

ARTICULOS

EVALUATION OF WOOD SORPTION MODELS FOR HIGH TEMPERATURES

Marcia Vidal Bastías¹, Alain Cloutier²

ABSTRACT

Seven wood sorption models available in the literature were parameterized for prediction of equilibrium moisture content for temperatures up to 220°C. The criterion used to evaluate the models is the uncorrected sum of squares of differences between the predicted equilibrium moisture content and experimental values published in literature for temperatures between 0°C and 160°C. The results show that the Malmquist model gave the best overall fit to experimental data for the relative humidities considered (40%, 52%, 65%, 75% and 85%). However, the García model performs better for temperatures between 110°C and 155°C at a relative humidity of 85%. Therefore, the choice of the sorption model depends on the specific hygrothermal conditions required by the user.

Keywords: sorption isotherm, relative vapor pressure, equilibrium moisture content, mathematical modeling.

INTRODUCTION

Modeling of heat and mass transfer in wood and wood-based composites requires the knowledge of material properties such as thermal conductivity, permeability, and sorption isotherms. Experimental data and model predictions of the equilibrium moisture content (EMC) as a function of temperature and relative humidity have been published in the literature for temperatures below 100°C (Simpson 1973, 1980, 1981). However, few data and sorption models are available for temperatures above 100°C (Wood Handbook FPL 1999, Kubojima *et al.* 2003). Nevertheless, a reliable sorption model is required for the development of models of heat and mass transfer in wood and wood composites.

Available sorption data and models at high temperature

Sorption models have been evaluated rigorously by Simpson (1973) for temperatures between 0 and 100°C. Unfortunately, these models cannot be applied directly to processes such as the hot pressing of wood-based composite panels (García 2002, Humphrey 1989) and high temperature wood drying due to temperatures higher than 100°C reached in these processes. A modification of Bradley's model to determine relative vapor pressure as a function of wood moisture content and temperature has been extensively used for wood drying at temperatures below 100°C (Tremblay 1999, Defo 2000, Turner 1996). Representative conditions for high-temperature wood drying include temperatures up to 130°C and vapor pressure up to 250 kPa (Perré, 1996). For the hot-pressing of wood-based panels, temperatures vary typically from 150 to 220°C and vapor pressure can reach values up to 150 kPa depending on the type of panel. Unfortunately, there are no studies which indicate a sorption model appropriate for temperature and vapor pressure conditions encountered in these processes (Dai and Changming, 2004). Therefore, there is a major interest in understanding and determining the most appropriate model

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Received : July 21, 2005 . Accepted : October 03, 2005.

describing the relationship between EMC, relative humidity and temperature, especially for the numerical modeling of processes occurring at high temperature as recognized by Thoemen (2003) and García (2002). On the other hand, Kauman (1956), Kollmann (1961), Strickler (1968), Engelhardt (1979), Lenth and Kamke (2001) and Kubojima *et al.* (2003) emphasized the technical problems associated with the determination of EMC at temperatures over 100°C. For instance, one major difficulty is the construction of an airtight chamber into which temperature and relative humidity can be controlled accurately. This probably explains why EMC data and sorption isotherm models at temperatures over 100°C are relatively scarce.

Some experimental results describing wood sorption isotherms obtained at high temperatures have been reported by Kauman (1956) up to 156°C, Strickler (1968) and Engelhardt (1979) up to 170°C and the Wood Handbook (FPL 1999) up to 132°C. More recently, Lenth and Kamke (2001) and Kubojima *et al.* (2003) presented sorption isotherms at temperatures up to 160°C. These experimental results can be used as a basis for the re-parameterization of models available in the literature and for validation of the modified models. For this study, we used the data presented in the Wood Handbook (FPL 1999) and from Kubojima *et al.* (2003). The latter determined wood EMCs for temperatures between 107 and 160°C and for relative humidity between 75 and 99%.

