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FILLED PAPER PULP SIZING FEATURES IN THE PRESENCE OF POLYELECTROLYTE

It is shown that to reduce the size of the filler particles from 3–5 microns (natural) to 0.65–0.82 microns ($\{[\text{CaCO}_3]_m \cdot n\text{CO}_3^{2-} \cdot (n-x)\text{Na}^+\}^{x-} \cdot x\text{Na}^+\}$) allows for the filling process in heteroadagulation and penetration. To obtain high elevated paper with high-hydrophobic and strength properties it is advisable to sequentially introduced into the pulp slurry, calcium chloride and sodium carbonate to obtain superfine particles of filler (consumption 10% of a. d. f.), then polyethylenimine (consumption 0.075% a. d. f.) and adhesive based on alkylketenedimer AKD (consumption 0.5% a. d. f.) demonstrating flocculating and sizing effect respectively.

Introduction. Different natural fillers are widely used in paper composition (chalk, kaolin, blanc fix, plaster, etc) [1-4]. Their use can not only replace a portion of deficient primary fibrous raw materials, but also impart the paper a high printability. However, heterogeneity and coarse dispersion are characteristic for dispersed phase particles of natural fillers and this does not provide their uniform distribution on the fibre surface.

Therefore, the replacement of natural fillers by superfine (produced by the chemical interaction of two or more compounds) would, in our opinion, make it possible to change the filling process of traditional coagulation mode into a more effective heteroadagulation mode. The consequence of this is the ability to provide uniform distribution and solid fixation of the filler particles on the surface (heteroadagulation mode filling) and in the fibre lumens (penetration mode filling).

The proposed technological mode of paper pulp filling in the heteroadagulation and penetration mode was performed by successive introduction of calcium chloride (component 1) and sodium carbonate (component 2) into its structure. The products of their interaction were calcium carbonate (acts as a filler) and sodium chloride. The subsequent step of filled paper pulp sizing provided the desired hydrophobic properties of the obtained paper samples.

Therefore, the study of distinctive features of filled paper pulp sized by superfine compounds is of great scientific and practical interest, the compounds having been obtained by successive introduction of CaCl_2 and Na_2CO_3 into the fibrous slurry.

The purpose of the research is to study the process of filled paper pulp sizing by superfine calcium carbonate in the presence of polyelectrolyte.

Main Part. The work was carried out in two stages: at the first stage influence of a superfine compound on dewatering capacity of filled fibrous slurry was examined; at the second stage we stud-

ied specific features of filled paper pulp sizing. Penetration process is of scientific and practical interest due to formation of dispersed phase particles of a superfine filler in fibres lumens [5-8].

The materials used in the research: hardwood bleached sulphate pulp (GOST 28172-89), calcium chloride (GOST 450-77), sodium carbonate (GOST 2156-76), polyethylenimine (PEI), polyamine (PA), alkylketendimer emulsion (trade mark Basoplast 850D (AKD)), reinforced rosin size (trade mark TM) (TU RB 00280198-017-95).

The net weight of one square meter of the prepared paper samples was 80 g. The freeness of the pulp slurry was 40°SR. The process of filling of a 1% pulp slurry was performed by successive adding to it of 10% solutions of the components 1 and 2, followed by stirring of the resulting disperse system during 150 c. The number of input components 1 and 2 resulted in the formation of the desired amount of CaCO_3 , which corresponded to 5, 10, 15% of the absolutely dry fiber (a. d. f.). On filling the paper pulp it was added with polyelectrolyte (PA or PEI), the consumption of which was increased in the range of 0 to 0.075% of a. d. f. Where upon the paper pulp was sized using the selected tested sizing agents (TM and AKD consumption was increased from 0 to 1.0% of a. d. f.).

At the first stage we studied the effect of the filler on the dewatering capacity of the filled pulp slurry using PA and PEI polyelectrolytes.

Pulp drainage rate was determined by Canadian techniques on the ShR-2 apparatus with a closed central opening. The techniques is based on determining the time required for separating a predetermined amount of the filtrate (700 cm^3) during free paper pulp drainage on a Schopper-Riegler apparatus. Mass concentration during drainage was 0.3% [9].

Drainage rate V , cm^3/c was calculated by the formula:

$$V = 700 / t, \quad (1)$$

where t – flow out time of 700 cm³ of filtrate through a pad weight layer, c.

To ascertain the content of suspended solids in the pit water 700 cm³ of filtrate which remained following the determination of the drainage speed were filtered using a Bunsen's flask, a Buchner funnel, a pump and a filter ("blue" ribbon). The filter was preliminarily dried to a constant weight. Then, the filter with the cake was dried in a drying oven to constant weight at a temperature $(103 \pm 2)^\circ\text{C}$. The content of suspended solids in the pit water B , mg/dm³ was calculated by the formula

$$B = m / V, \quad (2)$$

where m – mass of the residue dried to the constant weight, mg; V – volume of the pit water which remained following the determination of the drainage speed and equal to 0.700 dm³.

