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A. A. Dubovik, PhD student, junior researcher (BSTU); **V. V. Gorzhanov**, PhD (Engineering), researcher (BSTU); **T. P. Shkirando**, senior researcher (BSTU); **A. A. Penkin**, PhD (Engineering), assistant professor (BSTU); **T. V. Solovyeva**, D. Sc. (Engineering), professor (BSTU)

PAPERMAKING PROPERTIES OF VARIOUS PULPS USED FOR PRINTING PAPER PRODUCTION

Papermaking properties of recycled pulp obtained from office paper, thermomechanical and chemithermomechanical pulp were investigated. The optimal refining parameters of recycled pulp and chemithermomechanical pulp such as refining time, rotational disk speed and refiner disk gap, allowing to increase their papermaking properties, were determined. It was found that recycled pulp exhibits the greatest efficiency (among the pulps under investigation) of chemical pulps replacing in the furnish composition of offset printing paper.

Introduction. One of the main trends in manufacture of high-quality printing grades of paper is the use of cheap fibrous raw materials, such as recycled pulp and mechanical pulp. It allows the Belarusian enterprises not to be dependent on the price of the imported expensive bleached chemical pulps which are the most important raw material for manufacture of printing paper.

The mechanical pulp is one of the most economical raw materials as it has 96–98% yield from wood. The manufacture doesn't require any processes of cooking and regeneration of chemicals, thus preventing environmental pollution. One of the main disadvantages of mechanical pulp in comparison with chemical pulps is low strength of a paper sheet, which should be increased in the modern conditions.

Now in the process of printing paper-manufacturing mainly two kinds of mechanical pulp are used: thermomechanical (TMP) and chemithermomechanical (CTMP) [1]. Manufacture of TMP by the RTS-method already exists in the Republic of Belarus at RUE "Zavod Gazetnoy Bumagi" (Shklov). The construction of a new plant manufacturing CTMP at Dobrush paper factory «Geroy Truda» is under design.

Recovered paper, despite its low cost, is applied for high-quality printing paper production not so wide as chemical pulps due to its papermaking properties deterioration (strength loss) at multiple use in paper manufacturing. The strength loss in recycling is caused by irreversible changes in surface properties of the recycled fibers, the so-called hornification of fiber surface [2]. Therefore making a choice of the required kind of a fibrous material we ought to take into account its papermaking properties [3] that can provide the required quality of paper [4].

Main part. The aim of this work is to determine of replacing possibility of expensive bleached kraft pulp for cheap kinds of fibrous raw materials, such as recycled pulp and mechanical pulp, in the furnish composition of offset printing paper without decrease of its quality characteristics.

Throughout the investigation, we used the following pulps:

– TMP (obtained at RUE "Zavod Gazetnoy Bumagi" where is used for newspaper-manufacture);

– CTMP (obtained at "Oy Metsa-Botnia Ab", Finland);

– recycled pulp (obtained by disintegration of office paper samples, namely, white woodfree computer print-out (EN 643 3 07 00 grade of recovered paper);

– softwood bleached kraft pulp (SBKP, obtained at "Oy Metsa-Botnia Ab");

– hardwood pulp bleached kraft pulp (HBKP, obtained at "Ilim Pulp" (Russia).

SBKP and HBKP were used for comparison with mechanical pulps and for optimization of the furnish composition of printing paper.

Refining of the pulps was performed in the laboratory refining set LSR-1 equipped with a low consistency pulper and a disc refiner with variable rotational disk speed and disc gap (100 g, 4% consistency, 2.5 L).

It was found that the duration of processing the pulps under analysis in the pulper differs, that is, complete disintegration recovered paper takes 20 min, TMP – 15 min, CTMP – 10 min. Table 1 represents papermaking properties of the pulps after repulping.

Table 1 indicates that the refining degree of TMP is essentially higher, than that the other pulps. It is accounted for by the fact that TMP was refined to a high refining degree in the process of its manufacture in two stages. Low drainage rate of TMP is caused by its high fines content (32.7%).

The fiber length distribution of TMP and CTMP is presented basically by long fibers (66,6% and 59,9% respectively) and fines (32.7% and 28.47% respectively), SBKP – by long fibers (98.7%), and HBKP – by long (67,5 %) and middle fibers (14.6%) and fines (17.9%). Long (87.1%) and middle fibers (8.6%) prevail in the fiber length distribution of the recycled pulp.

The value of the average-weighted length of fibers varies from 15 to 114 dg and decreases from SBKP to CTMP.

Table 1

Papermaking properties of pulps after repulping

Papermaking properties	Pulp type				
	Recycled pulp	TMP	CTMP	HBKP	SBKP
Refining degree, ºShR	27	66	18	16	14
Value of the average-weighted fiber length, dg	27	36	15	37	114
Drainage rate, ml/s	29.0	3.4	32.0	70.0	100.0
Bauer-McNett fractions[a], %					
– R16 (long fibers)	46.63	42.15	11.37	0.05	87.18
– R30 (long fibers)	23.79	15.35	29.03	24.50	7.21
– R50 (long fibers)	16.72	9.11	19.50	42.90	4.32
– R100 (middle fibers)	8.59	0.70	11.63	14.60	1.17
– P100 (fines)	4.27	32.69	28.47	17.90	0.12

[a]R16, R30, R50, and R100: pulp fractions retained on the 16-, 30-, 50-, and 100-mesh screens; P100: pulp fraction passing through the 100-mesh screen (calculated by difference).

