УДК 676 (075.8); 655,531

V. V. Gorzhanov, PhD (Engineering), assistant lecturer (BSTU);
T. P. Shkirando, Senior Researcher (BSTU);
A. N. Aleksandrova, PhD student, junior researcher (BSTU);
T. V. Solovyeva, D. Sc. (Engineering), professor (BSTU)

USED PAPERMAKING PROPERTIES OF PULP THE COMPOSITIONS OF THE PRINTING PAPER

The article presents a study of two kinds of papermaking pulp properties, that is thermomechanical and chemi-thermomechanical. Optimal parameters of grinding chemical-thermo-mechanical pulp were defined. Influence of pulp on the structural, mechanical and optical properties of paper samples was studied for offset printing. It has been established that the use of wood pulp in composition does not adversely affect on the structural, mechanical, optical and printing properties of paper.

Introduction. Features offset printing method determines the basic requirements for the properties of offset paper. Thus are very important surface strength of paper, absorbency, dimensional stability when moistened and the subsequent drying during printing. To offset paper are also important opacity and accumulation of dust. To achieve these properties play an important role the pulp composition. In this capacity, the production of paper for offset printing is used mainly bleached sulphate pulp, wood pulp and waste paper high marks.

Cellulose is the pulp, which is recovered from wood by boiling chemicals. Yield kraft pulp does not exceed 45% and after bleaching it is further reduced by 8–10%. It is relatively expensive goods. The Republic of Belarus is currently no production of bleached pulp.

Pulp - is a fibrous semifinished product obtained by mechanical separation of wood in the fiber. Wood pulp is one of the most economical intermediates, since in its production is achieved 96–98% yield of fiber from wood. In its production no pulping processes, food preparation and recovery of chemicals, which considerably reduces pollution of envi-ronment. A disadvantage of the pulp is low as compared with cellulose, the strength of the paper sheet, but modern technology allows resolve this problem. In Belarus, there is already producing pulp in the form of thermomechanical (TMP) obtained by the method of RTS on RUE "newsprint mill" (Shklov).

These real research are aimed at the achievement of high structural and mechanical, optical and printing properties of paper for offset printing in the conditions of use in the compositions of pulp – the pulp which obtained with minimal loss of the wood.

Main part. They were investigated two types of pulp from different manufacturers: thermomechanical (RUE "Newsprint Mill" Shklov) and chemithermomechanical (OY METSA-BOTNIA AB, Finland) in the study of papermaking properties.

They were introduced as a bleached kraft pulp of hardwood and softwood from different manufacturers into the paper composition, when studying the effect of the pulp on the structural, mechanical and optical properties of paper samples for offset printing, produced in the laboratory.

We should take into account its papermaking properties which determine the achievement of the required quality of paper produced together when we are selecting the pulp. In this case meaning as in the behavior of the material processes are made from her paper and its effect on the properties of the resulting pulp and finished products. Papermaking fiber material properties include, for example, its ability to fibrillate the fibers or shortening with respect to the grinding process, speed the desired degree of grinding, and indicator of dewatering rate is an important for process of outflow of the pulp sheet [1, 2].

They are comparing two types of pulp: thermomechanical (TMP) and chemi-thermomechanical (CTMP), as well as conventionally used for manufacturing for offset printing paper bleached kraft pulp from hardwood (SFA^h) and softwood (SFA^s) rocks in the study. The research results are shown in Table. 1.

The raw semifinished fiber used in the studies are different from each other, as can be seen from the data shown in Table 1.

Degree of grinding which characterizes the ability of the pulp to pass through the water itself, have substantially higher TMP, than freeness of and CTMP bleached kraft pulp of softwood and hardwood. This is due to the fact that TMP was crushed in the course of its production, while other fibrous semifinished subjected to additional grinding papermaking. Thermomechanical pulp is produced by grinding wood chips in disc mills in two stages. The first grinding step is carried out at elevated pressure, and the second - under atmospheric. TMP is the main raw material in the manufacture of newsprint, which is manufactured from the mass with a high degree of grinding – 65–67^{o}ShR. Samples were taken from the TMP process stream newsprint production at RUE "Newsprint Mill" (Shklov). Currently TMP obtain samples with lower freeness is not possible. Slow dewatering TMP is connected with its high freeness. This high proportion of the pulp coarse fraction and fines (42 and 35%, respectively).

