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STUDY AND OPTIMIZATION OF PULP PAPER COMPOSITION TO PRODUCE PACKAGING PAPER

The paper deals with the study of paper pulp composition influence on properties of paper based on waste paper raw materials. Application of the method of mathematical planning and solution of optimization tasks helped to establish the optimum contents of a sizing agent and cationic starch in the paper pulp composition, comprising 0.109 и 0.5% of a. d. f. respectively. It is shown that the degree of paper pulp beating should be 45°ShR in order to achieve the required values of breaking length 3700 m, tensile energy absorption 34.2 J/m², bulk 2.39 sm³/g and elongation 1.6 mm.

Introduction. Developing technology of pulp and paper industries play an important role in reducing the resource-specific processes, improving the properties of the obtained materials and especially in improving the strength properties of paper and paperboard.

It may be noted some of the known ways of improving the strength characteristics of paper products: increased bond strength, improvement of paper web forming, application of chemical products having active groups with high energy of bond formation in the molecule, optimization of grinding, because there are the main components of weight in addition to chemicals: fiber and water, where fiber creates durable canvas not only due to the colloidal interactions and chemical bonds, but also due to mechanical interlacing.

However, it should be mentioned that the production of paper and paperboard is unthinkable without the use of natural and synthetic chemicals having inorganic and organic origin, without chemical technology not adapted to the specific conditions which solves the problem of increasing productivity of paper machines and the quality of products, of semi-finished products economy and fresh water and energy saving, of problem of environmental safety.

Previously, it was found [1] that the compositional change in the pulp leads to both structural and strength property changes of samples made of paper. Thus the smaller bulk is typical for paper samples with sizing agent in the composition. It is connected with the use of starch in furnish. It provides increased retention of the sizing agent in the paper structure as well as securing of small fibers binding. Their content is expanded with increase of beating rate.

Importantly the use of chemicals in combination with starch for hydrofobisation in the compositions of chemical pulp leads to an increase of tensile energy absorption. It indirectly characterizes change of quantity of the interfiber bonding force in paper. At the same time the rigidity of the test samples increases. Higher values are observed in the indicator sample containing the sizing agent composition in combination with starch.

Thus, the quality of the manufactured paper products is affected by several factors. Their operational management and control will provide competitive products on the world market with the desired combination of structural and mechanical properties.

Main part. The aim of this paper was to study pulp composition and optimization of the main factors (freeness pulp costs and auxiliary chemicals) of production of packaging paper from waste paper with the desired combination of structural and mechanical properties.

As starting materials for production of the fibrous paper samples mixed waste paper (GOST 10700-97) were used. Sizing paper pulp was performed with emulsion based on alkylketene dimers (AKD) (Ultrasize-200) in combination with cationic starch (Hi-Cat C 323 A).

The mathematical experiment planning with the implementation of Kono's plan was used to determine the optimal parameters of the manufacturing process of the paper samples [2].

The flow of cationic starch (X1), the flow rate of the sizing agent (X2) and the pulp freeness (X3) were varied in the composition of the pulp.

Selected factors are measurable with sufficient precision, controlled and unambiguous, compatible one with the other and not linked by linear correlations. Experimental conditions are represented in Table 1.

Table 1

Experimental conditions

Variation Factors	Variation Levels		
	1	2	3
X1	0.5	0.6	0.7
X2	0.08	0.10	0.12
X3	35	40	45

The following indicators were selected as optimization criteria comprehensively characterizing the quality of the manufactured paper products: bulk, cm³/g (Y1); elongation, mm (Y2); breaking length, km (Y3); tensile energy absorption (TEA), J/m^2 (Y4); absorbency at unilateral wetting, g/m^2 (Y5). Additionally, elastic modulus, GPa (Y6) and tensile strength, kN/m (Y7) were determined.

The tests results made of paper samples are presented in Table 2.

Based on the experimental data using MS Excel package coefficients second-order polynomial equations describing the change of indicators Y1–Y5 depending on the factor process X1–X3 were calculated. Adequateness of the mathematical models was evaluated by F-test [2]. Three-dimensional diagrams representing a graph of the quality indicators (bulkiness, breaking length, tensile energy absorption) of the paper samples made from the costs of the sizing agent and the cationic starch at fixed freeness pulp (35, 40 and 45°ShR) have been constructed for analysis of the obtained results. It is shown in Fig. 1–3.

