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STUDY ON THE GRINDING TIME DURATION IMPACT ON THE PROPERTIES OF PAPER FROM ALTERNATIVE RAW MATERIALS

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Abstract. *Both raw and recycled fiber materials are used for paper production. The increase in percentage use of the latter is due to their paper-forming properties, availability and low cost. The article explores the possibility of using pulp from the inner layer of mulberry twig bark. Mulberry twigs, after removing leaves, which are the main raw material in silk production, have no practical industrial application. Recycling waste - mulberry branches - for the production of pulp is therefore relevant as it is aimed at solving raw material and environmental problems. The purpose of this work is to use local raw materials for paper production, study the impact of processing method of the grinding process on paper forming properties. During grinding the mechanical processes of changes of fibers determine mainly structure of a paper sheet, and colloidal-physical processes - bind and ability of fibers to form strong, homogenous and smooth structure of paper. The structure of the sheet of paper facilitates excessive or "selective" ink absorption into the pores of the paper and thus predetermines the quality of reproduction during the printing process. Methods for determining the physical and mechanical properties of papers were used in this work, and changes in the surface structure of samples cast at various technological modes of the milling process were studied. The results of the study revealed that the addition of cellulose mass from the inner layer of mulberry twig bark helps to obtain a strong paper. The optical properties of the paper, which contains cotton and cellulose from the inner layer of mulberry branch bark, are explained by the whiteness of the added fibers themselves. The strength properties of the paper at a weight grinding degree of 300 CWR are explained by the bond between the split and strongly interwoven fibers of the cellulose fibers. It has been established that the addition of more than 30% cellulose from the inner layer of the mulberry branch bark to the paper pulp mass is undesirable, as this adversely affects the whiteness of the paper.*

Key words: *paper, alternative raw materials, structure, grinding process, fineness degree, strength properties of paper, optical microscope, paper structure, microphotography of paper.*

INTRODUCTION. Different types of cellulose fiber materials used for paper production, such as raw material yield, chemical composition, degree of cellulose polymerization, strength, whiteness and fiber structure [1], make it possible to obtain a wide range of papers with different properties. Proper selection of the main raw materials as well as technological modes of production contributes to the production of paper with the specified properties required for printing quality [2-4].

The structure of a paper sheet characterized by the size, form and mutual arrangement of the used fibers and their quantitative ratio facilitates excessive or "selective" absorption of printing ink into the pores of the paper and thus predetermines the quality of reproduction during printing [5].

The paper sheet structure and the paper's absorption ability depend both on the paper-forming properties of the fiber material and on the production process parameters. It is therefore difficult

to decide which of the paper production processes is most relevant in terms of the effect on the properties of the final product. However, the paper pulp grinding process has long been of great importance. During grinding, the mechanical processes of fiber change mainly determine the structure of the paper sheet and the colloidal-physical processes-the bond and the ability of the fibers to form a solid, homogeneous and smooth paper structure [6].

To determine the quality of paper pulp during grinding, various methods and instruments are used. The Schopper-Riegler instrument decides the degree of pulp fineness or its fastness. After grinding, an optical or electron microscope is used to test the fiber structure.

The resolving power of the optical microscope does not allow individual hydrogen bonds to be discerned, but the structure of the fiber after grinding can be seen in magnified images in the form of thin bars and fibrils between adjacent fiber surfaces [7].

In works [8-14], properties of paper from various recycled fibrous materials are investigated with the purpose of maintenance of required printing properties on the basis of the information on quality of printing. The problem of alternative raw materials selection for paper production and research of influence of grinding process on its paper-forming properties and structure of paper web is currently important as aimed at the solution of a raw materials problem for pulp-and-paper industry branch, at the expansion of the nomenclature and assortment of paper products and supply of the printing enterprises with a paper with the prescribed properties.

The purpose of this work is to study the impact of the grinding process on changes in the properties of paper which includes cellulose pulp from the inner layer of mulberry branch bark added to cotton lint cellulose.

The following tasks have been solved to achieve the goal:

- the paper based on cotton pulp from cotton lint with addition of cellulose pulp from the inner layer of mulberry branch bark was obtained at different processing methods of grinding process;
- physical and mechanical properties of paper samples were investigated;
- microscopic analysis of paper samples surface was carried out;
- characteristics of the obtained materials were studied and recommendations on their application were offered.

MATERIALS AND METHODS. Papers based on cotton lint cellulose with the addition of cellulose mass from the inner layer of mulberry branch bark were used as the study subject. The paper castings with a weight of 80 g/m2 were obtained in laboratory conditions under different grinding modes. The degree of milling of cotton pulp (CC) is 45 0SR, the pulp mass from the inner layer of the bark of mulberry branches (TC) is 10 0SR for the first version and 30 0SR for the second version. Properties of paper samples examined using standard methods [15] are inserted in Table 1.