Sorption theories for hygroscopic materials

A detailed description of several sorption theories was provided by Simpson (1973, 1980), Simpson and Rosen (1981), and Skaar (1988). These theories are intended to provide an explanation of water sorption in hygroscopic materials such as wood. The general shape of a sorption isotherm is shown in Figure 1. Generally, sorption isotherms present three zones according to the particular mode of water fixation in wood. Hearle and Peters (1960) and Skaar (1988) have reviewed sorption theories from the molecular standpoint. Water is believed to be hydrogen bonded to the hydroxyl groups of the cellulosic and hemicellulosic portions of wood. Not all hydroxyl groups are accessible to water molecules because cellulose molecules form crystalline regions where the hydroxyl groups of adjacent molecules hold them in parallel arrangement (Simpson 1980). Zone 1 of the sorption isotherm shown in Figure 1 is the result of Van der Waals forces on water molecules. The adsorption of water molecules continues progressively until the constitution of a monolayer which covers the external surface of the cell wall. At this moment, water exists as a rigid state due to the chemical bonds. The next zone (Zone 2) is produced when this first layer is saturated. It is characterized by the adsorption of water molecules on the first layer resulting in the creation of more layers. The isotherm in this zone can be represented graphically as growing linearly such as it is represented in Figure 1. In Zone 3, it is possible to find water in the liquid state in the wood capillaries. If we suppose that in the interface from Zone 2 to Zone 3 the adsorbed water covers the cell walls homogeneously, the layer thickness is enough to form liquid water in the pores by capillary condensation. Thus, micro capillary water forms a continuous phase.

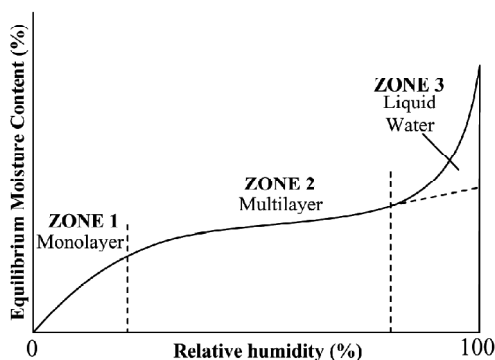


Figure 1. General shape of sorption isotherms (adapted from Jannot, 2003)

The process of water adsorption by wood is exothermic. The energies associated to this thermodynamic process such as heat of adsorption, vaporization of water, and heat of condensation have already been discussed by Hearle and Peters (1960), Skaar (1988) and Stamm (1964). The physical nature of sorption parameters in models are derived from the number of layers of molecules on a sorption site (n), number of sorption sites, thickness of adsorbed water, layers surfaces, and energies (C) involved during the sorption process. More details on the development of sorption models can be found in Skaar (1988), Simpson (1980), Siau (1995) and Jannot (2003). These models define the relationship between EMC, temperature and relative humidity. However, they can be expressed differently. A first group of mathematical expressions gives EMC as a function of temperature and relative humidity and a second group gives relative humidity as a function of EMC and temperature. We focus on the first group in the current work.

Values of the parameters used in the mathematical expressions of the sorption models for temperatures between 0 and 100°C were presented by Brunauer, Emmett, and Teller (BET) (1938), Hailwood and Horrobin (1946), Malmquist (1958) and King (1960). The Day and Nelson (1965) model has been tested at temperatures between 0 and 71°C by Avramidis (1989), and between 10 and 30°C by Ball *et al.* (2001) respectively. On the other hand, a model modified by García (2002) has been used for temperatures between 0 and 200°C.

The advantage of the models described above is mainly their easy mathematical manipulation and the good fit they provide to experimental data in the hygroscopic range. According to Siau (1995) EMC experimental data can also be related to mathematical expressions not mentioned above. For example, water potential could be associated to a logarithmic function to predict EMC in the complete range of moisture contents including the capillary sorption occurring above fiber saturation point according to the results presented by Cloutier and Fortin (1991). However, this function does not provide a very close fit to experimental data if we focus on the moisture content range below fiber saturation point.

Nowadays, mathematical and numerical modeling is increasingly used to simulate wood drying, hot pressing of composite panels and warping of wood-based composites in service. The availability of suitable mathematical expressions that relate EMC, relative humidity and temperature is basic in the development of such numerical models, especially when high temperatures are involved such as in the case of hot pressing of wood-based composite panels. Therefore, the objective of this study was to adapt and evaluate seven sorption models for temperatures between 0 and 220°C. The equilibrium moisture content below fiber saturation point was predicted from the models and compared to experimental data available in the literature in the 0 to 160°C temperature range.