Table 1

Papermaking properties of fiber semifinished

Indicator name	Value of the index			
	TMM	CTMP	SFA_h	SFA_s
Humidity, %	9.78	8.12	10,20	9.80
Degree of grinding, ^{oSR}	66.5	18	16	14
Weighted average fiber length, x	36	15	37	114
Dehydration rate, ml / sec	21.6	3.0	7.0	100.0
Fractional structure, % with different screen mesh, mm:				
– 1.19	42.15	11.37	0.05	87.18
– 0.59	15.35	29.03	24.50	7.21
– 0.29	9.11	19.50	42.90	4.32
– 0,14	0.70	11.63	14.60	1.17
– less 0.14	32.69	28.47	17.90	0.12

Weighted average fiber length varies from 15 to 114 and decreases from SFA^s to CTMP.

Fractional composition of CTMP is presented in the main fraction with an average fiber length and fines (29.03 and 28.47%, respectively). Fractional composition SFA_s consists mainly of long-fiber component (87.18%) and an average fiber length SFA_h (24.5 and 42.9%).

Bleached kraft pulp from softwood is the most valuable of the pulp.It is found of based on analysis of papermaking properties of fibrous semifinished. It consists primarily of long fibers, so it can be used as a composition material of short (bleached kraft pulp of hardwood, wood pulp), and independently [1–4].

Wood pulp is a mixture of fibers of different lengths, the rate of average fiber length is in the range 15–36 dg. It is known that the pulp has a better than cellulose optical properties (light scattering coefficient, opacity), but inferior in mechanical strength. Therefore, the pulp in the manufacture of paper for offset printing can be used only in conjunction with a bleached kraft pulp from wood of coniferous and deciduous species [6, 7]. Based on these studies we can conclude that due to its properties to the papermaking pulp of hardwood CTMP closest.

Appointment of the grinding process – give certain structure and size in length and thickness the fiber , make flexible and pliable fiber and provide them with a degree of hydration to link the fibers in the paper sheet, good formation (lumen) and the desired properties of paper [1, 2].

They were used plan Box [5] for determine the optimal parameters of the grinding process chemi-thermomechanical pulp, which provides a fairly complete information about the study area of the factor space. Were chosen: X1 –duration of grinding (min) X2 – interknife value of gap (mm) X3 – mill rotor speed (min^{-1}) as an independent control variables (factors). Varying levels of factors in the coded and real terms are presented in Table. 2.

Optimization criteria are indicators of pulp Y1 – freeness (°SR), Y2 – weighted average fiber length (x), Y3 – speed dehydration pulp (ml / s), Y4 – the amount of consumed energy for grinding (kW) in finding the optimal values of the selected variables.

Table 2

Levels of variation factors

Units of measurement factors	Levels of variation factors								
	X1 (duration of grinding, min)			X2 (value mezhnozhevogo gap, mm)			X3 (frequency rotation mill motor, min^{-1})		
Coded Units	–1	0	+1	–1	0	+1	–1	0	+1
Physical Units	10	20	30	0,2	0,3	0,4	1000	1500	2000

Using Add-ins “Finding Solutions” Microsoft Excel spreadsheets possible to establish the maximum value of the generalized optimization criterion *Wi* (0.46) and the corresponding optimal values of factors: the length of grinding – 21 minutes, the magnitude of the gap interknife – 0.2 mm, rotor speed mill - 1500 min^{-1}.

The values of the optimization criteria, obtained under optimum values following factors: the degree of grinding weight – 33°SR, weighted average fiber length – 20 dg, dehydration rate – 17.73 ml/s, power consumption for grinding – 0.157 kW.

The optimal parameters for the individual milling fibrous semifinished products used in the manufacture of laboratory samples of paper and weight characteristics, wich installed after implementation of the experiment, are presented in Table. 3.

Table 3

The parameters grinding fibrous semifinished

Kind of the pulp	The parameters grinding			Characteristics of mass			
	duration of grinding, min	value mezhnozhe-vogo clear-ance, mm	rotor speed mill, min^{-1}	freeness, °SR	indicator average fiber length, *x*	consumption power, kW	dehydration rate, ml / sec
SFA_s	15	0.2	1500	37	49	0.132	15.76
SFA_h	25	0.2	1500	34	29	0.170	18.32
CTMP	21	0.2	1500	34	15	0.140	3.02
TMM*	–	–	–	66	36	–	21.86

* TMP has a sufficiently high freeness and a disk mill not milled.

Table 4

Comparative characteristics of paper quality

Indicator name	Values of the paper produced from the composition		
	with TMM	with CTMP	woodfree
White, %	64	79	77
Opacity, %	95	84	81
Strength folding number	131	50	328
Air permeability,cc/min	226	656	380
Breaking length, km	7.13	6.03	7.54

The composite structure of the printing paper along the fiber is a ternary system consisting of hardwood and softwood kraft cellulose pulp. Well simplex lattice Scheffe plans that give an opportunity to get comfortable for the analysis of the chart “structure – property” [8] in solving optimization problems by definition compositional ternary.

