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THE EFFECT OF VARIOUS SIZING AGENTS ON THE PHYSICAL AND MECHANICAL PROPERTIES OF PACKAGING PAPERS CONTAINING TEXTILE FABRIC WASTE

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Annotation: This article studies the issues of improving the physical and mechanical properties of packaging papers containing textile fabric waste (TWF), the effective use of secondary and alternative raw materials, and stabilizing the strength indicators of paper products. The main goal of the study is to increase the mechanical strength of experimental packaging papers containing TWF and improve the efficiency of fiber bonding in the paper pulp. For this purpose, sizing agents based on hydroxypropylmethylcellulose (GPMS) and modified cationic starch (MCS) were added to the paper pulp in an amount of 2%, experimental paper samples were prepared, and their main physical and mechanical indicators were studied. The results obtained showed the possibility of producing high-strength packaging papers using TWF.

Keywords: paper, packaging paper, textile waste, secondary raw materials, cotton cellulose, modified cationic starch, hydroxypropylmethylcellulose, sizing agent, interfiber bonding, breaking length, breaking strength, density, physical and mechanical properties.

Аннотация: В данной статье рассматриваются вопросы улучшения физико-механических свойств упаковочной бумаги, содержащей текстильные отходы (ТО), эффективного использования вторичного и альтернативного сырья, а также стабилизации показателей прочности бумажной продукции. Основная цель исследования – повышение механической прочности экспериментальной упаковочной бумаги, содержащей ТО, и улучшение эффективности связывания волокон в бумажной пульпе. Для этого в бумажную пульпу добавляли 2% гидроксипропилметилцеллюлозы (ГПМЦ) и модифицированный катионный крахмал (МКК), готовили экспериментальные образцы бумаги и изучали их основные физико-механические показатели. Полученные результаты показали возможность производства высокопрочной упаковочной бумаги с использованием ТО.

Ключевые слова: бумага, упаковочная бумага, текстильные отходы, вторичное сырье, хлопковая целлюлоза, модифицированный катионный крахмал, гидроксипропилметилцеллюлоза, проклеивающий агент, межволоконное связывание, разрывная длина, разрывная прочность, плотность, физико-механические свойства.

Today, the widespread use of secondary raw materials in paper and cardboard production is gaining importance in terms of saving resources, reducing waste, reducing production costs and reducing negative environmental impacts. At the same time, the instability of the fractional composition, fiber length, dispersion, papermaking ability and interfiber bonding properties of alternative and secondary fiber raw materials can negatively affect the physical and mechanical properties of the finished paper.

Most types of paper and cardboard produced in our country are made on the basis of alternative and secondary raw materials. Problems in the use of alternative and secondary fibers and the associated difficulties in achieving stable physical and mechanical properties are mainly associated

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with problems such as the instability of the fractional composition of the raw materials and the papermaking properties.

The simplest, most accessible and economically effective way to solve this problem is to use adhesives that have a purposeful reinforcing effect on the paper structure. Currently, a wide range of such adhesives is presented on the world market [56]. The effectiveness of these adhesives and the possibility of using them to strengthen paper are also being studied by a number of scientists in our country.

The strength of paper depends on several factors, the main ones being: the strength of the fibers, their flexibility, their orientation (orientation), the strength of the interfiber bond, as well as the properties of the adhesives in the mass. Adhesives play an important role in the paper industry and in the production of printed materials.

The aim of this experimental study was to improve the mechanical properties of the experimental paper by adding 2% hydroxypropylmethylcellulose (GPMS) and Modified cationic starch (MCS) sizing agents to the paper stock and obtaining experimental paper samples. The results are presented in Table 1.

The study of the physical and mechanical properties of the experimental packaging papers containing MCS showed that the paper with the TWF sizing agent added has a significant advantage over the control samples with the GPMS sizing agent in terms of parameters such as breaking length, breaking strength, number of folds, and density.

