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PAPER PROPERTIES DEPENDING ON THE SYNTHETIC FILLERS FLOW

It is shown that the replacement of natural filler (barium sulfate) with particle size of the synthetic 1.50–2.00 microns with a particle size 0.50–0.57 microns allows us to give the correct paper whiteness and breaking length but to maximize the strength of the paper sheet. Found that decreasing the size of the filler particles from 1.50–2.00 to 0.50–0.57 microns can help improve their retention in the structure of the paper through the course of the process of filling in heteroadagulation while the process of penitration, which has a positive effect on its printability.

Introduction. A variety of natural excipients is widely used in the composition of paper and paperboard. They include blanfiks, kaolin, chalk, gypsum [1], etc. Their use allows to replace a part of the expensive fibrous material (bleached) as well as to give the paper and cardboard cover layers of printing super whiteness and ash contents. However, the presence of coarse and heterogeneous particles is natural for traditional fillers. It reduces their degree retention rate in the paper structure as well as the effect of the process of filling and the uneven distribution of unstable fixation and particles on the fiber surface. The process of filling in the process of homocoagulation is one of the main reasons for this phenomenon.

Therefore the replacement of natural coarse fillers into superfine synthetic fillers will change the filling process of the traditional homocoagulation mode into more effective heteroadegulation mode accompanied by a uniform distribution and strong fixation of the filler particles on the fiber surface.

Promising methods for replacement of barium sulphate (natural filler) include a method based on the production of highly synthetic filler by chemical interaction between two (e. g. barium chloride and sodium sulfate) or three compounds to form fine particles of the dispersed phase. At the same time it is known [1] that the translation filling process from homocoagulation mode into heteroadegulation mode provides the increased retention of filler in the paper structure and enhances the whiteness of finished products preserving its strength.

Therefore the researches in the field of the production of synthetic filler and its application in the composition of the coating layers of paper and paperboard printing form are of scientific and practical interest.

The aim of this articles the development of a technological mode of production of synthetic filler based on barium chloride and sodium sulfate and study of barium sulfate dispersion effect on its retention in the structure of the paper, its whiteness and breaking length.

Main part. The work was conducted in two phases: the first included the development of a technological mode of synthetic filler producing, the second supposed the development of a technological mode of its application in the fiber suspension to ensure the filling mode in the process of heteroadegulation. The process of flow penitration is of the greatest scientific and practical interest because of the formation of dispersed particles of synthetic fiber filler in lumen [2].

The average particle size of the filler was determined by the standard method by examining the speed of deposition in accordance with Stokes Law [1]:

$$r = K\sqrt{v}, \tag{1}$$

where r – an average particle size measured in microns; K – a constant value equal to 0.537; v – a velocity of the particle, m/s.

Filler Retention of the paper structure was determined by the formula

$$\text{STU} = \frac{(A_b - A_f)\cdot 100}{(100 - L)\cdot F}\cdot 100, \tag{2}$$

where STU – a filler retention,%; A_b – a paper ash content,%; A_f – a fiber ash content,%; L – a filler loss on ignition,%; F – a fuel filler, %.

Loss on ignition of the filler was determined by the formula [2]

$$L = \frac{F_1 - F_2}{F_2}\cdot 100, \tag{3}$$

where F_1 – an absolutely dry filler weight, g; F_2 – the mass of absolutely dry residue after calcination in a muffle furnace at (750 ± 5)°C, g.

Solutions of barium chloride and sodium sulfate were used to produce synthetic filler (barium sulfate) at the first stage. The following reaction took place in the aqueous (dispersion) medium

$$BaCl_2 + Na_2SO_4 = BaSO_4\downarrow + 2NaCl. \tag{4}$$

Properties of barium sulfate as obtained synthetic and natural filler are shown in the Table.

Comparative characteristics of properties of natural and synthetic fillers

Descriptor	Filler	
	synthetic	natural
Average particle size, μm	0.50–0.57	1.50–2.00
Filler losses on ignition, %	2.41	2.60
Whiteness, %	98–99	98–99

It was found that synthetic filler is significantly different from the natural dispersion.The size of the dispersed phase decreases from 0.50–0.57 to 1.50–2.00 μm. The whiteness of synthetic filler is comparable to the natural whiteness and equals to 98–99%.

The second stage was caracterized by the production of samples of paper and paperboard coating layers with printing mass of one square meter in 50 g. Beating rate of fibrous slurry was 78°ShR. The filling process of a 1% fibrous slurry was performed by sequentially adding to it of the 10% solution of barium chloride (component 1) and sodium sulfate (component 2). The number of input components corresponded to stoichiometric ratio according to reaction (5). The barium sulfate consumption was increased from 5 to 20% of a. d. s. by the corresponding increase of the amount of input components. The corresponding temperature (20 ± 3)°C, the concentration of the used components (10 ± 3)% and the uniform mixing of the dispersed system after the introduction of each component during not less than 150 seconds are necessary to produce any highly synthetic filler in the dispersion medium with the following filling process atheteroadegulation mode and in fiber lumens.

In the course of the researches the following materials wereused: thermomechanical pulp RTS, barium chloride (GOST 4108-72) and sodium sulfate (GOST 21458-75). For comparis on blanfiks $BaSO_4$ (GOST 30240.1-95) was used as a natural filler. Samples of paper were produced by sheet-making «Rapid-Ketten» apparatus (company «ErnstHaage», Germany) .