As can be seen from Fig. 1 the maximum plumpness value of paper samples (2.40–2.70 cm³/g) was observed at a cost of cationic starch and sizing agent (0.1 and 0.6% on a. d. f. respectively over the entire range of variation of the pulp freeness). However samples of paper made from pulp with a freeness of 35°ShR have the greatest values of bulk.

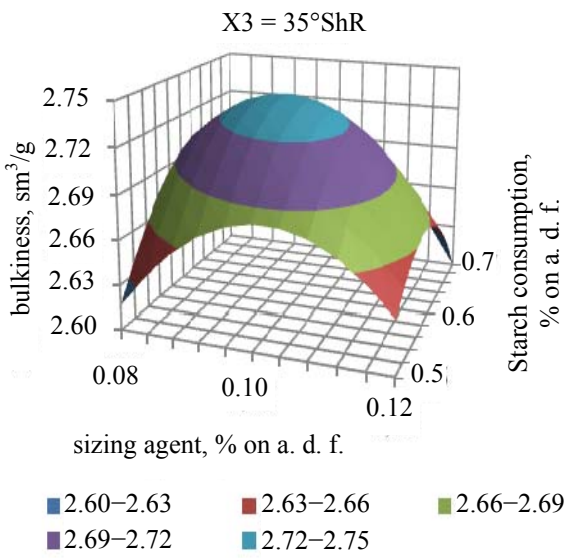
Relatively high values of bulkiness of paper samples with freeness of 35°ShR are related to the large number of long fiber fraction and a less dense packing of the paper sheet structure [1].

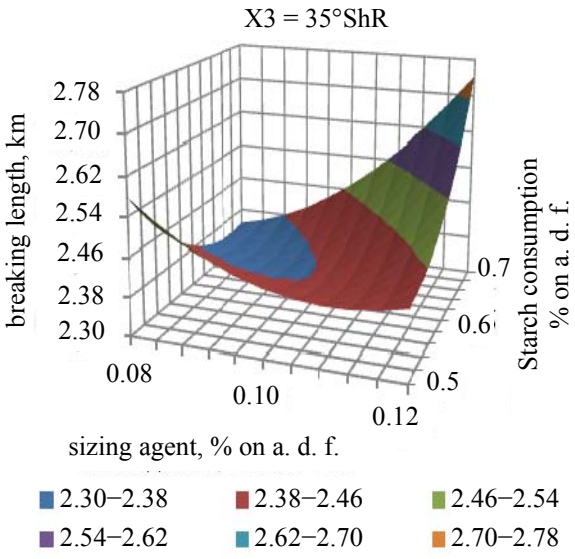
Significant increase of the breaking length is observed with increasing of freeness pulp from waste paper from 35 to 45°ShR (Fig. 2). It is associated with large fibers fibrillating achieved in the process of grinding. And the increasing of cationic starch consumption while reducing of sizing agent consumption contributes to the strength of paper samples.