Table 1

Paper samples properties in different cast variants

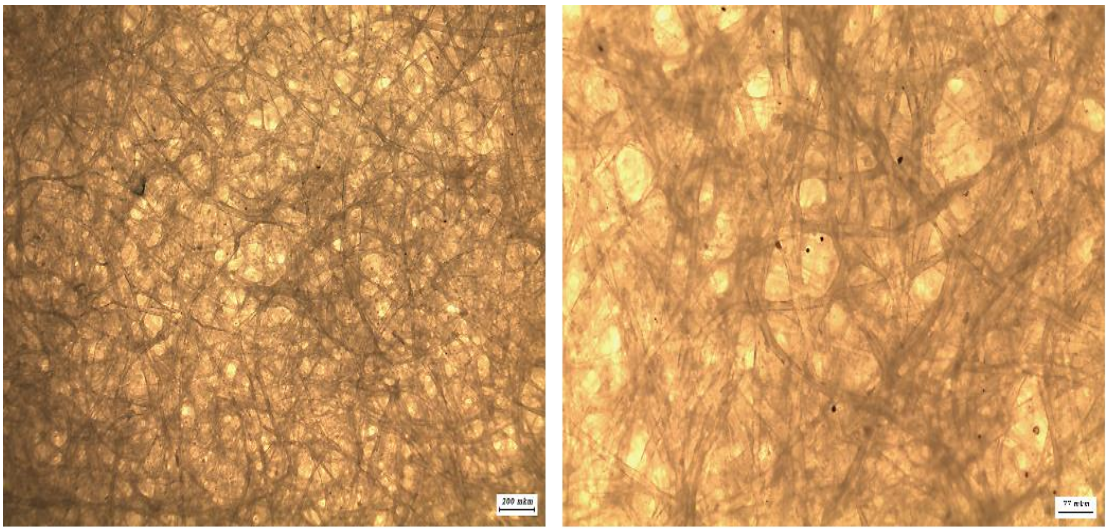
Blend composition of paper CC: MC, %	Whiteness, %		Breaking force, N		Breaking length, m		Folding endurance, number of double folds	
	1	2	1	2	1	2	1	2
100 :0	77	82	58,1	49,1	4940	4180	300	280
90:10	70	80	59,2	51,1	5030	4340	180	300
80:20	57	79	61,2	53,6	5200	4560	150	320
70:30	54	78	59,7	55,6	5080	4730	50	350
0:100	34	74	35,4	60,1	3010	5110	30	550

RESULTS. Analyzing the results of studies of the paper samples properties (Table 1) it was revealed that the breaking force determined according to GOST and ISO 1924-1-96 characterized the maximum force that the paper sample withstood before breaking. Using the test results, the breaking length of a strip of paper that was torn by its own weight was calculated. The increase in the mechanical strength of the paper under study relative to the strength of cotton cellulose can be explained by the fact that in two variants the grinding time contributed to the formation of a mass of fibrillated fibers of the inner layer of the mulberry branches bark, which promoted better mechanical interweaving between different fibers.

The optical properties of paper which contains cellulose from cotton and the inner layer of the mulberry branches bark is accounted for the degree of whiteness of the added fibers themselves.

The addition of cellulose from the inner layer of the mulberry branches bark with fineness degree of 30 ^{0}SHR to the cotton pulp made it possible to obtain paper where no significant or abrupt changes in mechanical strength and whiteness were observed.

The Motic BA210 optical microscope, designed for laboratory and scientific research in biology, medicine, botany, chemistry and other fields of science was used to study the changes in the surface structure of paper samples cast under different grinding modes. The head part of the microscope consists of a binocular attachment with a 30^{o} tilt and 360° rotation with a built-in 3.0 Mp (2048x1536) digital color camera, wide-field eyepieces N-WF10x / 20 with diopter adjustment. CCIS (Color Corrected Infinity System) - optics designed for "infinity" and color corrections.