SORPTION MODELS CONSIDERED

The models evaluated for the determination of EMC are the following:

Model 1 : Hailwood and Horrobin (1946)

$$M = \frac{1800}{M_p} \left[\frac{Kh}{1 - Kh} + \frac{\sum_{i=1}^n i(Kh)^i K_1 K_2 \cdots K_i}{1 + \sum_{i=1}^n (Kh)^i K_1 K_2 \cdots K_i} \right] \quad (1)$$

where

M = moisture content (%)

RH = relative humidity (%)

h = relative vapor pressure $\left(\frac{RH}{100}\right)$

1800 = molecular weight of water x 100 $\left(\frac{g}{mol}\right)$

n = number of hydrates formed ($i=1 \dots n$)

$K(T)$ = equilibrium constant between dissolved water and surrounding water vapor

$K_1(T), K_2(T) \dots K_i(T)$ = equilibrium constant between dissolved water and hydrates

$M_p(T)$ = molecular weight of a polymer unit that forms a hydrate $\left(\frac{g}{mol}\right)$

For equations (1) to (7)

T = temperature (K)

For a one hydrate model ($n = 1$) the equation is:

$$M = \frac{1800}{M_p} \left[\frac{Kh}{1 - Kh} + \frac{K_1 Kh}{1 + K_1 Kh} \right] \quad (2)$$

Model 2 : Hailwood and Horrobin (1946)

For a two hydrates model ($n = 2$) the equation is:

$$M = \frac{1800}{M_p} \left[\frac{Kh}{1 - Kh} + \frac{K_1 Kh + 2K_1 K_2 K^2 h^2}{1 + K_1 Kh + K_1 K_2 K^2 h^2} \right] \quad (3)$$

Model 3 : King (1960)

$$M = \frac{1800}{M_p} \left[\frac{BK_1 p_s (p_v / p_s)}{1 + K_1 p_s (p_v / p_s)} + \frac{DK_2 p_s (p_v / p_s)}{1 - K_2 p_s (p_v / p_s)} \right] \quad (4)$$

Where

P_v = partial vapor pressure (Pa)

P_s = saturated vapor pressure (Pa) (Note that $h = \frac{P_v}{P_s} = \frac{RH}{100}$)

$B(T)$ = constant proportional to the number of sorption sites in a monolayer

$K_1(T)$ = equilibrium constant between monolayer water and external vapor pressure

$D(T)$ = constant proportional to the number of sorption sites in a multilayer

$K_2(T)$ = equilibrium constant between multilayer water and external vapor pressure

Model 4: Malmquist (1958)

$$m = \frac{m_s}{1 + n \left[\frac{1}{h} - 1 \right]^{1/3}} \quad (5)$$

where

m = moisture content $\left(\frac{kg}{kg}\right)$

h = relative vapor pressure

$m_s(T), n(T), i(T)$ = temperature dependent parameters

Model 5 : Brunauer, Emmett, and Teller (1938)

$$m = \left[\frac{W_m Ch}{1-h} \right] \left[\frac{1 - (n+1)h^n + nh^{n+1}}{1 + (C-1)h - Ch^{n+1}} \right] \quad (6)$$

where

m = moisture conten $\left(\frac{kg}{kg}\right)$

h = relative vapor pressure

$C(T)$ = constant related to the energy of adsorption

$W_m(T)$ = moisture content when the monolayer is full

$n(T)$ = number of layers of molecules on a sorption site

Model 6: Day and Nelson (1965)

$$M = \left[\frac{\ln(1-h)}{(b_1 T^{b_2})} \right]^{\frac{1}{(b_3 T^{b_4})}} \quad (7)$$

where

M = moisture content (%)

b_1, b_2, b_3, b_4 = estimated parameters from Avramidis (1989) (-3.4x10⁻¹⁷; 5.98; 3x10² and -0.93)