The average particle size of the filler was determined by conventional techniques, i.e. by examining the deposition rate in accordance with Stokes Law [1].

$$r = K \cdot \sqrt{v}, \quad (3)$$

where r – average particle size, mm; K – coefficient equal to 0.537; v – speed of particle movement, m/s.

It has been ascertained that the particle sizes of the filler obtained (0,65–0,82 μm) are much less than those of the natural one (3–5 μm).

Fig. 1 and 2 show influence of the polyelectrolyte type and consumption on the drainage rate and suspended solids content in the pit water.

Comparative analysis of characteristic curves shown in Fig. 1 and 2 proves that the use of PEI in a composition with superfine calcium carbonate accelerates paper pulp drainage in comparison with that of PA. The use of PEI reduces the suspended solids content in the pit water by 27.6% compared with that of PA.

Using PEI as compared to PA can be regarded advantageous when superfine calcium carbonate is used in the paper pulp composition. Therefore, fur-

ther studies were carried out with the polyelectrolyte in question.

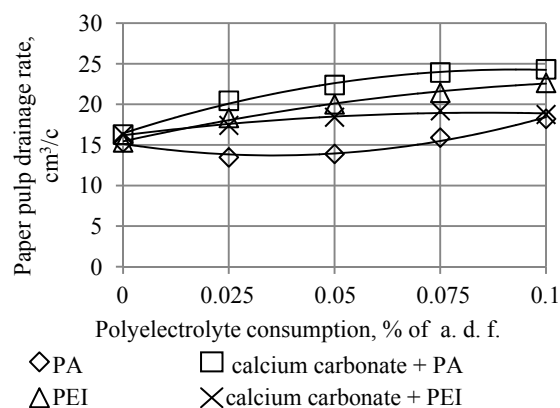


Fig. 1. Influence of polyelectrolyte type and consumption on paper pulp drainage rate

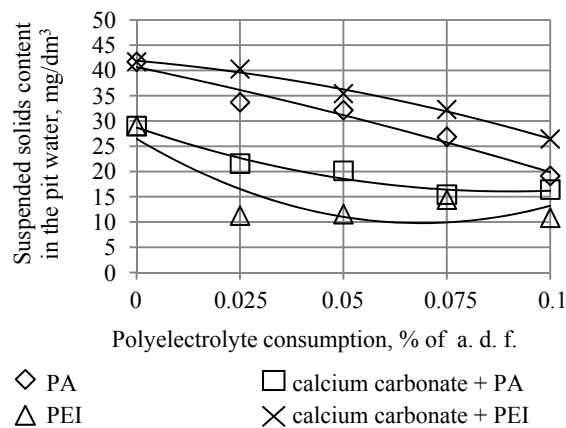


Fig. 2. Influence of polyelectrolyte type and consumption on suspended solids content in pit water

An important factor in producing high quality paper is the order of introduction of chemicals into the paper pulp. Influence of paper pulp composition on the paper quality parameters is presented in a Table. The table shows that with the increase of a filler consumption from 5 to 15% of a. d. f., its retention rate in the texture of paper changes from 93 to 96% respectively.

Paper samples quality depending on the sequence of chemicals introduction into the fibrous slurry

Sequence of chemicals introduction into the fibrous slurry	Filler consumption, % of a. d. f.	Parameters		
		filler retention rate, %	breaking length, m	whiteness, %
Without chemicals	—	—	10 460	66.53
Superfine filler preparation: CaCl ₂ +Na ₂ CO ₃	5	99.89	9000	66.43
	10	99.73	8750	68.57
	15	92.77	6380	72.27
Stage 1. Superfine filler preparation: CaCl ₂ +Na ₂ CO ₃ ; Stage 2. PEI introduction (consumption 0.075 of a. d. f.)	5	96.14	8080	67.87
	10	94.13	6910	73.57
	15	93.94	6040	75.57
Stage 1. PEI introduction (consumption 0.075 of a. d. f.); Stage 2. Superfine filler preparation: CaCl ₂ +Na ₂ CO ₃	5	95.54	6260	70.24
	10	93.64	6020	74.13
	15	91.81	5700	73.37

These data indicate that the superfine filler is well retained in the paper texture and is partially removed (4–7%) with pit water. The use of the tested compound allows to carry out paper filling in a heteroadagulation mode. Increase of the retention rate of the compound in paper texture shows progress of the penetration process.

Whiteness increases from 67 to 76% and breaking length decreases from 10460 to 6040 m. These results indicate that a high retention rate of a filler in the paper texture reduces the strength properties and increases whiteness. In this case paper quality corresponds to the regulated values.

At the second stage we studied the consumption effect of the sizing agent, introduced into filled paper pulp, on the hydrophobic properties of paper samples.

Influence of the type and consumption of the sizing agent on the breaking length and saturation capacity upon a unilateral wetting of paper samples is shown in Fig. 3 and 4.