Microphotographs of the surface of 100% CC paper

Fig.1. Microphotographs of paper samples surface consisting of 100% CC

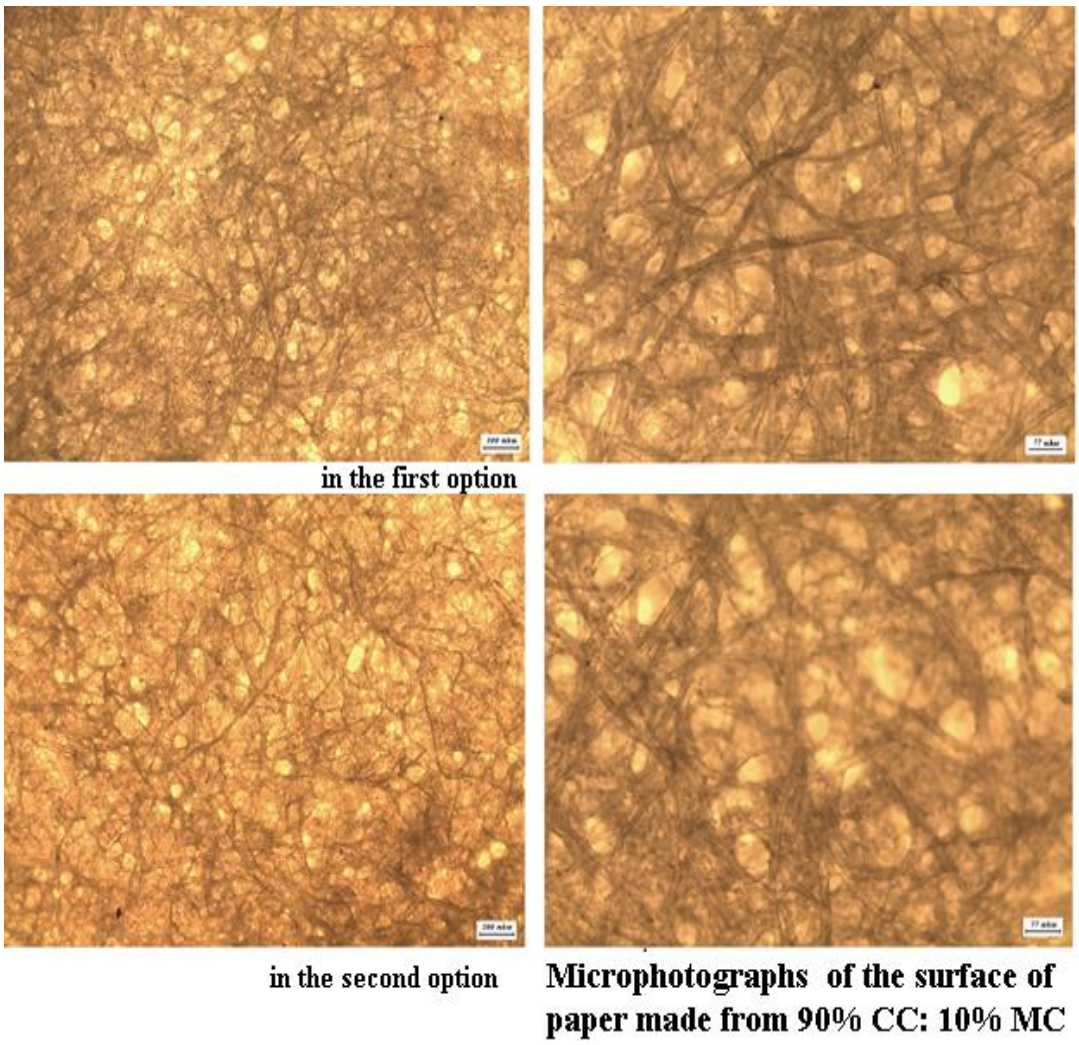


