HALF-DURATION OF HUMIDITY SORPTION CHANGES IN WOOD FLOORING

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Abstract

Half-duration of humidity sorption changes in wood flooring. Half-times and index exponents of equation enabling time calculation of wooden flooring equaling by adsorption or desorption to new climate conditions were determined.

Key words: *Sorption, moisture content, half-time, wooden flooring*

INTRODUCTION

Basic behavior of wood products in dwellings basing on literature was thorougly described by Domański, Matejak [2000]. Thermal comfort chart, based on Frank [1986], takes into account relative humidity and air temperature, shows calculated equivalent moisture content of wood in boundary conditions. Calculation of equivalent humidity was based on Krieczietow equations [1980]:

Relative humidity of air $\varphi = 0{,}0 \div 0{,}5$

$$W_r = W_0 + 0{,}72\,\varphi\left[29{,}5 - \left(\frac{T}{100}\right)^2\right];$$

$$W_0 = 0{,}36\left[13{,}9 - \left(\frac{T}{100}\right)^2\right]$$

Relative humidity of air $\varphi = 0{,}5 \div 1{,}0$

$$W_r = \frac{0{,}512}{1-\varphi}\left[21{,}7 - \left(\frac{T}{100}\right)^2\right]$$

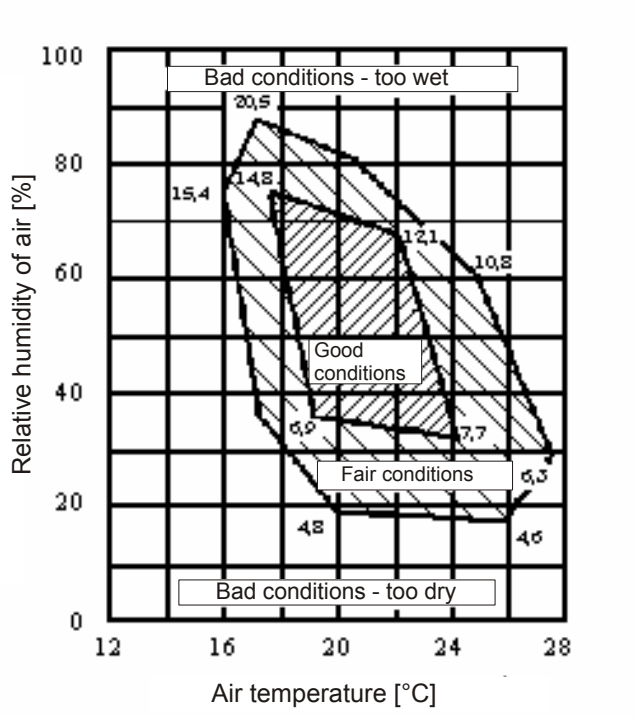

Fig. 1. Thermal comfort zones for wall temperatures 19,5 ÷ 23,0 °C and speed of air flow 0 ÷ 0,2 m/s (Frank [1968]) with marked equivalent humidity of wood (Domański, Matejak [2000]).

In human-friendly climate equivalent humidity of wood reaches 6,9 ÷ 14,8 % and in fair conditions 4,6 ÷ 20, 5 %.

Wood flooring humidity according to PN–EN 13226:2004 standard should be 7 ÷ 13 %. If wooden flooring with moisture content according to Polish Standard will be placed in room with fair conditions, after some long enough time its moisture content may increase by 13,5 or decrease by 8,4 percentage point.

Moisture content change rate of unpainted wood after placing in new climate conditions depends on dimensions and wood species [Hartwig 1959; Kollmann, Schneider, Serrand 1966].

Equation shows connection between equivalent humidity of wood in old and new climate conditions, seasoning time and half time:

$$\frac{W - W_p}{W_r - W_p} = 1 - e^{-k\left(\frac{\tau}{\tau_{0,5}}\right)^n}$$

where:

W – moisture content in wood in news climate after time τ,

W_p – initial moisture content of wood in new climate conditions,

W_r – equivalent moisture content of wood in new climate conditions,

k, n – empirical constants,

$\tau_{0,5}$ – half time (time in which moisture content of wood changes by half of initial and equivalent moisture content difference).

Solution of this equation by half-time
k = ln 2.

After knowing half-time one may calculate time of achieving assumed moisture content in news climate conditions:

$$\tau = \tau_{0,5}\left(\frac{1}{k}\ln\frac{W_r - W_p}{W_r - W}\right)^{\frac{1}{n}}$$

Analysis of the above equation shows, that reaching of the equivalent moisture content may take several times longer than half-time. Wood relatively quickly changes its moisture content from initial to half change; second part of the process takes longer time. Practical moisture content changes take place in half-time. Taking this into account it was decided to determine absorption and desorption half-time in wooden flooring.

MATERIALS AND METHODS

First sort oak wood floor boards in dimensions 200x60x22 [mm] were taken to experiment. From boards kept in climate conditions referring to 7 ÷ 9 % equivalent moisture content 10 pieces were picked randomly for each experiment (adsorption, desorption).

Adsorption half-time tests were performed first.

Test boards after weighting with accuracy ± 0,1 g were placed in desiccator containing NaCl water solution. Desiccator was placed in room with controlled temperature 20 ÷ 22 °C, average 21,4 ± 0,28 °C with variation coefficient ν =3,7 %. In above conditions relative humidity of air averaged 75,8 %. For desiccator climate equivalent moisture content of wood calculated accordingly to Krieczietow [1980] equations was 14,5 % - good conditions in thermal comfort chart (fig.1).

