CAPILLARY PRESSURE IN WOOD

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Introduction. The invisible mechanism without moving parts drives the huge mass of water through plants. They absorb water microscopic root hairs and send on stalks to leaves where the part it is used for photosynthesis, and other part goes to the atmosphere. During the vegetative period it is movement goes continuously, and the large tree is capable to pump over through itself per day more than 2500 liters of water. Its evaporation by leaves called as a ***transpiration***, is an important component of a water cycle on Earth [2]. And all movement of water in wood up happens because of rather low pressure of water vapor in capillaries.

Influence of radius of a capillary on a vapor pressure. On basic data [1, page 74] made tabular model, is given in table 1. In it massifs X and Y basic data for introduction to the program CurveExpert-1.40 [3] environment are noted.

Table 1

Compliance of radius of a capillary with pressure of water vapor

Capillary radius in wood r, nanometer	Relative pressure of water vapor φ, %
0.67	20.00
1.17	40.00
2.11	60.00
4.83	80.00
10.25	90.00
21.90	95.00
107.00	99.00
1077.00	99.90

That says professor I.V. Krechetov [1, page 74] about the physical effect: «Pressure of water vapor in the capillary moistened by liquid over a concave surface of a meniscus is less, than over a flat water surface … From here it is visible that the vapor pressure considerably goes down only in ultramicroscopic capillaries …».

Note that the data in table 1 are valid only for the temperature 20 °C. The ratio between the radius of a capillary r and relative pressure decline of water vapor φ is suitable only for a raising explanation a tree on the considerable height of water solution of nutrients from roots for foliage.

The determined model. On Weibull's distribution received (fig. 1) a formula

$$\varphi = 99{,}31529 - 447{,}33912 \exp(-1{,}94294 r^{0{,}29330}) . \quad (1)$$

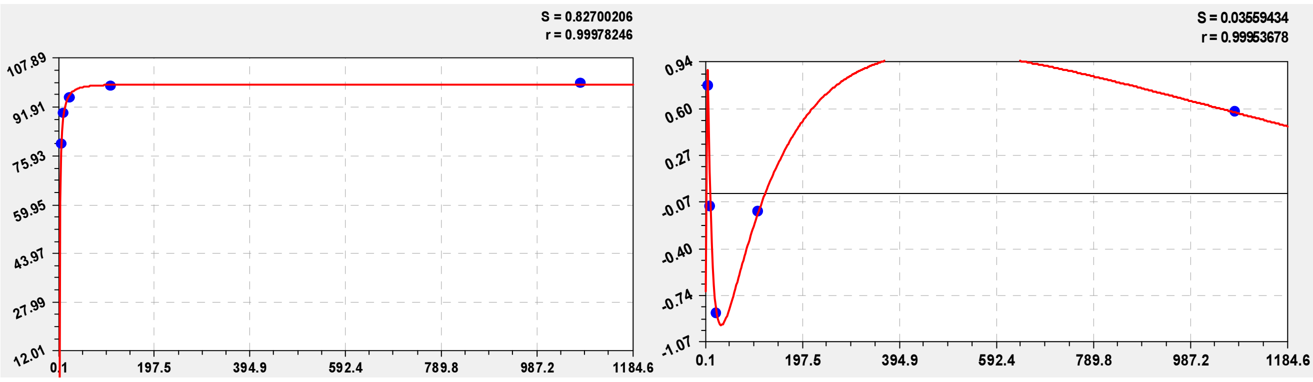

Fig. 1. Schedules of a trend (at the left) and wave function of a wavelet signal (on the right)

In the right top corner there are following designations: S - dispersion or sum of squares of deviations; r - correlation coefficient. The coefficient of correlation 0,9998 at the schedule in figure 1 (at the left) according to table 2 belongs to the level «almost unambiguous» model.

Assessment of an error of a trend. For such assessment it is necessary to add the table of 1 basic data, at least, with three columns (tab. 2).

In this table the following symbols are accepted: $\hat{\varphi}$ - the actual experimental values of relative pressure of water vapor on basic data [1, page 74], %; φ - settlement on model (1) value of an indicator, %; ε - absolute error of model (remains) from a formula (1), %; Δ - relative error of model (1), %.

The first four lines from table 2 belong to nanocapillaries. The maximum relative error is on the second line and is equal $|\Delta_{\max}| = 2{,}07\%$.

