characterizes by a nonlinear curve, by a flux decreases with time, and at the end the third phase sa Curve is linear has a very low constant flux that vanishes over time.

The study of Sample 4 (Eucalyptus grandis)

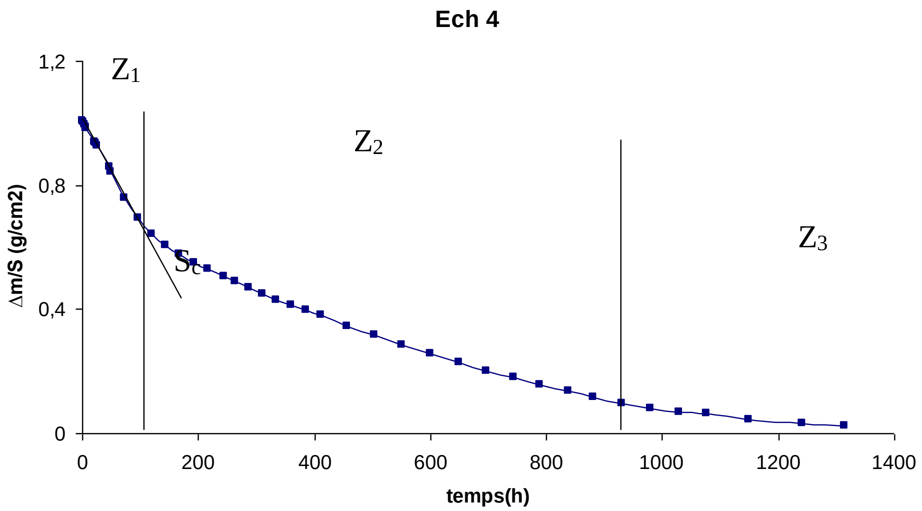


Figure 4: curve of evaporation kinetics of the sample 4 at 75% relative humidity, test piece 5 cm in height and 6.25 cm^2 in area.

H.R 75%	Flux F1 ($g.cm^{-2}.h^{-1}$)	Sc(%)	t_{Sc}(h)
Ech 4	$-3,37.10^{-3}$	68,6	100

Table 4 : Drying kinetics measured on sample 4 after capillary saturation at 75% relative humidity, temperature 22 °C. and without agitation of the air

The kinetic curve of the sample 4 consists of three zones, the first one being linear, a constant flux F1 = - $3.37.10^{-3}$ ($g.cm^{-2}.h^{-1}$), and a critical saturation point Sc = 68.6% its critical saturation time is tsc = 100h. From the critical saturation point begins Zone 2 that is non-linear its flow is decreasing over time, and at the end the 3rd zone its curve is linear has a very low constant flux which vanishes over time.

The study of Sample 5 (Pin Radiata)

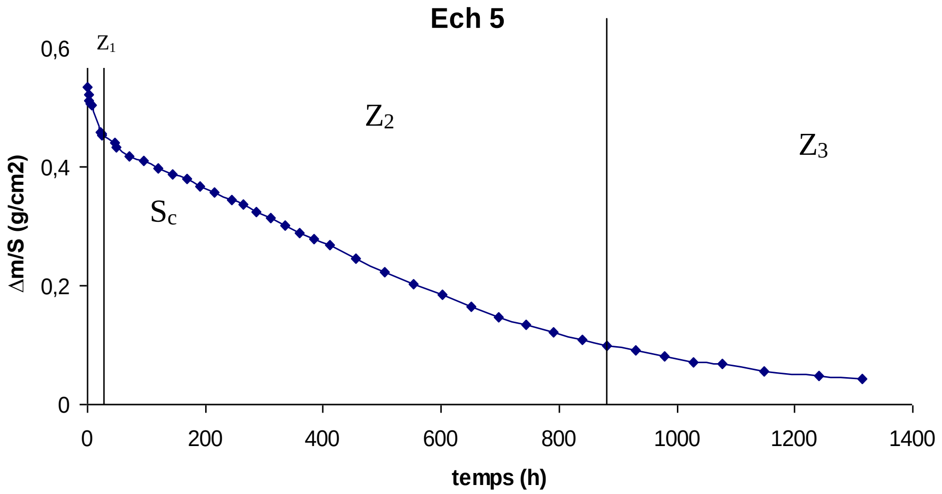


Figure 5: curve of evaporation kinetics of the sample 5 at 75% relative humidity, test piece 5 cm high and 6.25 cm^2 of surface.

