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COMPOSITE TECHNOLOGY FOR THE PRODUCTION OF PAPER AND CARDBOARD INCLUDING SYNTHETIC FIBERS

Abstarct. In the modern world, the importance and volumes of packaging produced are constantly increasing. It is a powerful means of promoting goods on the market, but at the same time, the role of its quality increases. Currently, paper and paperboard packaging is not only a significant part of paper and paperboard market in general, but also a large part of the world's packaging consumption. Currently, the world pays special attention to the use of secondary paper waste for the production of paper and cardboard and increase the volume of their processing. The article is devoted to the production of new types of multilayer paper and cardboard with the addition of chemical fiber and secondary waste, as well as high-quality paper and cardboard that can be used in the printing industry, in order to save valuable cotton cellulose in the country. However, the article shows in what proportions it is advisable to use secondary fibers in combination with cellulose in the production of multilayer composite paper and cardboard for the printing and paper industries.

Keywords: cotton cellulose, modified polyacrylonitrile fiber waste, multilayer composite paper and cardboard

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КОМПОЗИЦИОННАЯ ТЕХНОЛОГИЯ ПОЛУЧЕНИЯ БУМАГИ И КАРТОНА, ВКЛЮЧАЮЩАЯ СИНТЕТИЧЕСКИЕ ВОЛОКНА

Аннотация. В настоящее время в мире особое внимание уделяется использованию вторичных бумажных отходов для производства бумаги и картона и увеличению объемов их переработки. Показано производство новых видов многослойной бумаги и картона с добавлением химических волокон и вторичных отходов, а также качественной бумаги и картона, которые можно использовать в полиграфической промышленности с целью экономии ценной хлопковой целлюлозы в стране. Найдены необходимые пропорции, которые целесообразно включать во вторичные волокна в сочетании с целлюлозой при производстве многослойной композиционной бумаги и картона для полиграфической и бумажной промышленности.

Ключевые слова: хлопковая целлюлоза, отходы модифицированного полиакрилонитрильного волокна, степень помола, многослойная композиционная бумага и картон

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Introduction. At present, Uzbekistan pays great attention to the processing of secondary raw materials into finished products. Research is being carried out in the country on the production of paper and cardboard products using various local secondary raw materials, including textile industry waste [1, 2].

Uzbekistan is one of the largest suppliers of materials such as cotton, natural and synthetic fibers. Cotton cellulose plays an important role among the raw materials used in paper production. It is used to make high-quality paper, but given that the production of paper from pure cotton pulp is not economically viable, the addition of chemical waste to cotton pulp can effectively and rationally use existing raw materials in the country, solve problems in the paper industry, eliminate shortages of printing materials, helps to save valuable cotton cellulose, reduce the cost of paper.

At Navoiazot, synthetic polyacrylonitrile (PAN) nitron fiber is obtained in the form of staple fibers and tow by the rhodanide method from three types of copolymers of monomers (92.5 % acrylonitrile, 6 % methylacrylate, 1.5 % itaconic acid).

PAN fiber is widely used in the textile industry. Fiber waste generated during the production process serves as a valuable raw material for the production of paper and cardboard [3, 4].

At present, Uzbekistan pays great attention to the use of semi-finished products from local raw materials in the pulp and paper industry. In addition, the use of waste generated by enterprises in the paper industry is aimed at significantly reducing the cost of production through the expansion of the range of paper and the use of waste.Advantages of using secondary waste in terms of savings:the consumption of electricity for crushing the fiber mass is reduced by 2–4 % of the cost of 1 ton of paper [5, 6].

Studies have been conducted on the introduction of modified polyacrylonitrile (MPAN) fiber waste into the paper composition to ensure strong adhesion of the fiber mass in both wet and dry conditions. Modification of PAN fibers is carried out by treatment with a solution of natural silk waste [7]. Research has been conducted to obtain multilayer paper and cardboard based on cotton cellulose, modified polyacrylonitrile (MPAN) and secondary raw materials and to study their strength properties.