Fig.2. Microphotographs of paper samples surface consisting of 90% CC:10% MC

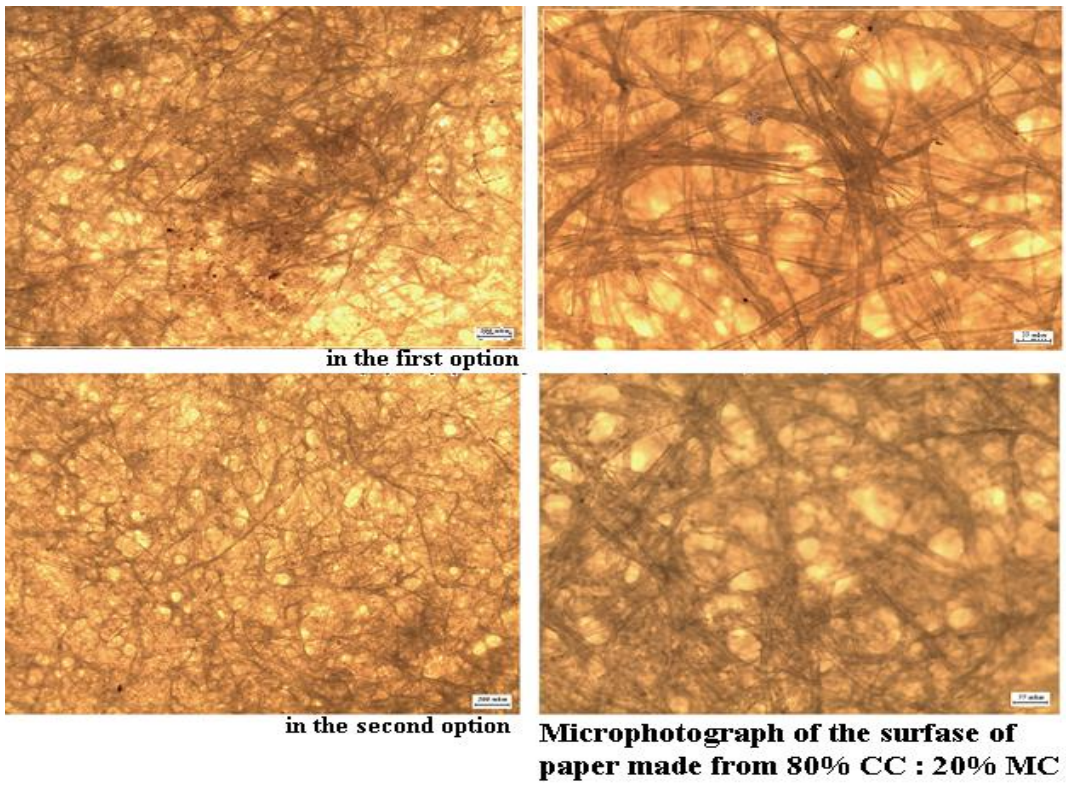
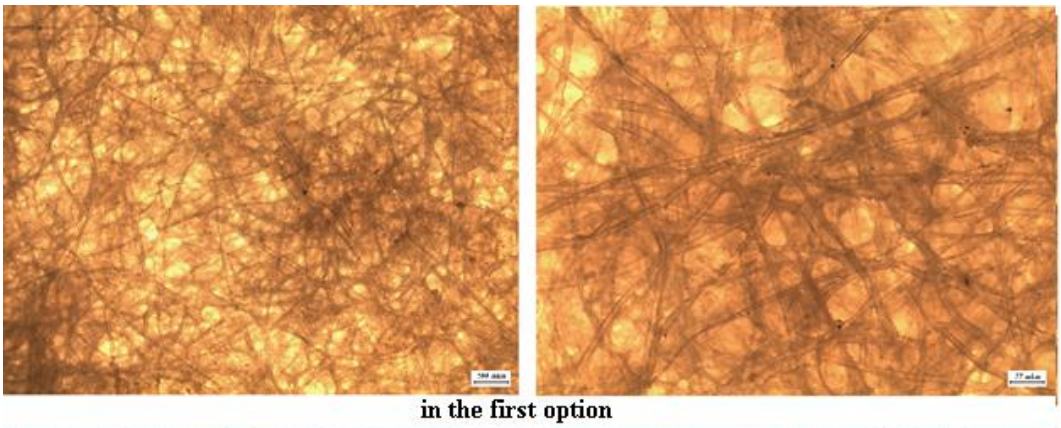
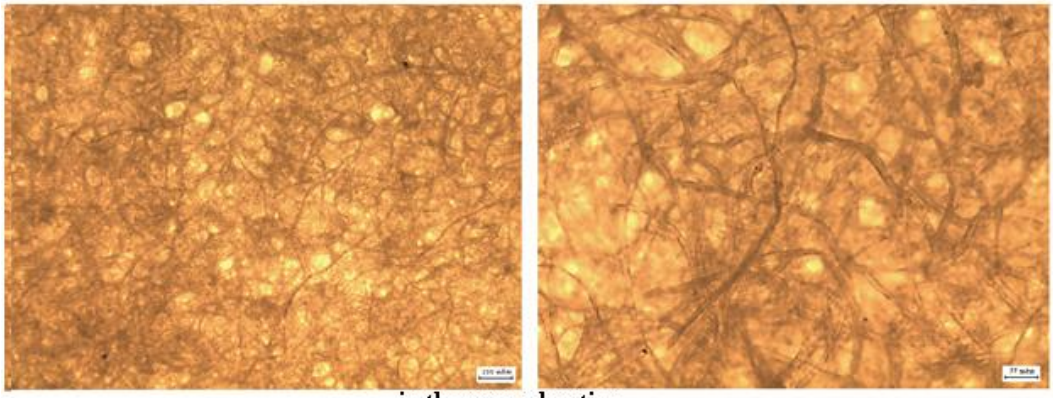