Table 2. **Assessment of an error of a trend of influence of radius of a capillary on pressure of water vapor at a temperature 20 ^{0}C**

Capillary radius in wood r, nanometer	Relative pressure of water vapor $\hat{\varphi}$, %	Calculated values on model (1)			Calculated values on model (2)		
		φ, %	$\varepsilon = \hat{\varphi} - \varphi$, %	$\Delta = 100\varepsilon / \hat{\varphi}$, %	φ, %	$\varepsilon = \hat{\varphi} - \varphi$, %	$\Delta = 100\varepsilon / \hat{\varphi}$, %
0.67	20.00	19.82	0.1803	0.90	20,00	0,0050	0,02
1.17	40.00	40.83	-0.8277	**-2.07**	40,01	-0,0135	**-0,03**
2.11	60.00	59.48	0.5169	0.86	59,99	0,0142	0,02
4.83	80.00	78.83	1.1698	1.46	80,01	-0,0146	-0,02
10.25	90.00	89.75	0.2510	0.28	89,99	0,0107	0,01
21.90	95.00	95.65	-0.6488	-0.68	95,00	0,0036	0,00
107.00	99.00	99.10	-0.1024	-0.10	99,00	-0,0028	0,00
1077.00	99.90	99.32	0.5848	0.59	99,90	-0,0028	0,00

Trend building. Because of high precision we will add in model (5.1) only one wavelet. Wavelet is a signal (fig. 1, on the right) therefore for the analysis of the sucking force of live wood of growing trees further it is necessary to analyse the general equation with wave component. For the physical and mathematical analysis of heat treatment of wood cages it is necessary to make experiments at high temperatures.

Combining trend with wavelet. Each new member has to be attached to the previous design of a formula [3]. The effect of «shake-up» and «consolidation» by analogy to packing of different subjects in a box is thus gained.

We will write down ready statistical model (fig. 2) in a look

$$\varphi = 99{,}36491 - 442{,}69694 \exp(-1{,}93249 r^{0{,}29733}) - A \cos(\pi r / p - 0{,}52199), \qquad (2)$$

$$A = 0{,}92273 r^{0{,}020768}, \quad p = 0{,}024240 + 0{,}14079 r^{0{,}95835},$$

where A - amplitude (half) of fluctuation, %, p - a half-cycle of fluctuation, nanometer.

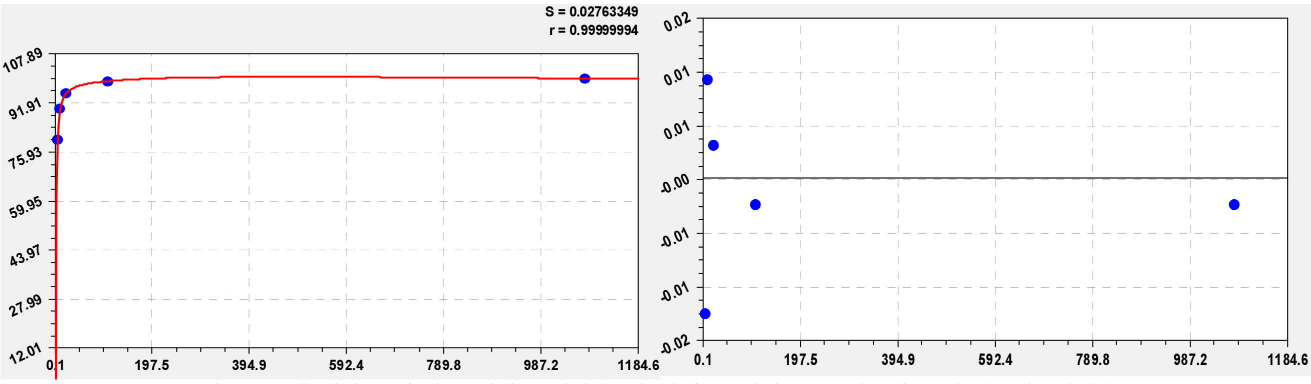

Fig. 2. Schedules of trinomial model (at the left) and the remains from it (on the right)

According to table 3 the maximum relative error of biotechnical regularity (2) is equal only 0,03%. Introduction of a wave component increased modeling accuracy in 2,07 / 0,03 = 69 times.

Conclusion. The remnants of figure 2 show that another possible wave component in nanoradii of capillary wood. But for further modeling it is necessary to make new experiments with much more exact measurements.

Literature

1. Krechetov I.V. Wood drying. Moscow: Forest industry, 1972. 440 pages.

2. Mazurkin P. M. Dendrometry. Statistical studying of a tree: manual H. 1. Yoshkar-Ola: MarSTU, 2003. 308 pages.

3. Mazurkin P.M. Solution of the twenty third problem of Hilbert // Interdisciplinary research in the field of mathematical modeling and computer science. Proceedings of the 3-rd scientific and practical internet-conference. Ulyanovsk: SIMJET, 2014. P 269-277.