Materials and methods. During the experimental work, multilayer composite paper and cardboard were prepared using primary and secondary fiber materials and polymers. Preparation of paper samples and assessment of their physical and mechanical properties were carried out in the testing laboratory of JV "Global Komsco Daewoo" in accordance with the approved technological regulations.

According to GOST 7420, the mass of 1 m^2 of cardboard designed for flat layers of corrugated cardboard is in the range of 125–250 g. In Uzbekistan, materials with a mass of 150 g/m^2 are used in most cases, which require image printing for the top flat layer of corrugated cardboard.

Therefore, the preparation of samples with a mass of 150 g/m^2 was carried out in the sheet casting laboratory "Rapid" (Germany) In research, an adhesive was added to the mass in an amount of 1.5 % relative to the usual paper mass. To achieve a good gluing effect, the pH of the paper mass was required to be 4.5–5.0, for which $Al_2(SO_4)_3$ was used as a precipitating reagent.

T a b l e 1. **Options of two-layer castings of compositional content**

Option Number	Compositional content		
	Top layer 40–55 °ShR		The lower layer 21–28 °SHR
	CC, %	MPAN, %	MS-5B, %
Sample N1	100	–	100
Sample N2	80	20	100
Sample N3	50	50	100
Sample N4	30	70	100

In the preparation of the samples, the cellulose was ground to a grinding level of 40–55 ° SHR for the top layer of the composite material and 21–28 ° SHR for the bottom layer. Paper castings with a mass of 150 g/m^2 were made from ground cellulose (top layer weight 60 g/m^2, bottom layer weight 90 g/m^2 (Table 1).

As the main raw material for the production of a new type (grades) of multilayer paper and cardboard, bleached cotton cellulose and waste with the following technical indicators were used:

Bleached cotton pulp from linter BCP (Specifications TSh 13-91:2003). BCP obtained from the Yangiyul paper mill according to the current technology. The lint is de-seeded, loosened, boiled in NaOH, washed and bleached in an alkaline solution of hydrogen peroxide. From 1300 kg of lint, 1000 kg of pure pulp is obtained with the following indicators:

Mechanical strength during grinding in the CRA mill up to 600 ShR,

Breaking length, m, 3500

Whiteness, % 75

Humidity, % up to 12

Part of the cotton cellulose was replaced by waste of modified synthetic fiber nitron manufactured by Navoiyazot JSC with indicators according to the quality certificate of staple fiber and tow of polyacrylonitrile cotton-like type: (Specifications TSh 6.1-00203849-51:2002). Brand H-3, batch 13.

Nominal linear density of fiber, tex 0.17
Nominal fiber length, m 0.037
Number of twists per 0.010 m 3.5
Specific breaking load of fiber, mN/tex, 362
Specific breaking load of fiber in a loop, mN/tex, 89
Fiber elongation at break, % 35
Fiber whiteness, % 76.4

For the production of composite packaging paper and cardboard, waste paper of group B, grade MS-5B was used – the content of primary fiber is up to 70 %; average fiber length, not less than 1.9 mm; pH, no more than 8.5; ash content not more than 5 %; specific tensile strength not less than 1.3 kN.

Pine rosin, item No. 27 (GOST 19113), (open joint stock company "Lesohimik").

Rosin is a mixture of resin acids of the composition $C20H30O_2$.

Softening temperature, °C 73 (66–69)
Acid number, mg KOH 171 (166–169)

Prototypes of paper and cardboard were produced and their quality was assessed in the testing laboratory of JV "Global Komsco Daewoo" in accordance with the approved technological regulations. Castings of samples containing cotton cellulose fibers, fibers obtained from modified nitron waste, and MS-5V waste paper in various ratios were obtained. Grinding of fibrous materials was carried out on a pilot plant of the Central Research Institute of Paper (Moscow) at Massroll-22.5. According to GOST 7420, the mass of 1 m2 of paper and cardboard is in the range of 125–250 g/m^2. In this work, the preparation of paper and cardboard samples weighing 150 g/m^2 was carried out in the laboratory of sheet casting "Rapid" (Germaniya). To achieve a good bonding effect, it was required that the pH of the paper pulp be 4.5–5.0, for which $Al_2(SO_4)_3$ was used as a precipitating agent.