h = relative vapor pressure

Model 7: García (2002)

$$m = \alpha(T) \left(\left(\frac{b}{h} \right)^d - 1 \right)^{\frac{1}{c}} \quad (8)$$

where:

$$\alpha(T) = a_1 \exp \left(- \left(\frac{T + a_2}{a_3} \right)^{a_4} \right)$$

and $a_1, a_2, a_3, a_4, b, c, d$ are defined constants from García (2002) (1865.75x10⁻⁴; 1025; 1163.31; 12.7441; 1.09603; 2.36069 and 1.84447)

m = moisture content $\left(\frac{kg}{kg}\right)$

h = relative vapor pressure

T = temperature (°C)

Parameterization procedure

The parameters of the models Hailwood and Horrobin for one and two hydrates (1946) (Eqs. 2 and 3 respectively), King (1960) (Eq. 4), Malmquist (1958) (Eq. 5), and Brunauer, Emmet, and Teller (1938) (Eq. 6) were calculated and extrapolated to cover a range of temperature from 0 to 220 °C from experimental sorption data available in Simpson (1973) up to 100°C. MATLAB® was used to fit polynomial or exponential functions to Simpson (1973) data for model parameters. The resulting equations were then extrapolated up to 220°C. For the Day and Nelson (Eq. 7) and García (Eq. 8) models, we kept the parameter values given by the authors because they were not defined as temperature dependent. The sorption models thus obtained were validated against experimental data as described below.

Comparison between sorption models

Sorption isotherms were calculated with the new parameters obtained for each model in order to compare them statistically. For this purpose, the EMC was evaluated at five different values of relative humidity: 40, 52, 65, 75 and 85% for temperatures varying between 0 and 160°C and compared to experimental data from the Wood Handbook (FPL 1999) and Kubojima *et al.* (2003). It is important to note that a statistical comparison up to 220°C was not possible due to the unavailability of experimental data in this range.

The criteria used to determine the model that gives the best fit to the EMC data is the uncorrected sum of squares (USS) of the differences between the EMCs predicted by the models and EMCs given in the Wood Handbook (1999) Table 3-4 and in Kubojima *et al.* (2003). The SAS version 9.1 software was used for that purpose. Since the EMC data available from Kubojima *et al.* (2003) were obtained from 0 to 160 °C at high relative humidity values, we calculated the USS within this range of temperature. During this analysis we did not take into consideration sorption hysteresis, possible variations of the sorption isotherms due to the different species of wood used for the determination of the sorption isotherms taken from the literature, and variations due to internal structures such as heartwood and sapwood (Ball *et al.* 2001).

RESULTS AND DISCUSSION

The following equations are the results of the parameterization procedure described above:

Model 1: Hailwood and Horrobin (1946)

For one hydrate model ($n = 1$)

$$\begin{aligned} K &= -1.5816 \times 10^{-7} T^2 + 0.0012829T + 0.37448 \\ K_1 &= -9.98 \times 10^{-6} T^2 + 0.007356T + 4.1436 \\ M_p &= 0.00039605T^2 + 2.151T - 417.03 \end{aligned} \quad (9)$$

Model 2: Hailwood and Horrobin (1946)For two hydrates model ($n = 2$)

$$\begin{aligned}
 K &= -3.3289 \times 10^{-8} T^2 + 0.00047238T + 0.68405 \\
 K_1 &= 4.05 \times 10^{-5} T^2 - 0.0587818T + 19.641 \\
 K_2 &= -0.000006414T^2 + 0.0016795T + 2.6172 \\
 M_p &= 0.00028368T^2 + 2.3468T - 330.03
 \end{aligned} \tag{10}$$

Model 3: King (1960)

$$\begin{aligned}
 B &= 2.287 \times 10^{-7} T^2 + 0.0099407T - 1.1322 \\
 K_1 &= 6857.3e^{(0.062T)} \\
 D &= 1.0394 \times 10^{-7} T^2 + 0.00083442T + 0.2677 \\
 K_2 &= 116.9e^{(-0.051T)} \\
 M_p &= 0.00030753T^2 + 2.025T - 372.72
 \end{aligned} \tag{11}$$