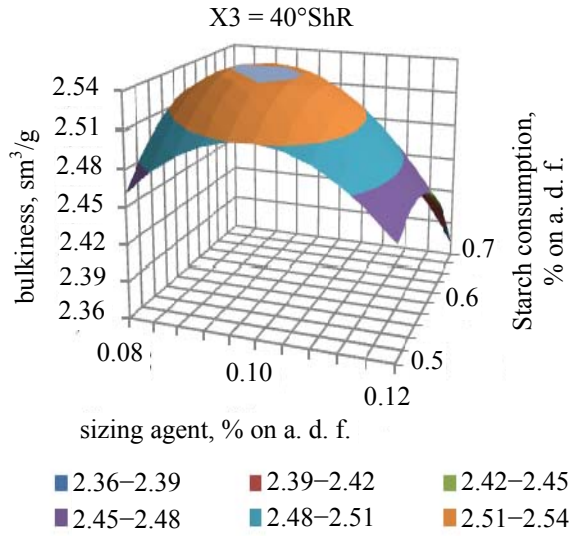
Table 2

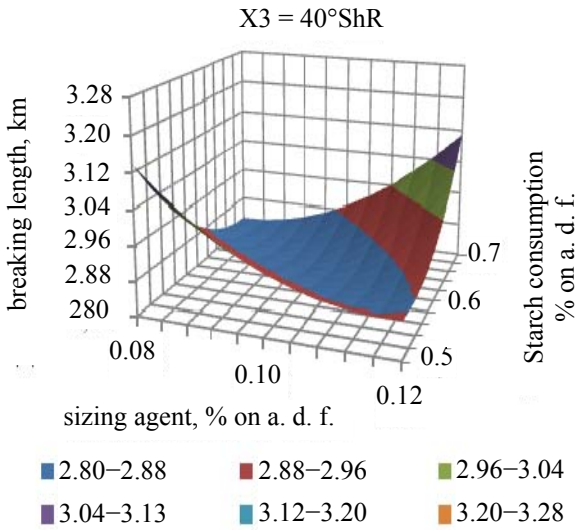
Taste results of paper tests

Probe number	Y1, sm³/g	Y2, mm	Y3, km	Y4, J/m^2	Y5, g/m²	Y6, GPa	Y7, kN/m
1	2.677	1.17	2.44	14.78	57.68	1.548	305.0
2	2.402	1.47	3.80	29.66	67.35	2.242	410.0
3	2.374	1.26	2.84	18.53	73.39	1.893	344.4
4	2.541	1.54	2.92	23.95	70.40	1.740	325.6
5	2.492	1.54	3.55	28.93	67.06	2.075	382.4
6	2.689	1.22	2.46	15.49	73.92	1.511	298.4
7	2.686	1.15	2.35	13.90	58.27	1.454	289.9
8	2.551	1.45	2.79	21.60	30.30	1.782	326.1
9	2.406	1.61	3.69	31.63	42.81	2.226	393.8
10	2.697	1.25	2.53	16.70	50.15	1.565	307.2
11	2.654	1.22	2.45	15.27	28.63	1.456	288.0
12	2.381	1.66	3.55	31.55	45.95	2.097	368.5
13	2.583	1.35	2.86	20.46	35.53	1.787	339.4
14	2.421	1.44	3.12	23.86	48.35	1.995	361.2
15	2.165	1.64	3.92	34.27	28.89	2.507	409.9
16	2.439	1.36	2.81	19.95	26.74	1.837	332.4
17	2.634	1.32	2.39	17.22	26.87	1.466	290.3
18	2.635	1.20	2.57	16.12	23.90	1.621	327.6
19	2.541	1.35	2.88	20.26	34.58	1.783	339.7
20	2.421	1.57	3.63	30.33	26.74	2.168	394.1
21	2.251	1.53	3.67	29.85	57.23	2.279	398.1









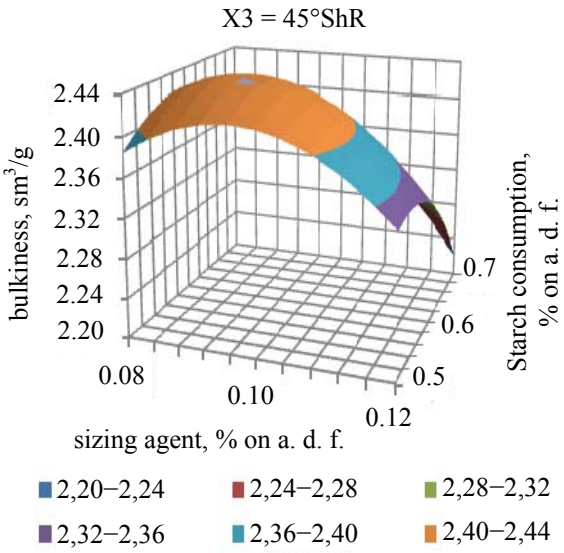


Fig. 1. Dependence of bulkiness of paper samples on the flow rate of the sizing agent and the cationic starch at fixed values of freeness pulp (35; 40; 45°ShR)

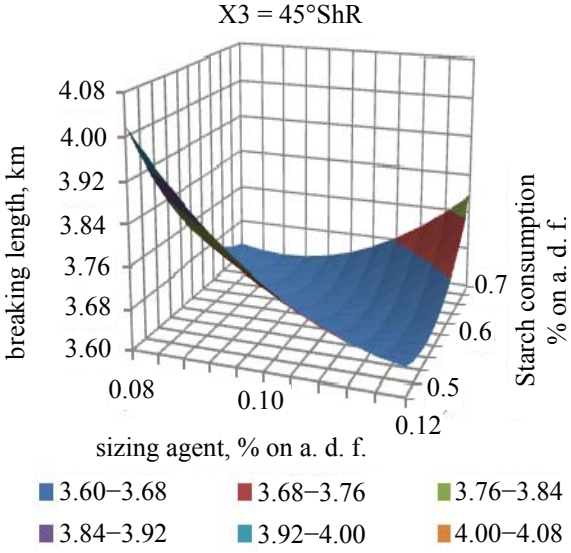


Fig. 2. Dependence of breaking length of paper samples on the flow rate of the sizing agent and the cationic starch at fixed values of freeness pulp (35; 40; 45°ShR)