The sizing agent - MCS was added to the paper mass in an amount of 2%. It is known that MCS not only increases the strength of the paper, but under certain conditions it also serves to retain the fibers contained in the paper in the papermaking web. Also, the introduction of MCS into the paper composition has a number of advantages - the composition of this sizing agent is close to the composition of cellulose and in the swollen state, like hemicellulose, it forms additional hydrogen bonds with cellulose through hydroxyl groups.

The effect of adhesives on the physical and mechanical properties of packaging paper containing TWF

Indicators	Composition, %																	
Weight, g/m²	90±4 g/m²																	
Adhesive	GPMS, 2%									MCS, 2%								
Options	1*	2*	3*	4**	5**	6**	7***	8***	9***	10*	11*	12*	13**	14**	15**	16***	17***	18***
CS, %	100	50	-	100	**50**	-	100	50	-	100	50	-	100	**50**	-	100	50	-
TWF, %	-	50	100	-	50	100	-	50	100	-	50	100	-	50	100	-	50	100
Break length, L, m	3640	**3621**	3611	3642	**3611**	3510	3639	3325	3191	3640	**3650**	3632	3641	**3665**	3648	3640	3520	3298
Bending resistance	56,6	**68,0**	65,2	61,0	**60,3**	51,6	55,5	30,0	22,0	56,6	**63,0**	61,2	61,0	**63,3**	52,6	55,5	32,0	26,0
Thickness, mm	0,13	**0,14**	0,12	0,13	**0,13**	0,12	0,13	0,13	0,14	0,13	**0,14**	0,12	0,13	**0,13**	0,12	0,13	0,13	0,14
Density, g/m³	2,78	**2,78**	2,75	0,73	**3,80**	2,71	1,74	1,80	1,71	0,78	**0,88**	0,75	0,76	**0,85**	0,72	0,78	0,82	0,76
Ash content, %	0,7	0,9	0,9	0,8	0,9	0,8	1,6	3,8	7,9	0,7	0,8	0,9	0,8	0,9	0,8	1,3	3,7	7,8

*Note: *- type 1 TWF*
***- type 2 TWF*
****- type 3 TWF*

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The increase in the thickness of the packaging paper containing TWF, the increase in the amount of MCS sizing agent in combination with TWF in the cotton cellulose (CS) content can be explained by the positive interaction of natural fibers in the paper pulp. Adding MCS sizing agent to the paper pulp is one of the effective methods widely used in paper production. We can see that it forms a stronger bond with cationic groups and fibers. MCS forms a much higher molecular cross-linking with textile fabric waste, thereby increasing the efficiency of sizing. In particular, the modified cationic starch strengthens the hydrogen bonding between fibers, which improves the mechanical properties of the paper. MCS contains NH_4^+ groups, which enter into a strong electrostatic attraction with the negatively charged surfaces of the fibers. This bonding results in increased high-fiber bonding, increased paper breaking length, improved tensile strength, increased adhesive retention, and reduced additional adhesive consumption.

When CS, TWF and GPMS were added to the paper pulp, the density indicators of the experimental packaging papers improved, which indicates that this glue fills the CS between the fibers. Based on the results obtained, it can be noted that the experimental papers containing TWF in the paper pulp can be recommended for printing packaging products.

Based on the results obtained, it was found that MCS, as a component of paper pulp, CS to increase the strength properties of paper due to its unique physicochemical properties presented in the literature. When 2% of MCS sizing agent was added to the paper pulp, the strength properties of the paper increased by 8%. When MCS sizing agent and 50% of TWF were added to the paper samples, an increase in strength properties by 10% was observed, despite the use of secondary fibers. MCS sizing agent significantly increases the strength properties of paper, and is even more effective due to its hydrophobicity. In conclusion, the MCS and GPMS sizing agents used in this experiment increase the strength and durability of paper. At the same time, they serve to comply with sustainability and environmental requirements. The importance of these sizing agents in modern paper production is significant, providing broad opportunities for creating high-quality, environmentally friendly paper and cardboard products that meet the demands of a rapidly changing world.

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