Model 4: Malmquist (1958)

$$\begin{aligned}
 m_s &= -5.8964 \times 10^{-7} T^2 - 0.00009736T + 0.40221 \\
 n &= -2.1825 \times 10^{-6} T^2 + 0.018552T - 2.6939 \\
 i &= 2.0637 \times 10^{-6} T^2 - 0.0016742T + 2.2885
 \end{aligned} \tag{12}$$

Model 5 : Brunauer, Emmett, and Teller (1938)

$$\begin{aligned}
 C &= -4.8631 \times 10^{-6} T^2 - 0.0022385T + 7.1289 \\
 W_m &= -5.87 \times 10^{-8} T^2 - 0.00020371T + 0.12258 \\
 n &= 3.7722 \times 10^{-6} T^2 + 0.033873T - 4.074
 \end{aligned} \tag{13}$$

where for all equations

 T = temperature (K)

The USS values obtained for each model at the relative humidity levels and temperatures considered are given in Table 1. The model providing the best fit to the experimental data is the one resulting in the lowest sum of uncorrected square (USS) of the differences between the EMCs predicted from the models and EMCs given in the Wood Handbook (1999) Table 3-4 and in Kubojima *et al.* (2003) over the range of relative humidity values (40%, 52%, 65%, 75% and 85%) and temperatures (0 to 160°C) considered.

For the range of relative humidities analyzed, the Malmquist model (Eq. 5) gave the lowest USS value (373.1 %²) followed by the Hailwood-Horrobin for two hydrates (Eq. 3) (441.8 %²), García (Eq. 8) (459.0 %²), Day and Nelson (Eq. 7) (533.6 %²), Hailwood-Horrobin for one hydrate (Eq. 2) (692.0 %²), BET (Eq. 6) (816.2 %²), and King (Eq. 4) (1293.0 %²) respectively. Therefore, the Malmquist model (Eq. 5) gave the best overall fit to the experimental EMC data.

On the other hand, we observe from Table 1 that the models performance varies depending on the relative humidity values. Our results show that the best model at 40% relative humidity is the Hailwood - Horrobin for two hydrates (Eq. 3) with an USS of 8.2 %². At 52% and 65% relative humidity, the best model is the Malmquist (Eq. 5) model with an USS of 7.7 and 4.6 %², respectively. Finally, the best model at 75% and 85% relative humidity is the García model (Eq. 8) with an USS of 66.9%² and 78.0%², respectively. It can be also noticed that generally, USS increases with relative humidity. This means that for higher values of relative humidity we have larger differences between predicted and experimental values.

Figure 3 presents the deviations obtained between EMCs calculated from the Malmquist model (Eq. 5) and experimental data from the Wood Handbook (1999) and Kubojima *et al.* (2003) for temperatures varying from 0 to 160°C. The deviations vary between -1.5 and 1.5 % EMC for temperatures between 0 and 90°C. From this point on, the deviations increase strongly as temperature increases, reaching 5.7 % in EMC for a relative humidity of 85%. It is noticeable from Figure 3 that the EMC deviation from experimental data increases also with relative humidity. This shows that even though the Malmquist model gives the best overall fit to experimental data, the deviation can be important at high temperature and relative humidity. Therefore, we compared again the models studied at 85% relative humidity for temperatures between 110°C and 155°C.

TABLE 1. Uncorrected sum of squares (USS) of differences in EMC obtained from the models studied and from experimental results of Wood Handbook (1999) and Kubojima *et al.* (2003) for temperatures varying between 0 and 160°C.