In aim to determine desorption half-time wood samples after weighting were placed in desiccator containing CH_3COOK water solution. Desiccator was placed in room with controlled temperature 21 ÷ 26 °C, average 24,7 ± 1,73 °C with variation coefficient ν =9,8 %. In above conditions relative humidity of air averaged 18,4 %. For desiccator climate equivalent moisture content of wood calculated accordingly to Krieczietow [1980] equations was 4,6 % - fair conditions in thermal comfort chart (fig.1).

During the both desorption and adsorption tests samples were removed periodically from desiccator and weighted with accuracy ± 0,1 g, ten times daily, then every two days and every four days. Samples were kept in desiccator until 12 days, when their weight did not change between subsequent tests – wood reached its equivalent moisture content. Initial and final moisture contend was calculated.

Having initial and final moisture content (recognized as equivalent) half-times $\tau_{0,5}$ were determined. After calculation of half-times and times and periods after weight of test samples was lower (adsorption) or higher (desorption) by 0,1 g — ($\Delta W \approx 0{,}99\ \Delta W_{max}$) from final weight, coefficients n were determined.

TEST RESULTS AND ANALYSIS

Experiment results are presented in table 1.

Table 1. Results of sorption humidity change tests of wooden flooring.

Value	Adsorption			Desorption		
	Range	Average	ν [%]	Range	Average	ν [%]
Initial humidity [%]	7,1 ÷ 8,7	7,90	6,48	6,2 ÷8,8	7,17	13,20
Final humidity [%]	13,7 ÷14,3	14,00	16,5	4,9 ÷ 5,8	5,35	5,80
Time of reaching final humidity [days]	58 ÷ 67	64,3	5,27	50 ÷ 65	58,6	10,65
Half-time [days]	4,6 ÷ 5,9	5,2	9,61	6,9 ÷ 8,3	7,52	6,04
Relative time	12,1 ÷ 3,5	12,5	—	6,6 ÷ 9,0	7,8	—
Index exponent n	0,69 ÷ 0,79	0,750	5,23	0,50 ÷0,83	0,657	15,19

Using reduced humidity and relative time moisture content plot change in time is presented.

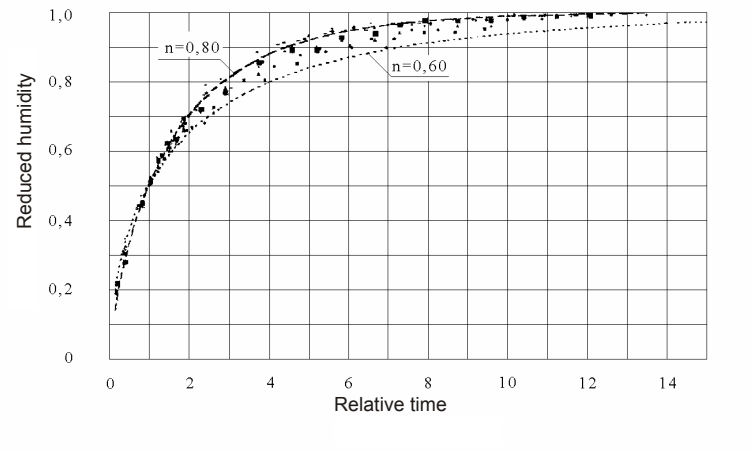

Fig. 2. Reduced humidity in relative time function plot – adsorption.

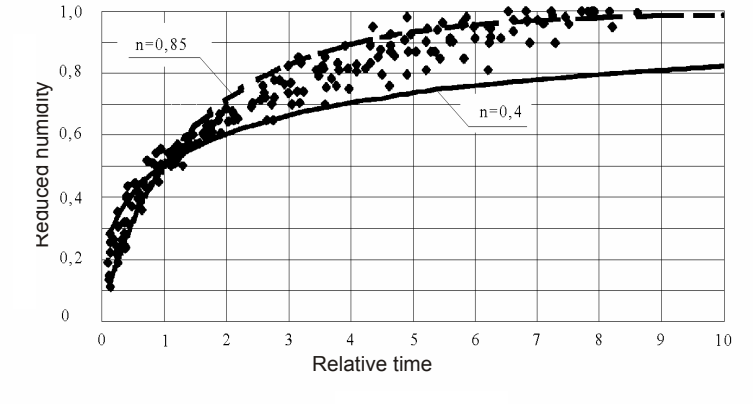

Fig. 3. Reduced humidity in relative time function plot – desorption.

Reduced humidity: $\frac{W - W_p}{W_r - W_p}$; Relative time: $\frac{\tau}{\tau_{0,5}}$

Adsorption half-time averaging 5,20 days, is shorter than desorption half-time averaging 2,32 days.

Average time of gaining equivalent humidity in adsorption process equals 64,3 days, it is longer by 5,7 days than desorption time.

Index exponent n averaging 0,750 with adsorption, is 0,093 higher than in desorption process.

Authors, considering low number of test wood flooring samples did not analyze differences between data gained in adsorption and desorption process. Obtained data is to be entry to more sophisticated research.

CONCLUSION

One practical conclusion may be withdrawn from experiment:
1.Wood flooring boards placed in room during winter (desorption) or summer (adsorption) may change their moisture content by 1,5 ÷ 3,5 percentage point in just 5 ÷ 8 days.

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