In addition, samples were made in which, in addition to fibrous materials, a filler was introduced. Kaolin was chosen as the filler. The choice of this filler is due to the following considerations:

the most accessible and relatively cheap;
improves physical and chemical affinity of paper in relation to paint.

In composite wrapping paper, it is necessary to introduce sizing to improve water resistance and strength. Therefore, sizing agents were introduced into the prototypes. In all model paper samples, rosin glue was used as a sizing agent. The production of prototypes was carried out according to the approved technological regulations. The consumption of materials based on 1 ton of paper from the mixture was:

1) cotton cellulose 0–100 %;
2) chemical fiber waste 2–100 %;
3) waste paper MS-5V 0–100 %;
4) kaolin – 145 kg/t;
5) alum – 43 kg/t;
6) rosin glue – 25.7 kg/t;
7) unifloc – 0.2 kg/t.

To determine the optimal composition of the paper composition, studies were conducted using four options.In the first variant, cotton cellulose and waste paper were used, in the remaining variants the percentage composition of the main components of the paper composition was varied: cotton cellulose + modified PAN fiber + waste paper.

For the production of multilayer composite paper and cardboard, the process of gluing the surface with a polymer adhesive was additionally introduced (Figure). Glue from the surface serves to improve the structure of the paper surface, increase mechanical strength and resistance to moisture [8, 9].

A solution of rosin glue, acrylic emulsion and alcohol product of secondary polyethylene terephthalate with diethylene glycol was used to glue the paper composition. Kaolin obtained as a filler is sufficient and a relatively inexpensive product, as well as improves the physicochemical flexibility of the dye relative to the paper.

№ 1 paper sample consists of 100 % cotton cellulose, № 2 and 4 paper samples contain 20 to 70 % of modified PAN fiber waste. Material consumption for 1 t of paper was as follows.

Mass of paper was prepared separately for each layer of multilayer composite papers. For producing such papers, we can use two technological systems and two net paper-casting machines were used.