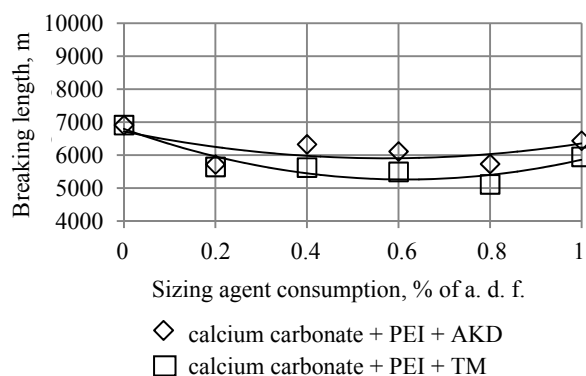


Fig. 3. Influence of sizing agent type and consumption on the breaking length of paper samples

Characteristic curves in Fig. 3 and 4 show that increasing sizing agent consumption from 0 to 1% of a. d. f. leads to preferable use of paper sizing with alkylketendimer emulsion AKD, the consumption being 0.6% of a. d. f. This reduces saturation capacity at a unilateral wetting of paper samples by 48%, the breaking length decreasing slightly (by 5–11%).

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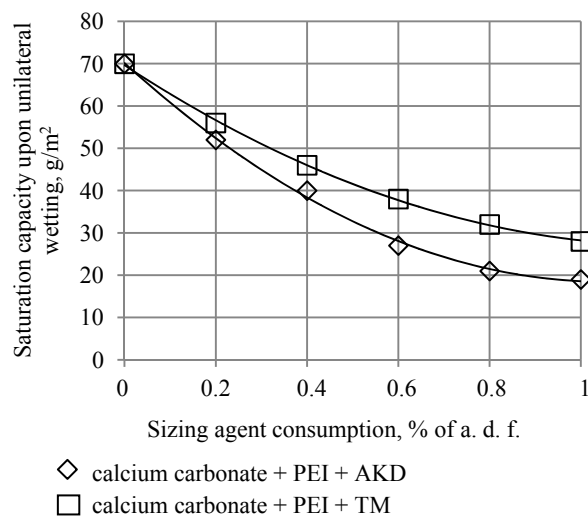


Fig. 4. Influence of sizing agent type and consumption on saturation capacity upon unilateral wetting of paper samples

Analysis of the data obtained shows that in order to achieve comparable breaking length values (5500–6000 m) it's necessary to introduce sizing agent AKD (consumption 0.5% of a. d. f.) or TM (consumption 0.8% of a. d. f.) into the filled paper pulp.

However, consumption of AKD sizing agent is 35% less than that of the TM sizing agent, which is of practical importance.

The process of the filled paper pulp sizing by alkylketendimer emulsion AKD and by superfine calcium carbonate is schematically shown in Fig. 5.

In both cases, as is evidenced by saturation capacity upon unilateral wetting, high degree of paper samples hydrophoby (not exceeding 30 g/m²) is achieved.

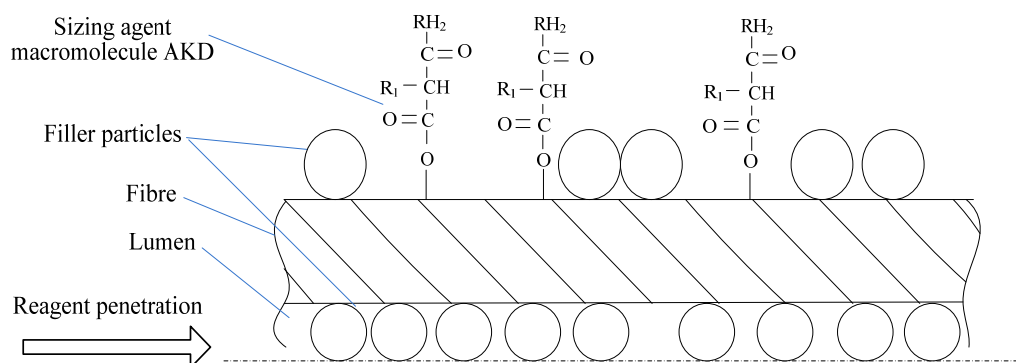


Fig. 5. Schematic illustration of the filled paper pulp sizing at pH 8.1

It should be noted that paper samples have the desired properties when filled paper pulp is sized with such sizing agents as AKD (pH 8.1) and TM (pH 6.2).

Fig. 5 shows that the process of paper pulp filling is carried out in the mode of heteroadagulation. This is evidenced by high retention rate (94.13%) of a filler in the paper texture. Heteroadagulation proceeds simultaneously with penetration thereby freeing the surface of the cellulose fibers for sizing as is evidenced by paper saturation decrease in case of sizing agent consumption increase.

Conclusion. Specific features of the filled paper pulp sizing include: sequence of chemicals introduction into the fibrous slurry, their consumption rates and pH of the resulting paper pulp. The preferred order of chemicals introduction is as follows: first it's necessary to dose 10% solutions of calcium chloride and sodium carbonate to get a particle size of the filler dispersed phase 0.65–0.82 μm (consumption 10% of a. d. f.), polyelectrolyte PEI (consumption 10% of a. d. f.) and sizing agent AKD (consumption 0.5% of a. d. f.). pH of the resulting paper pulp is 8.1. Samples manufactured from the obtained paper pulp have the following properties: breaking length 6910 m, whiteness 73.5%. In this case the filler retention rate in paper texture is 94.13%.

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