UDC 674.815:631.572 ***Assoc. prof. R.O. Kozak – UNFU***

DETERMINATION OF THE EQUIVALENT DIAMETER AND SPECIFIC STRAW PARTICLES SURFACE

The values of the equivalent diameter and specific straw particles surface based on their dimensions, shape and average diameter of sieve holes after sieve analysis of particles were determined. It was graphically described the dependencies of specific straw particles surface of their longitudinal comminution degree, the ratio of length to diameter of particles and the multiplicity coefficient of this ratio.
Keywords: equivalent diameter, specific surface, straw particle, sphericity factor.

Formulation of the problem. When you are making the research of technological processes of drying, pneumatic transportation, resination of crushed particles the great importance is the size, shape and the area of particles, which are expressed of their equivalent diameter (d_e) and specific surface (a), according to formulas [1-4]:

$$d_e = \varphi \cdot d_{\kappa\,V} = \frac{d_{\kappa\,V}}{f} = \varphi \cdot \sqrt[3]{\frac{6 \cdot V_ч}{\pi}} = \varphi \cdot \sqrt[3]{1{,}91 \cdot V_ч} \tag{1}$$

$$a = \frac{6 \cdot \pi \cdot d^2_{\kappa\,V} \cdot f}{\pi \cdot d^3_{\kappa\,V}} = \frac{6 \cdot f}{d_{\kappa\,V}} = \frac{6}{d_e} \tag{2}$$

where: φ – sphericity factor; f – a geometric shape factor; $d_{\kappa V}$ – diameter of the sphere, whose volume (V_κ) is equivalent to the volume of the particle ($V_ч$), m.

However, for straw particles which are different in shape from wood particles the values of these parameters are not available. That's why the determination of the equivalent diameter and specific surface of straw particles for further use in technological calculations of straw particleboard production processes is relevant.

Results. The volume of straw particles of certain size can be written as follows:

$$V_ч = n \cdot \left(V_c - V_n\right) = 0{,}25 \cdot \pi \cdot n \cdot l \cdot \left(d_c^2 - d_n^2\right) \tag{3}$$

where: V_c – volume of straw without internal cavity; V_n – volume of the cavity of straw; n – coefficient which taking into account the longitudinal degree of straw particles (n = 1 for tube-shaped particle; n = 1/2 for half tube-shaped particle, etc.); l – length of the straw particle; d_c and d_n – respectively the outer and inner diameters of the straw particles body.

The sphericity factor for straw particles is [5]:

- for tube-shaped straw particles:

$$\varphi = \frac{\left(1{,}5 \cdot l \cdot \left(d_c^2 - d_{ì}^2\right)\right)^{2/3}}{0{,}5 \cdot \left(d_{ñ} + d_{ï}\right) \cdot \left(2 \cdot l + d_{ñ} - d_{ï}\right)} \tag{4}$$

- for non tube-shaped straw particles:

$$\varphi = \frac{\pi \cdot \left(1{,}5 \cdot n \cdot l \cdot \left(d_c^2 - d_n^2\right)\right)^{2/3}}{0{,}5 \cdot n \cdot \pi \cdot \left(d_c + d_n\right) \cdot \left(2 \cdot l + d_c - d_n\right) + d_c - d_n} \tag{5}$$

Taking into account formulas (1) – (5) equivalent diameter and specific surface of straw particles respectively is:

- for tube-shaped straw particles:

$$d_e = \frac{3 \cdot l \cdot \left(d_c - d_n\right)}{2 \cdot l + d_c - d_n} \tag{6}$$

$$a = \frac{4}{d_c - d_n} + \frac{2}{l} \tag{7}$$

- for non tube-shaped straw particles:

$$d_e = \frac{1{,}5 \cdot \pi \cdot n \cdot l \cdot \left(d_c^2 - d_n^2\right)}{0{,}5 \cdot n \cdot \pi \cdot \left(d_c + d_n\right) \cdot \left(2 \cdot l + d_c - d_n\right) + d_c - d_n} \quad (8)$$

$$a = \frac{2 \cdot \pi \cdot n \cdot \left(d_c + d_n\right) \cdot \left(2 \cdot l + d_c - d_n\right) + 4 \cdot \left(d_c - d_n\right)}{\pi \cdot n \cdot l \cdot \left(d_c^2 - d_n^2\right)} \quad (9)$$