In order to obtain the maximum papermaking properties of the pulps at the minimum refining energy consumption, the optimum conditions for the pulp refining process were determined. We used the Box experimental design and varied three refining parameters for all pulps at three levels: refining time – 10, 20, 30 min, refiner disk gap – 0.2, 0.3, 0.4 mm and rotational disk speed – 1,000, 1,500, 2,000 rpm. Exponential functional forms were selected to calculate the desirabilities associated with individual criteria: refining degree, value of the average-weighted fiber length, drainage rate and refining energy consumption, and the use of the geometric mean for weighting these criteria together to calculate overall Harrington's desirability D function [5]. The maximization of the overall desirability D was carried out by using Microsoft Excel software.

Table 2 represents the optimal refining parameters of the pulps and pulp characteristics achieved at these parameters.

Table 2 indicates that the refining of recycled pulp at the obtained optimal parameters allows to improve its papermaking properties and to bring them to the properties of bleached kraft pulps.

To determine the optimal furnish composition of the offset printing paper containing the investigated types of pulp we applied simplex-lattice design [6] and varied pulps percentage in the paper furnishes in the following intervals: HBKP 20–40%, SBKP 30–50%, CTMP, TMP and recycled pulp 10–50%.

The handsheets with a basis weight of approximately 80 g/m^2 were formed from the above-listed furnishes using a Rapid-Köten sheet former without white water recirculation. The number of paper sheets for each refining condition was ten.

Handsheet paper properties including breaking length, ISO brightness, folding endurance, air permeability and resistance to picking were measured in concordance with relevant standards.

For every type of pulps the optimal percentage in printing paper furnishes was defined:

– furnish 1: HBKP – 28%, SBKP – 32% and recycled pulp – 40%;

– furnish 2: HBKP – 33%, SBKP – 32% and TMP – 35%;

– furnish 3: HBKP – 37%, SBKP – 32% and CTMP – 31%;

– furnish 4 (control): HBKP – 60 %, SBKP – 40%.

Table 2

Optimal refining parameters of pulps

Pulp type	Refining parameters			Pulp characteristics			
	Refining time, min	Refiner disk gap, mm	Rotational disk speed, rpm	Refining degree, °ShR	Value of the average-weighted fiber length, dg	Refining energy consumption, kWh/t a. d. s.	Drainage rate, ml/s
SBKP	15	0.36	1500	37	49	1320	15.76
HBKP	25	0.30	1325	35	29	1700	18.32
CTMP	21	0.22	1500	35	15	1400	3.02
TMP	–	–	–	66	36	–	21.86
Recycled pulp	11	0.30	1500	37	21[b]	1750	15.39

[b]The value of the average-weighted fiber length for recycled pulp while calculating the overall desirability was not taken into account as its changes were in error limits.

Comparative assessment of handsheet properties formed from various furnishes is given in Table 3.

Table 3

Comparative assessment of printing paper properties

Наименование показателя	Paper furnish			
	1	2	3	4
ISO brightness, %	90	64	79	82
Opacity, %	92	84	95	81
Folding endurance, number of double folds	280	131	50	328
Air permeability, cm^3/min	100	230	660	380
Breaking length, km	7.63	7.13	6.03	7.54
Resistance to picking, critical wax strength number (in concordance with TAPPI Standard T 233)	18	14	12	14

As seen from Table 3 the use of the printing paper furnish comprising recycled pulp in comparison with the control furnish leads to increase of resistance to picking (+22%), ISO brightness (+9%) and opacity (+12%). The use of the paper furnish comprising TMP results in opacity increase (+3%) and significant reduction of brightness and strength properties of handsheets. The use of the paper furnish comprising CTMP leads to increase of paper opacity (+15%) and to simultaneous decrease of its brightness (–3%) and strength properties. The value of air permeability that characterizes the structure of paper e.g. quantity and pore diameter in handsheets containing CTMP is 40% higher than in handsheets obtained only from HBKP and SBKP. Porous paper will provide the best printing properties because of the best absorption of typographical paints at offset printing.

The presented data prove that recycled pulp exhibits the greatest efficiency (among the pulps under study) of chemical pulps replacing.

Conclusions. Papermaking properties of recycled pulp obtained from office paper, TMP and CTMP have been investigated.

1. It was stated that TMP, due to the special peculiarities of its manufacturing has high refining degree and low drainage rate. The fiber length distribution of TMP and CTMP is presented basically by long fibers (66.6 % and 59.9% respectively) and fines (32.7% and 28,5% respectively), recycled pulp – by long fibers (87.1%) and middle fibers (8.6%).

2. The optimal refining parameters of CTMP and recycled pulp have been determined. It is shown that CTMP should be refined for 21 min at rotational disk speed of 1500 rpm and disk gap of 0.22 mm, recycled pulp – for 11 min at rotational disk speed of 1500 rpm and disk gap of 0.3 mm. Refining of recycled pulp at the defined optimal parameters has allowed to improve its papermaking properties and to bring them to the properties of bleached kraft pulps.

3. It was found that recycled pulp exhibits the greatest efficiency of chemical pulps replacing in the furnish composition of offset printing paper. The optimal furnish composition of printing paper have been defined: HBKP – 28%, SBKP – 32% and recycled pulp – 40%.

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