Models	Uncorrected sum of squares of differences in equilibrium moisture content (% ²)					Sum of USS (% ²)
	Relative humidity (%)					
	40	52	65	75	85	
H-H (Eq. 2)	12.0	12.4	11.6	237.6	418.4	692.0
H-H2 (Eq. 3)	8.2	9.0	6.5	158.1	260.0	441.8
King (Eq. 4)	14.9	30.0	64.1	259.0	925.0	1293.0
Malmquist (Eq. 5)	8.5	7.7	4.6	141.3	211.0	373.1
BET (Eq. 6)	9.3	23.9	37.7	342.3	403.0	816.2
Day and Nelson (Eq. 7)	13.1	36.6	43.3	193.0	247.6	533.6
García (Eq. 8)	169.9	127.2	17.0	66.9	78.0	459.0

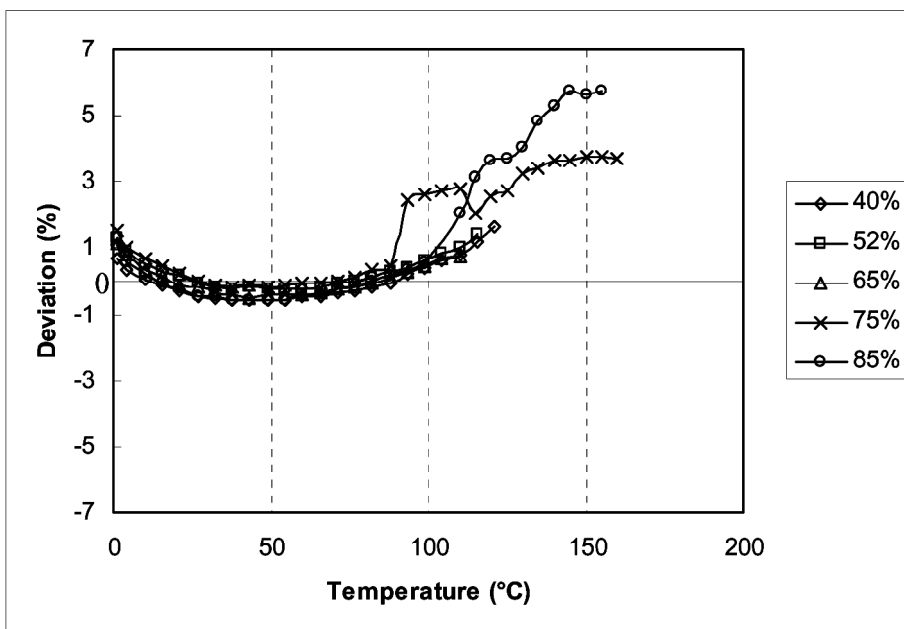


Figure 3. Deviations between EMC obtained with the Malmquist model and experimental results from the Wood Handbook (1999) and Kubojima *et al.* (2003) for temperatures varying between 0 and 160°C.

Comparison of models results to equilibrium moisture contents at high temperature from the literature

Table 2 shows EMCs obtained from the models studied compared to experimental data from the Wood Handbook (1999) and Kubojima *et al.* (2003) at 85% relative humidity for temperatures varying between -1.1°C and 155°C. The data of Table 2 surrounded by a dotted line show the results obtained for temperatures between 110°C and 155°C. A graph of the models EMCs versus experimental EMC for the data between 110°C and 155°C is presented in Figure 4. A perfect fit between model and experimental data would coincide with the dotted line shown in Figure 4.

From the results presented in Table 1 for 85% relative humidity, the García model (Eq. 8) is the more appropriate to predict EMC at 85% relative humidity with an USS of 78.0%² followed by the Malmquist model (Eq. 5) with an USS of 211.0 %². Also, according to the results presented in Table 2 and Figure 4, the García model is the most appropriate to predict EMC at temperatures varying between 110°C and 155°C at 85% relative humidity. This shows that depending on the temperature and relative humidity conditions necessary for a given application, the Malmquist model or the García model can be appropriate. However, if one requires a general sorption model to cover the complete range of relative humidity and temperature conditions considered in this study, the Malmquist model (Eq. 5) is the most appropriate of the seven sorption models evaluated to predict EMC. The sorption isotherms obtained from the Malmquist model for temperatures between 0 and 155°C and extrapolated to 220°C are presented in Figure 5.

TABLE 2. Comparison of EMC obtained for the models studied with experimental data from the Wood Handbook (1999) and Kubojima *et al.* (2003) at 85% relative humidity for temperatures varying between -1.1°C and 155°C. The data surrounded by a dotted line were considered as high temperature.