H.R 75%	Flux F1 ($g.cm^{-2}.h^{-1}$)	Sc(%)	t_{Sc}(h)
Ech 5	$-2,8.10^{-3}$	86,1	25

Table 5: Drying kinetics measured on sample 5 after capillary saturation at 75% relative humidity, temperature 22 ° C. and without stirring of air.

It is observed that the kinetic curve of the sample 5 consists of three phases, the first being very short linear, not exceeding 25 h, but constant high flux F1 = -2.8×10^{-3}($g.cm^{-2}.h^{-1}$),and a very large critical saturation point Sc = 86.1%. The nonlinear phase 2 its duration is very long equal to its flux is decreased with time, and at the end of the 3rd phase its curve is linear with a very low constant flux which vanishes over time.

Comparison of all samples

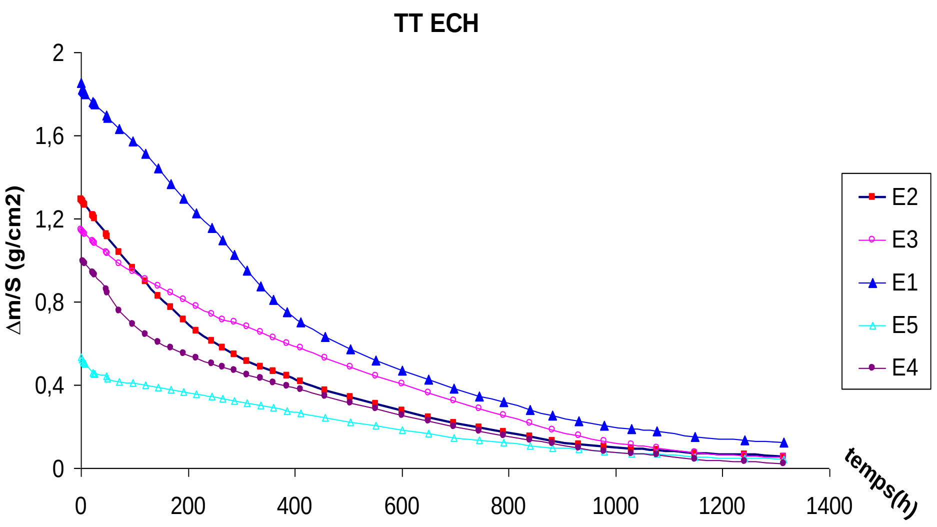


Figure 6: Curve of evaporation kinetics of all the specimens at 75% relative humidity, test piece 5 cm high and 6.25 cm^2 of surface.

H.R 75%	Flux F_1 ($g.cm^{-2}.h^{-1}$)	Sc(%)	t_{Sc}
Ech 1	$-2,56.10^{-3}$	38	420
Ech 2	$-3,45.10^{-3}$	55,1	180
Ech 3	$-2,2.10^{-3}$	76,4	140
Ech 4	$-3,37.10^{-3}$	68,4	100
Ech 5	$-2,8.10^{-3}$	86,1	25

Table 6: drying kinetics measured on all samples of wood after capillary saturation at 75% relative humidity, temperature 22 °C. and without agitation of the air.

We have samples of wood of the same size but have critical fluxes and saturation points and the critical drying time different from one to another one can interpret this variance by having samples of different type (Pin Aleppo, Maritime Pine, Rocaria Sapin, Eucalyptus fir, Radiata Pine), which leads to a porosity, water content and degree of saturation, that is to say the kinetics of absorbing and losing a quantity of water Is different from one to the other there are also factors related to the wood itself density, thickness, meaning, nature of wood.

3. Conclusion

The evaporation kinetics are represented by curves of loss of weight per unit area, or desaturation as a function of time. Usually, drying kinetics decompose into three phases. During the first phase, capillary transfers are sufficient to wet the surface and the evaporation flow (F1) is contant. The second phase starts from a critical saturation which depends on the relative humidity and initial saturation of the test piece during this phase, the flux decreases progressively as the evaporating surface dries out. During the 3rd phase, weight loss is constant but low. It corresponds to the diffusion of water vapor through the air contained in the porous network.

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