According to formulas (6) and (8) the values of equivalent diameter of straw particles depending on their longitudinal comminution degree (form), the length of the particle, the maximum and minimum diameters of straw and its cavities, which are submitted in Table 1 were calculated. According to formulas (7) and (9) the graphical dependency of diameters influence, length and coefficient of longitudinal comminution degree of straw particles on its specific surface (Fig. 1) were obtained.

According to Fig. 1 the particles with the ratio of length to diameter which is equal to unity when the coefficient of longitudinal degree is minimal have the most specific surface. When the coefficient of longitudinal degree of straw particles increases, its specific surface decreases and reaches a minimum when this coefficient is equal to unity, which corresponds to the tube-shaped straw particle.

Table 1. The value of the equivalent diameter (d_e) of straw particles for certain dimensions and their longitudinal comminution degree

Length of the straw particles, mm	The longitudinal comminution degree of straw particles							
	n = 1 (tube-shaped)		n = 0,5 (half tube-shaped)		n = 0,25 (1/4 of tube-shaped)		n = 0,125 (1/8 of tube shaped)	
	max	min	max	min	max	min	max	min
2	2,000	0,667	1,899	0,609	1,808	0,561	1,650	0,484
5	2,500	0,714	2,435	0,687	2,374	0,661	2,260	0,615
10	2,727	0,732	2,688	0,717	2,651	0,703	2,578	0,676
15	2,813	0,738	2,785	0,728	2,758	0,718	2,705	0,699
20	2,857	0,741	2,836	0,733	2,814	0,726	2,773	0,711
25	2,885	0,743	2,867	0,736	2,850	0,730	2,816	0,718
30	2,903	0,744	2,888	0,739	2,874	0,734	2,845	0,723

Note. Diameter of straw: max – 5 mm, min – 1 mm; diameter of straw cavity: max – 3 mm, min – 0,5 mm [6].

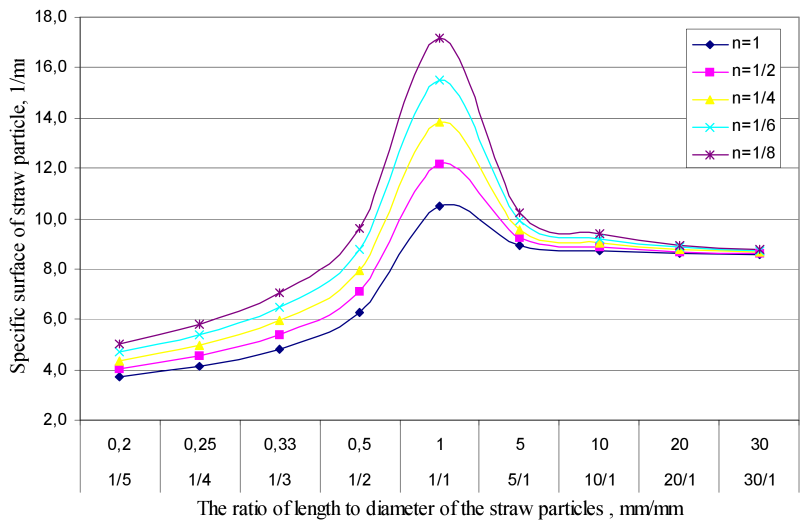

Fig. 1. Dependence of specific straw particles surface of their sizes and longitudinal comminution degree

The increasing of the straw particles diameter when the other parameters are constant causes a rapid decrease of its specific surface. Herewith the ratio of the length to particles diameter is less than unity. When the value of the ratio of the length to its particle diameter increases greater than unity, which corresponds to the particles length increase at constant other parameters, the value of the specific straw particles surface decreases. However, this decrease is less significant than the straw particles diameter increase. An example is the dependence of specific straw particles surface from the multiplicity of its dimensions when the coefficient of longitudinal comminution degree is constant (Fig. 2). According to Fig. 2 specific particles surface decreases with the increasing of their sizes when the coefficient of straw particles longitudinal comminution degree and the ratio of length to diameter of straw particles is constant. Furthermore, the diameter of the particle has greater impact on specific surface then the length of the particle. This dependence is described by the power function.