Temperatures °F(°C)	Calculated wood EMC (%)						Experimental wood EMC (%)	
	BET (1938)	H-H (1946)	H-H 2 (1946)	Malmquist (1958)	King (1960)	Day-Nelson (1965)	García (2002)	Wood Handbook (1999) and Kubojima <i>et al.</i> * (2003)
30(-1.1)	17.0	21.0	20.4	19.6	16.8	21.9	20.7	18.5
40(4.4)	17.0	20.0	19.7	19.1	18.3	21.5	17.0	18.5
50(10.0)	17.1	19.1	19.0	18.6	20.2	21.1	16.7	18.4
60(15.6)	17.1	18.4	18.4	18.1	22.4	20.7	16.4	18.2
70(21.1)	17.1	17.7	17.8	17.7	24.7	20.3	16.2	17.9
80(26.7)	17.1	17.1	17.3	17.3	27.0	19.8	15.9	17.7
90(32.2)	17.0	16.6	16.8	16.8	28.6	19.4	15.6	17.3
100(37.8)	17.0	16.1	16.3	16.4	29.1	18.9	15.3	17.0
110(43.3)	16.9	15.7	15.9	16.0	28.0	18.4	14.9	16.6
120(48.9)	16.8	15.3	15.5	15.6	25.7	17.9	14.6	16.2
130(54.4)	16.6	14.9	15.1	15.3	22.6	17.4	14.2	15.8
140(60.0)	16.5	14.6	14.7	14.9	19.5	16.9	13.9	15.3
150(65.6)	16.3	14.3	14.4	14.5	16.7	16.4	13.5	14.9
160(71.1)	16.1	14.1	14.0	14.2	14.3	15.9	13.1	14.4
170(76.7)	15.8	13.8	13.7	13.8	12.2	15.4	12.7	14.0
180(82.2)	15.6	13.6	13.4	13.5	10.5	14.5	12.3	13.5
190(87.8)	15.3	13.4	13.1	13.2	9.0	14.4	11.8	13.0
200(93.3)	15.1	13.3	12.9	12.9	7.8	13.9	11.4	12.5
210(98.9)	14.7	13.1	12.6	12.6	6.8	13.4	11.0	12.0
230(110.0)	14.1	12.9	12.1	12.0	5.1	12.4	10.0	9.9*
248(120.0)	13.4	12.7	11.7	11.5	3.9	11.5	9.2	7.8*
257(125.0)	13.1	12.6	11.5	11.2	3.4	11.1	8.8	7.5*
266(130.0)	12.7	12.6	11.4	11.0	2.9	10.7	8.3	6.9*
275(135.0)	12.3	12.5	11.2	10.7	2.5	10.3	7.9	5.9*
284(140.0)	11.9	12.5	11.0	10.5	2.2	9.9	7.5	5.2*
293(145.0)	11.5	12.5	10.8	10.3	1.9	9.5	7.1	4.5*
302(150.0)	11.1	12.4	10.7	10.0	1.6	9.1	6.6	4.4*
311(155.0)	10.6	12.4	10.5	9.8	1.4	8.8	6.2	4.1*

