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Development of Technology for Producing Multilayer Paper and Cardboard Containing Synthetic Fibers

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Abstract

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

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].

Main Purpose of Scientific Research

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.

Experimental Research

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 / m2 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 Al2 (SO4) 3 was used as a precipitating reagent.

Table 1: Options of two-layer castings of compositional content

Option №	compositional content		
	Top layer 40-55 °ShR		The lower layer 21-28 °SHR
	ПЦ, %	МПАН, %	МС-5Б, %
Sample №1	100	-	100
Sample №2	80	20	100
Sample №3	50	50	100
Sample №4	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). 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.

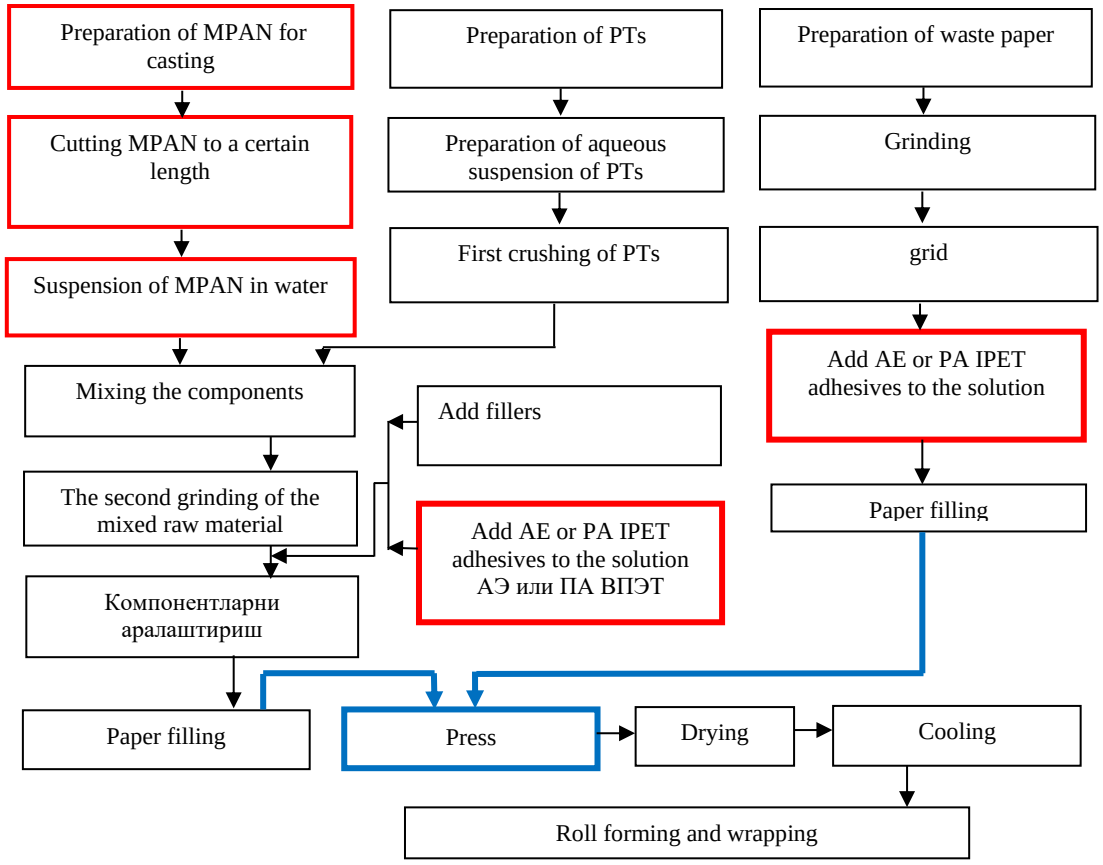

Figure 1. Production of multilayer paper and cardboard based on cotton cellulose and MPAN waste

For the production of multilayer composite paper and cardboard, the process of gluing the surface with a polymer adhesive was additionally introduced (Fig. 1). 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 (Table 2).

Table 2: Material consumption in the production of composite papers

№	For the surface layer:	№	For the bottom layer:
1	cotton cellulose: 0 - 100%, waste of modified PAN fiber: 20 - 70%	1	Secondary waste paper:
2	Kaolin - 145 kg / t	2	
3	Alum - 43 kg / t	3	
4	Roofing oil - 25.7 kg / t	4	Roofing oil - 25.7 kg / t
5	Uniflok - 0.2 kg / t	5	Uniflok - 0.2 kg / t

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. 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

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 3).

Table 3: 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
1	Mass 1 m^2, g	150	150	150	150
2	Thickness, mm	0,24	0,21	0,22	0,25
3	Humidity,%	5,3	5,1	5,5	5,8
4	Smoothness, p	40	39	33	22
6	Ashes ,%	5,1	6,4	7,1	7,8
7	Absorption in unilateral wetting (Kobb60) g / m2	148	144	144	145
8	Break length, m	2235	2220	2201	1902
9	Fracture resistance, number of bends in both directions	79	75	74	75
10	Abrasion resistance, kPa	372	365	362	365
11	Elongation resistance, mN	270	274	271	274

The obtained data (Table 3) 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 composition When 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 / m2 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].

An adhesive is added to the paper mass to ensure a strong adhesion of the fibrous mass, to give it the properties of moisture resistance, strength of the paper in both wet and dry conditions. Currently, rosin-based adhesives [12], as well as synthetic adhesives, are widely used in paper gluing.