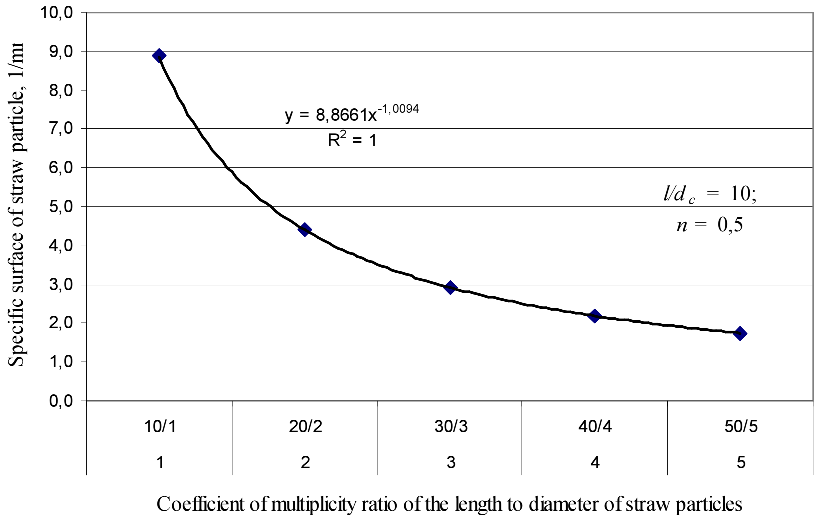

Fig. 2. The dependence of specific straw particles surface from the multiplicity of its ratio of length to straw particles diameter when the coefficient of longitudinal comminution degree is constant

In working conditions of particle boards production is not always possible to determine the size of particle. It is used to operate the fractional composition parameter of the particles, which is determined by sorting. That's why the determination of equivalent diameter and the specific surface of straw particles through the particle properties of separate fraction are important. The equivalent diameter and specific straw particles surface of separate fractions can be calculated by the average diameter of sieve holes where the particles pass, and where the particles are delayed [4, 5]:

$$d_e = \frac{k_V^3}{k_F^2} \cdot d_{o.c} \qquad (10)$$

$$a = \frac{6 \cdot k_F^2}{k_V^3 \cdot d_{o.c}} \qquad (11)$$

where: k_F – proportionality coefficient between the diameter of the ball which is equivalent to the particle with the same surface ($d_{\kappa F}$) and the average diameter of sieve holes where the particles pass, and where the particles are delayed ($d_{o.c}$); k_V – proportionality factor between the diameter of the ball (with the same volume as particle) ($d_{\kappa V}$) and the arithmetic mean of two sieves holes diameter through the first sieve particles pass, and on the second one - delays ($d_{o.c}$). Proportionality factors k_F and k_V are defined by the formulas [5]:

$$k_F = 2{,}5387 - 0{,}2762 \cdot d_{o.c} + \frac{0{,}3416}{d_{o.c}}, \qquad (12)$$

$$k_V = 1{,}2491 - 0{,}0527 \cdot d_{o.c} + \frac{0{,}2446}{d_{o.c}}. \qquad (13)$$

Using the formulas (10)-(13) the values of equivalent diameter and specific straw particles surface of the separate factions which are listed in the Table 2 were calculated.