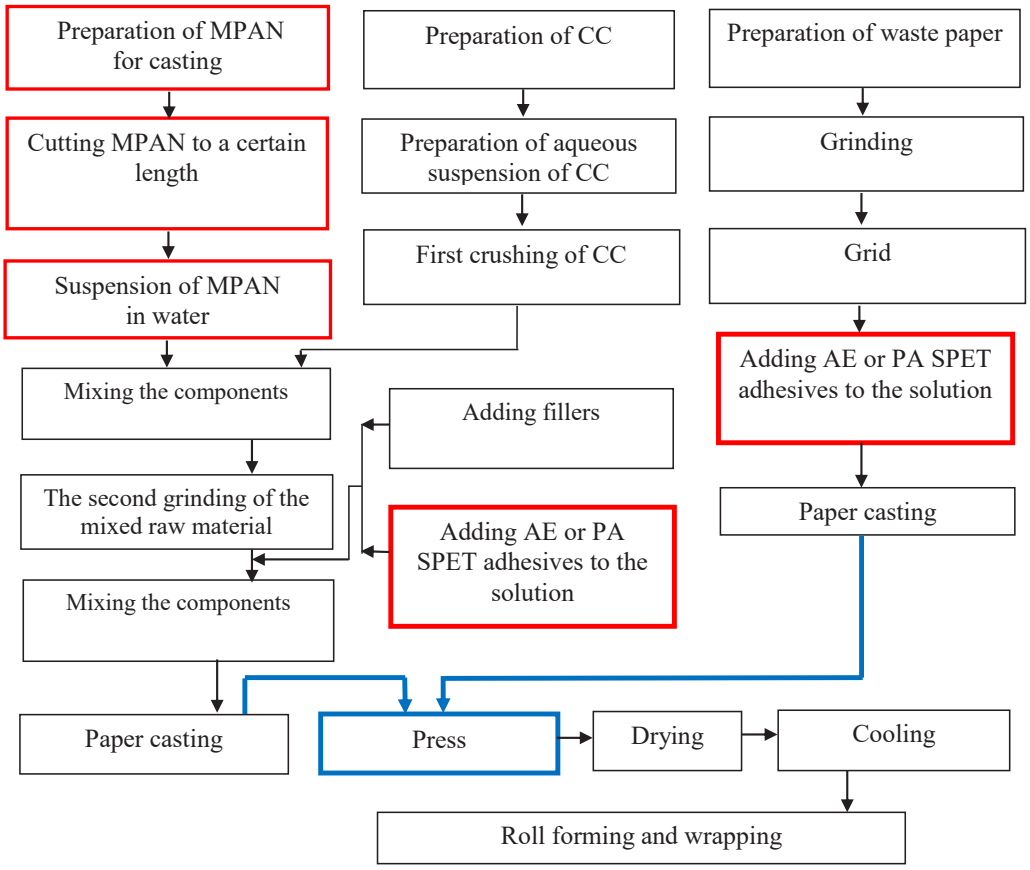

Fig. 1. Production of multilayer paper and cardboard based on cotton cellulose and MPAN waste

Initially, the bottom layer is formed. The mass of the top layer prepared according to the appropriate composition is transferred from the second reservoir and at the time of formation is combined with the bottom layer, and in the pressed state the layers are joined.

Results and discussion. In order to study the mechanical properties of the newly developed materials, research was carried out on the drying of samples and their storage under standard conditions, followed by the study of their physical and mechanical properties. The dependence of the physical and mechanical properties of paper on the nature and amount of components in the paper composition was studied (Table 2).

The obtained data (Table 2) show that the addition of 100 % cotton cellulose to the mass composition in sample №1 provided good crushing and fibrillation of cotton fibers, which affected the mechanical properties of the paper. The value of fracture resistance is 79 i.b.s., which is 3.0–3.5 times higher than the norms established for offset printing paper in accordance with GOST 9094, and the length of the cut was 2235 m. The results of the determination of the shear length values of the test papers № 2 and 3 confirmed the possibility of using modified PAN fiber waste in the amount of 20 to 50 % in the mass of the top layer compositionWhen the amount of modified PAN fiber waste is increased again, the total amount of inter-fiber bonds between the cellulose fibers decreases, which is reflected in a 17 % decrease in the break length of № 4 sample compared to № 1 sample. The indicators characterizing the resistance to abrasion and elongation remained almost the same, regardless of the percentage of PAN fiber waste added to the modification.

A decrease in the swelling value in one-sided wetting from 148 to 144 g/m^2 indicates an increase in hydrophobic properties due to the compaction of the paper surface structure or the addition of modified PAN fiber waste [10, 11].

Conclusions. Based on the obtained datas, the following results were identified. The physical and mechanical properties of composite multilayer paper with the addition of modified PAN fiber waste to

Table 2. **Physical and mechanical properties of experimental paper and cardboard**

Parameters	№ 1 100/100	№ 2 80:20/100	№ 3 50:50/100	№ 4 30:70/100
Mass 1 m^2, g	150	150	150	150
Thickness, mm	0.24	0.21	0.22	0,25
Humidity, %	5.3	5.1	5.5	5.8
Smoothness, p	40	39	33	22
Ashes , %	5.1	6.4	7.1	7.8
Absorption in unilateral wetting (Kobb60) g/m^2	148	144	144	145
Break length, m	2235	2220	2201	1902
Fracture resistance, number of bends in both directions	79	75	74	75
Abrasion resistance, kPa	372	365	362	365
Elongation resistance, mN	270	274	271	274

the composition of cotton cellulose were studied. By analyzing the values of mechanical properties, the optimal composition of the paper composition, which serves to maintain the strength properties of cotton fibers was determined. Experiments have shown that the breaking length and refractive index of multilayer paper and cardboard with the addition of modified PAN fiber waste to the composition of cotton cellulose allow to obtain a quality product that meets the normative document. The use of multilayer paper and cardboard as packaging material has been confirmed to solve the problem of raw materials in the paper industry through the use of secondary domestic raw materials, reducing the cost of the finished product and its suitability for recycling.

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