Whiteness was determined with a «Kolir» spectrophotometer (Ukraine) according to CIED 65/10. Breaking length of paper samples and the covering layers of printing cardboard were measured by the horizontal tensile testing «Tensileteste» machine (company «Lorentzen & Wettre», Sweden), ISO 1924-2.

Properties of the paper samples depending on the flow of synthetic and natural fillers are shown in Fig. 1-3.

Fig. 1 shows that increasing of the synthetic filler flow from 5 to 20 % of a. d. s. results in its reduction in the paper structure from 84 to 80% (4%) and using of natural filler flow reduces from 83 to 69% (14%). These data indicate that the coarse natural filler is mechanically retained in the paper structure and partially removed by the sub grid water. The synthetic filler allows to use the heteroadegulation mode. The high percentage of its retention in the structure of the paper indicate son the behavior of penitration.

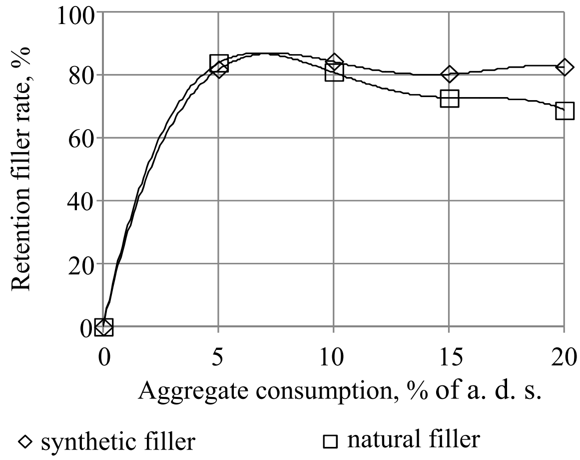

Fig. 1. Changing of the retention of synthetic and natural fillers depending on their costs

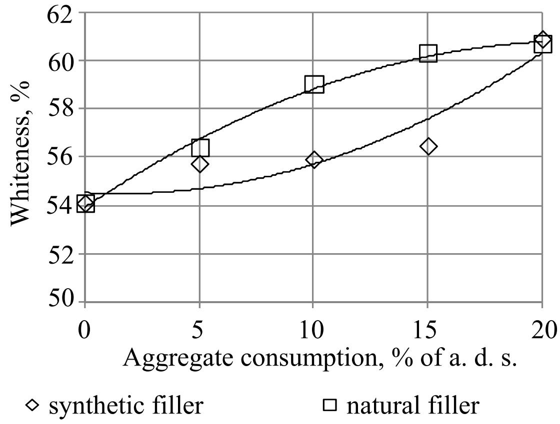

Fig. 2. The change of whiteness of paper samples depending on the consumption of natural and synthetic fillers

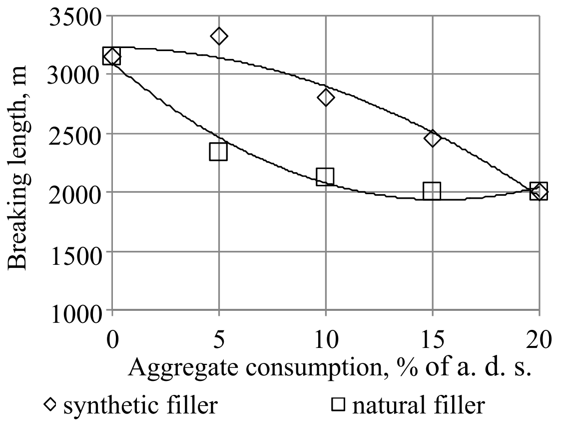

Fig. 3. Changing of the breaking length of paper depending on the costs of synthetic and natural fillers

These data indicate that the coarse natural filler is mechanically retained in the paper structure and partially removed by the sub grid water. The synthetic filler allows to use the heteroadegulation mode. The high percentage of its retention in the structure of the paper indicate son the behavior of penitration.

Fig. 2 shows that increasing of the flow of natural and synthetic fillers from 0 to 20 % a. d. s. results in increasing of paper samples from 54 to 61%. One of the main reasons is the increasing of retention degree of particles of synthetic filler in the structure of the paper in the process of improving of the uniformity of distribution of finely disperse particles of synthetic filler compared with natural .

Fig. 3 shows that the breaking length of paper samples depends on the filler flow as well as on its retention in the paper structure. However the uniform distribution and strong fixation of fine particles on the surface of synthetic fiber filler helps to maximize preservation of the original strength of the samples of paper. In practical terms it can increase the aggregate consumption by 5–8%. Thus it is possible to replace the expensive primary fibrous materials (thermomechanical pulp) for an adequate amount of synthetic filler.

Comparative analysis of the data indicates that the superfine synthetic fillers have positive effect on whiteness and breaking length of paper. The achieved effect is explained by the displacement of the filling process of the traditional homocoagulation mode into a more effective heteroadegulation mode. By the way the penetration process raises the possibility of pulp saving.

Conclusion. The synthetic filler production (barium sulfate) is based on the chemical interaction of barium chloride and sodium sulfate. The 10% solution as to be introduced at the temperature of (20±3)°C to form finely divided synthetic filler in fibrous slurry. Having introduced each component the uniform mixing of the dispersed system should be at least 150 second. The resulting fine particles of synthetic filler are evenly distributed and firmly fixed on the surface of the fibers. It indicates that the process of filling takes place in heteroadegulation mode. Their increased retention in the structure of the paper explains the occurrence of additional process of penetration. It has been established that the whiteness and the breaking length of paper samples contain the synthetic filler to be increased by 2.3% and 500–1000 m respectively comparing with the paper samples containing natural filler.

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