Table 2. The value of the arithmetic mean of two sieves holes diameter, equivalent diameter and specific straw particles surface of the separate fractions

Parameters	Fractions				
	5,0/3,15	3,15/2,0	2,0/1,25	1,25/0,63	0,63/0,315
$d_{o.c}$	4,075	2,575	1,625	0,940	0,473
d_e	2,3833	1,1826	0,6968	0,4188	0,2547
a	2,5176	5,0738	8,6103	14,3281	23,5565

Conclusions. The particles, whose ratio of length to diameter is equal to the unit at a minimum longitudinal degree, have the largest specific surface. By increasing the coefficient of the longitudinal degree, the specific surface of straw particles decreases. When this coefficient is equal to unity, that is the characteristic of tube-shaped straw particle, it reaches a minimum. Increasing the straw particles diameter when the other parameters are constant causes a rapid decrease of its specific surface.

Also found that decreasing of straw particle fractions size causes the increasing of its specific surface. In particular, the decreasing of fraction from 5.0 / 3.15 to 0.63 / 0,315 causes the specific surface increasing of more than 9 times. The obtained values of equivalent diameter and specific straw particles surface, based on the results of calculations of the sieve analysis are equal to the results of the calculations of these parameters by the size and particles form. However, the method of determining the equivalent diameter based on the results of sieve analysis is technically much simpler.

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Визначення еквівалентного діаметра та питомої поверхні солом'яних частинок

Визначенні значення еквівалентного діаметра й питомої поверхні солом'яних частинок за їх розмірами, формою та середньоарифметичним діаметром отворів сит після ситового аналізу частинок. Графічно описано залежності питомої поверхні солом'яних частинок від частки їх поздовжнього поділу, співвідношення довжини до діаметра солом'яних частинок та коефіцієнта кратності цього співвідношення.

Ключові слова: еквівалентний діаметр, питома поверхня, солом'яна частинка, коефіцієнт сферичності.

UDC 674.028.9 ***Assist. V.R. Solonynka, assoc. prof. B.Ya. Kshyvetskyy – UNFU***

WATER EFFECT ON THE STRUCTURE OF ADHESIVE FILMS FORMED BY PVA DISPERSION-BASED COMPOSITION

The results of studies of water effect on the structure of polymeric films formed by modified and non-modified polyvinylacetate dispersion-based adhesives (PVAD-51P trade mark) are given. Also, conclusions have been drawn concerning applicability of PVA adhesives, modified with Fenton reagent or acid-salt complex, for glueing wood parts depending on the usage environment for the produced articles.

Key words: modifying agent, polyvinylacetate (PVA) dispersion, polyvinyl alcohol, spectrophotometer, infrared (IR) spectroscopy, absorption rate, transmission capacity.

Problem formulation. The manufacture of products in joinery, furniture making and other branches of woodworking industry involves application of glueing operations, proper choice of adhesive compositions being of great importance. The choice is primarily influenced, along with economic factors, by the product's intended use and service conditions. However, it is not unfrequent practice in furniture industry to brush aside demands for ensuring appropriate water- and heat resistance of adhesive joints when making articles for indoor area service. It should be noted that such an approach is unacceptable for kitchen furniture, bathrooms as well as wares to be used in unheated housekeeping areas.

For the purpose of ensuring appropriate service characteristics of glued articles, a great variety of PVA dispersion-based composition have been developed in woodworking industry, while a large number of researchers all over the world are engaged in finding ways of enhancing operational performance of adhesive joints [3,4,6,7]. However, despite the fixed interest in this direction of investigations, the majority of the research works give little attention to the study of aggressive environment effects on polymeric films. That is why the objective of this work is to investigate the direct water effect on polymeric films which are formed by modified and non-modified PVA dispersions. This is to be done by studying chemical transformations of their composition by means of infrared spectral characterization of adhesive films transmission capacity.

Methods and materials. The dibutyl phthalate-plasticized PVAD-51P dispersion was chosen as the basis composition to conduct the experiments. Fenton reagent was used as a modifying agent (an oxidation-reduction complex composed of ferrous sulphate (II)($FeSO_4$)) and hydrogen peroxide (H_2O_2, 35%), alternatively was used the mixture of a 30% aqueous solution of nitric acid (HNO_3) and Aluminium nitrate ($Al(NO_3)_3$) as modifying agent. The infrared spectra within the range of wavenumbers of 4000–400