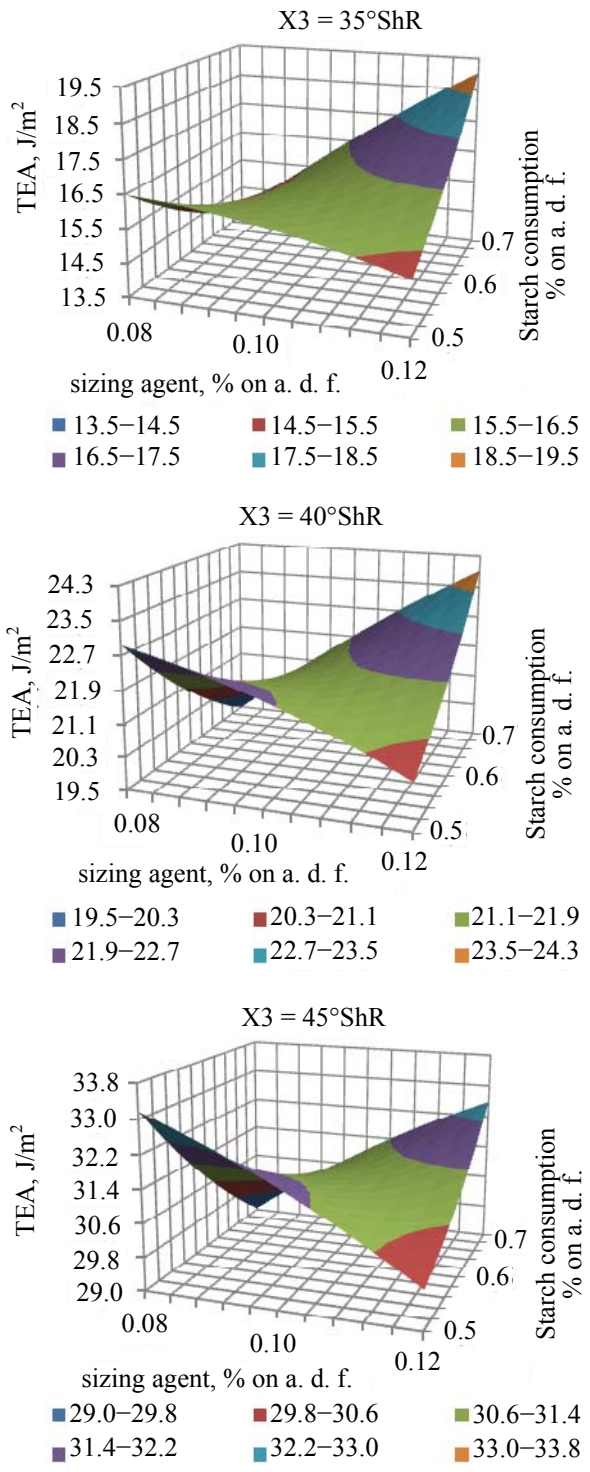


Fig. 3. Dependence of the tensile energy absorption of paper samples on flow rate of the sizing agent and a cationic starch at fixed power pulp grinding (35, 40, 45°ShR)

As can be seen from Fig. 3, the highest values of tensile energy absorption of the samples are observed at the lowest flow rate of the sizing agent and the largest consumption of cationic starch with degree of beating of 45°ShR.

The sizing agent flow gain while the cationic starch flow gain contributes to the elongation of paper samples at a given pulp freeness. However it should be taken into account the hydrophilic properties of the cationic starch. In the process of one-sided wetting the best absorption is observed if the cationic starch is consumed less.

Optimal expendable and operating parameters of furnish composition for packaging paper making were determined by mathematical treatment of the resulting experimental data by calculating the generalized optimization criterion.

Conclusion. The optimum cationic starch content (0.5% on a. d. f.) and based sizing agent on the base of AKD (0.109 % on a. d. f.) in a paper composition with pulp freeness of 45°ShR was determined. The calculation of the breaking length value will be 3700 m, of the tensile energy absorption will be 34.2 J/m^2, of the bulkiness will be 2.39 sm^3/g, and of the elongation will be 1.6 mm.

Thus the obtained results allow us scientific substantiating and broadening of our understanding of the formation of structural mechanical paper properties in the process of its production. They can be used to select process parameters, equipment and raw materials for the purpose of improving the quality control.

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