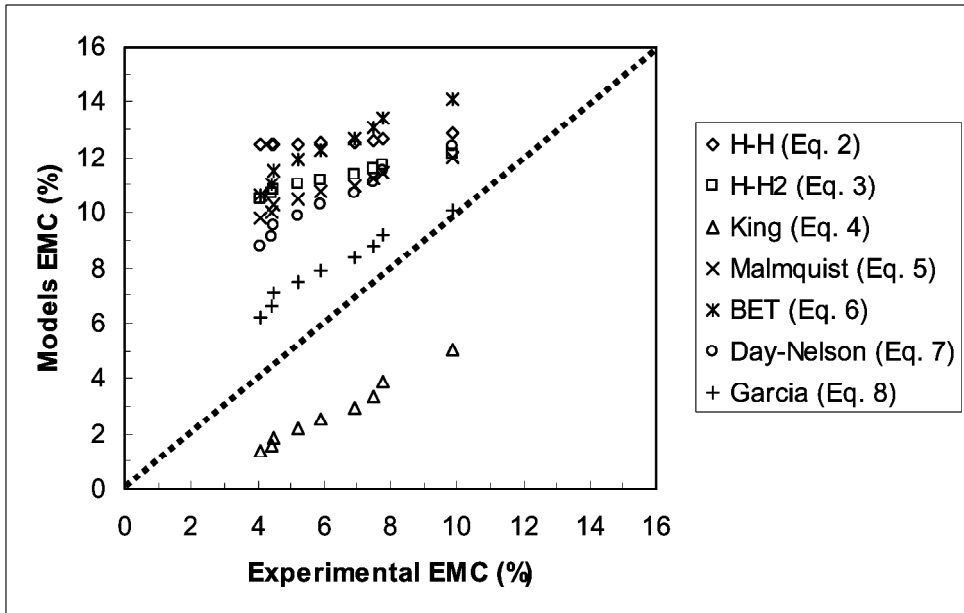


Figure 4. Relationship between EMC obtained from the models studied and experimental data from Kubojima *et al.* (2003) at temperatures between 110°C and 155°C at 85% relative humidity.

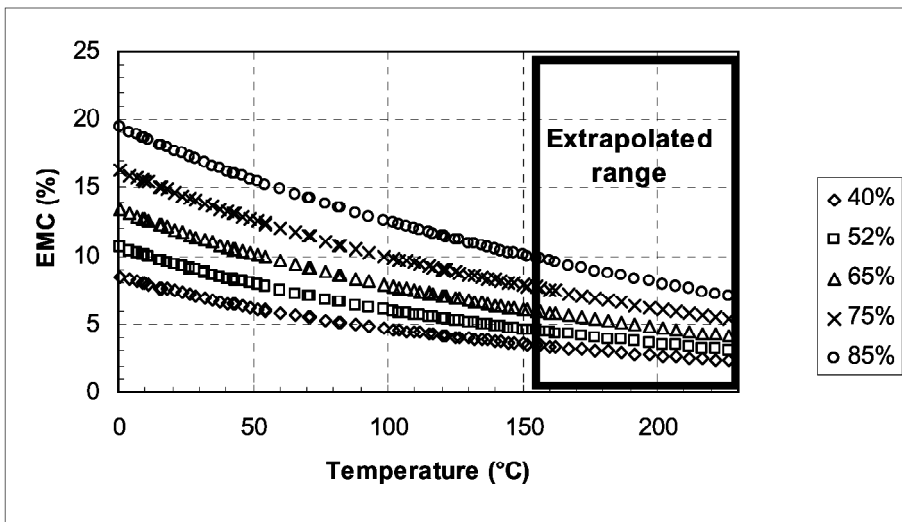


Figure 5. Equilibrium moisture content (%) obtained from the Malmquist sorption model at 40%, 52%, 65%, 75% and 85% relative humidity. The model results presented over 155°C were not validated against experimental results.

CONCLUSIONS

Seven sorption models available in the literature were extrapolated for temperatures up to 220°C. The resulting models were then used to predict equilibrium moisture content in the 0°C to 160°C temperature range and the results were compared to corresponding experimental data from the literature. The criteria used to determine the model that gives the best fit is the uncorrected sum of squares of the differences between the equilibrium moisture content predicted from the models and equilibrium moisture content given in the Wood Handbook (1999) and in Kubojima *et al.* (2003).

The results show that the Malmquist model gave the best overall fit to experimental data for the relative humidities considered (40%, 52%, 65%, 75% and 85%). However, the García model performs better for temperatures between 110°C and 155°C at a relative humidity of 85%. Therefore, our study demonstrates that the choice of the sorption model depends on the specific range of temperature and relative humidity conditions required by the user.

This study provides a useful guideline for the treatment of the sorption isotherm in the development of numerical models or control of processes such as wood-based panels hot-pressing or wood drying.

ACKNOWLEDGEMENTS

The authors would like to thank Mr. Gaétan Daigle of Département de mathématiques et statistiques, Université Laval for assistance and to the Natural Sciences and Engineering Research Council of Canada (NSERC) for funding under grant no. 121954-02.

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