In order to to give the paper the necessary mechanical strength at this stage of the study A solution of acrylic emulsion and alcohol product of secondary polyethylene terephthalate with diethylene glycol was used as an adhesive instead of rosin glue. [13].

Three different types of secondary polyethylene terephthalate are used.

They were obtained as follows: the alcoholization was carried out in a four-necked flask, which was equipped with a mechanical stirrer, a reverse refrigerator, a thermometer, and a capillary to inert the inert gas. The flask was filled with a solution of alcohol product of secondary polyethylene terephthalate with diethylene glycol in a ratio of 1 mol.

With good stirring, the temperature was raised to 220 ± 50C and maintained for 6 h. At the end of the alcoholization period, three ratios were conditionally set as follows:

1) Sample №2^{A} secondary polyethylene terephthalate alcohol product with diethylene glycol in a ratio of 1: 2 mol;

2) Sample №2^{B} secondary polyethylene terephthalate alcohol product with diethylene glycol in a ratio of 1: 3 mol;

3) Sample №2^{V} secondary polyethylene terephthalate solution of alcohol product with diethylene glycol in a ratio of 1: 4 mol;

4) When using a sample №2^{G} - acrylic (AE) emulsion.

Two series of tests were performed during the study.

In the first series of tests, the following composition of the paper mass was used: cotton cellulose + modified PAN fiber + secondary waste paper and 1.5% experimental adhesive to the paper mass was added a solution of secondary polyethylene terephthalate alcohol product with diethylene glycol.

In the second series of tests, the following composition of the paper mass was used: cotton cellulose + modified PAN fiber + secondary waste paper raw material (MS-5B) and 2% experimental adhesive to the paper mass. [14].

To maintain the strength characteristics of the cotton cellulose, grinding was carried out at 40–55° SR for the top layer and 48–50° SR for the bottom layer. Papers with a mass of 150 g / m^2 (top layer 60 g / m^2, bottom layer 90 g / m^2) were obtained with the addition of 20% PAN fiber waste to the modified (Table 4).

Table 4: Options for adding adhesives to the composition of multilayer paper №2 (80% cotton cellulose and 20% MPAN)

Option №	Experimental glue composition	The amount of glue relative to the mass
Sample №2A	IPET and DEG 1: 2 mol ratio	1,5%
		2%
Sample №2B	IPET and DEG 1: 3 mol ratio	1,5%
		2%
Sample №2V	IPET and DEG 1: 4 mol ratio	1,5%
		2%
Sample №2G	Acrylic emulsion	1,5%
		2%

In this study, not only the adhesive and its quantitative ratio, but also the percentage of its addition to the total mass were studied. In this regard, two series of experiments were performed with a №2 paper sample with 20% modified PAN fiber waste. In this case, the mass of paper with a uniform fractional composition provided the strength of adhesion between different fibers. If 1.5% of the adhesive was applied in the first series of experiments, 2% of the total mass was added in the second series of experiments.

The results of the study of the quantitative ratio of the solution of alcoholic product of secondary polyethylene terephthalate with diethylene glycol and the percentage of adhesives in the composition to the physical and mechanical properties of multilayer paper are presented in Table 5. The table shows the values of the sample of multilayer paper №2 with the addition of an adhesive in the amount of 1.5% relative to the total mass on the basis of 80% cotton cellulose and 20% modified PAN fiber, the values of 2% adhesive in the denominator.

Table 5: Multi-layer paper №2 (80% cotton cellulose and 20% MPAN) sample Physical and mechanical properties

№	Options / parameters	№2 Sample numbers			
		№2^{A} 1:2 and	№2^{B} 1:3 at	№2^{B} 1:4 and	№2^{G} AƏ yes
1	Mass 1 m^2, g	150			
2	Thickness, mk/m	219/207	230/208	221/224	230/227
3	Humidity,%	5,30/5,71	6,09/7,97	6,10/6,43	5,60/5,43
4	Smoothness, p	39/40	32/31	33/30	48/55
6	Ash,%	3,3/3,1	3,5/3,4	3,1/3,1	3,4/3,6
7	Swelling in unilateral wetting, ($Kobb_{60}$), g / m2	80,1/81,2	76,1/75,1	71,6/71,4	91,9/99,1

8	Break length, m	2842/2913	2440/2351	2512/2441	3241/3254
9	Fracture resistance, number of bends in both directions, i.b.s.	32/36	24/26	25/24	33/37
10	Abrasion resistance, kPa	365/372	154/131	125/115	365/362
11	Elongation resistance, mN	270/274	171/174	168/171	211/201

Analysis of Results

A comparative analysis of the break length values showed that when acrylic emulsion is used, it is possible to obtain multilayer paper and cardboard with a mechanical strength of more than 3000 m with a break length, and when added at 2%, this value reaches 3254 m. This may be due to the high flexibility of polymethylacrylate macromolecules.

Addition of a secondary polyethylene terephthalate solution of diethylene glycol with alcohol in a ratio of 1: 2 to 2% of the total mass increases the strength of the bond between the fibers by 31%, when used in other proportions, the addition of 2% of the adhesive increases the structure by 5.9% and 9.9%. strengthens. At the same time, the resistance to abrasion and elongation remained unchanged, the resistance to fracture decreased by 2.3%..

A comprehensive assessment of the mechanical properties of multilayer paper and cardboard shows that multilayer paper and cardboard have the best strength performance when the adhesive is used in acrylic emulsion. The use of acrylic emulsion serves to strengthen the bonds between different fibers, thereby increasing the mechanical strength of the paper.

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 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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