Fig.3. Microphotographs of paper samples surface consisting of 80% CC : 20% MC

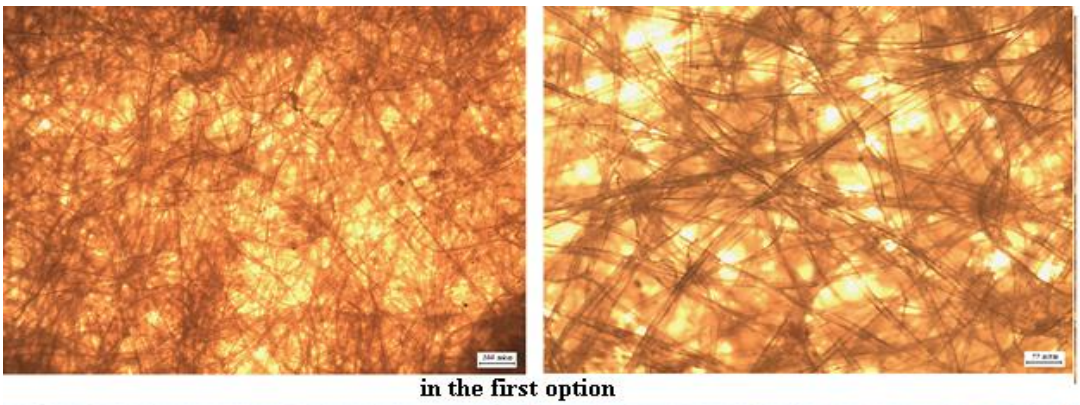


in the first option

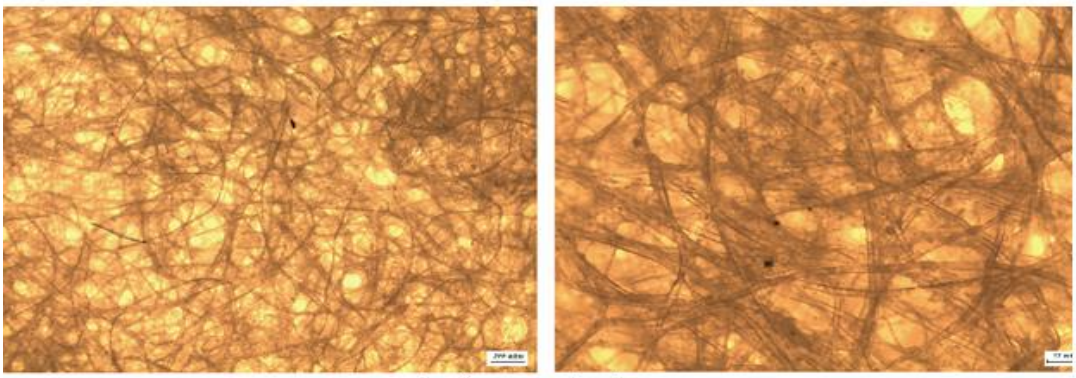


in the second option

Fig.4. Microphotographs of paper samples surface consisting of 70% CC : 30% MC



in the first option



in the second option

Fig.5. Microphotographs of paper samples surface consisting of 100% MC in two variants of cast

Analyzing the microgeometry of the surface of paper samples, the following should be noted:

- cotton fibers - long and thin, have a ribbon-like shape with entanglement, a canal is visible inside the fiber (Pic. 1);

- the pulp from the inner layer of the mulberry branches bark has long and thin fibers, elongated, rounded (Pic. 5);

- the addition of cellulose pulp from the inner layer of the mulberry branches bark to the paper composition helps to fill the voids inside the cotton fibers (Pic. 2-4).

- the strength properties of paper in the second variant of the cast are accounted for the bonding forces between the splitted and strongly intertissued fibrils of cellulose fibers, provided at a pulp fineness degree of 30 ^{0}ShR.

CONCLUSION. It was found that the addition of pulp from the inner layer of the mulberry branches bark contributes to the production of strong paper;

Optical properties of the paper which includes cellulose from cotton and the inner layer of mulberry branch bark are accounted for the degree of whiteness of the added fibers themselves;

Strength properties of the paper at the fineness degree of 30^{0}SHR are accounted for the bonding forces between the splitted and strongly intertissued fibrils of cellulose fibers*;*

It has been established that the addition of more than 30% of cellulose pulp from the inner layer of mulberry branch bark to the paper pulp is undesirable, as it adversely affects the whiteness of the paper.

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