A mass fraction of hardwood pulp in the composition denoted by X1, softwood pulp – X2, pulp – X3 for construct the simplex lattice plan.

The decision was made on the simplices computer using the package Microsoft Excel, and charting “structure – property” – using the package STATISTICA.

The diagrams are obtained for the brightness, transparency, strength, folding number, and the air permeability of the breaking length of paper for a composition comprising TMP, and compositions containing CTMP.

Were calculated generalized optimization criterion *Wi* plan in each row of the experiment for determine the optimal values of the component composition.

The maximum value of the generalized optimization criterion regression equation is W = 0,871 for the composition comprising TMM, W = 0,571 for the composition containing CTMP.

Next, we calculated the optimum values of the components in a papermaking furnish:

– SFAl – 33% SFAhv – 32% TMP – 35% for the composition containing TMP

– SFAl – 37% SFAhv – 32% CTMP and – 31% for compositions containing CTMP

Comparative characteristics of the quality of the paper produced is shown in Table. 4 from the composition with the optimal content of TMP, CTMP and woodfree (SFAl – 60% SFAhv – 40%).

The composition of the fiber component has a significant influence on the structural, mechanical and optical properties of the paper as seen from the data presented.

Use of the composition causes an increase in TMP paper opacity, but significantly reduces its whiteness. Strength TMM folding number and breaking length are on the level of control options when used in the composition to 30%. The air permeability of paper porosity and characterizes its ability to absorb inks slightly lower than the control options.

Use of the composition of CTMP increases whiteness and improve transparency as compared to the control, however, reduces the strength characteristics of the paper - the tensile strength and the length of the folding number. Outside air permeability is higher than that of the control group of 40%, which characterizes the structure of the paper (the number and diameter of pores), samples containing the composition of CTMP. Porous media will provide the best printing properties due to better absorption of inks with offset-printing is selected.

Conclusion. Studied papermaking pulp properties of two types: TMP and CTMP. It was established that TMM and CTMP different freeness, weighted average fiber length, the speed of dehydration, white and fractional composition. Fractional composition is represented mainly by a large fraction and fines of TMM, and CTMP – mostly middle fraction and fines.

The optimum parameters of grinding TMM. It is shown that the CTMP the bleached kraft pulp of hardwood on its papermaking properties. It was found that the milling time – 21 minutes, the magnitude of the gap mezhnozhevogo – 0.2 mm, rotor speed mill – 1500 min^{-1}, the values of the optimization criteria, obtained under optimum values following factors: the degree of grinding weight - 33°SR, the weighted average rate fiber length – 20 dg, dehydration rate- 17.73 ml/s, power consumption for grinding – 0.157 kW.

The effect of pulp on the structural, mechanical and optical properties of the sample paper for offset printing. It is shown that the use of the composition causes an increase in TMP paper opacity, but significantly reduces its whiteness and breathability. Use of the composition up to 30% does not affect the TMM strength folding number, and breaking length of the paper.

Found that the use of the composition of CTMP increases transparency and increase whiteness of the paper compared to samples made without the pulp, but it reduces the strength characteristics – the tensile strength and the length of the folding number. Indicator breathability higher than the control group of 40% in samples, containing compositions CTMP. Porous media will provide the best printing properties due to better absorption of inks in offset printing.

References

1. Технология целлюлозно-бумажного производства: в 3 т. / редкол.: П. Осипов [и др.]. СПб: Политехника, 2002–2006. Т. 2: Производство бумаги и картона. Ч. 1: Технология производства и обработки бумаги и картона / В. Комаров [и др.]. 2005. 423 с.

2. Фляте Д. М. Технология бумаги. М.: Лесная промышленность, 1988. 440 с.

3. Фляте Д. М. Бумагообразующие свойства волокнистых полуфабрикатов. М.: Лесная промышленность, 1990. 136 с.

4. Смирнова Е. Г., Евтюхов С. А. Влияние композиционного состава по волокну и проклеивающих реагентов на свойства бумаги для офсетной печати // Целлюлоза. Бумага. Картон. 2006. С. 32–33.

5. Соловьева Т. В., Шульга В. Э. Технология древесной массы их щепы. Минск: БГТУ, 2008. 136 с.

6. Пузырев С. С. Современная технология механической массы: в 3 т. СПб.: ВЕСП, 1995–1998. Т. 2: Механическая масса из щепы. 1996. 236 с.

7. Пен Р. Э. Статистические методы моделирования и оптимизации процессов целлюлозно-бумажного производства. Красноярск: КГУ, 1982. 120 с.

8. Колесников В. Л. Математические основы компьютерного моделирования химико-технологических систем: учеб. пособие для студентов вузов. Минск: БГТУ, 2003. 312 с.

Received 26.02.2014