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P. I. Pismenskiy, junior researcher (BSTU);
E. K. Timofeeva, PhD student (BSTU);
T. P. Shkirando, senior researcher (BSTU);
T. V. Solovyeva, professor (BSTU)

CHEMICALLY MODIFIED MECHANICAL PULP OF WOOD CHIPS OF DIFFERENT BREEDS

The results of studies that allow to establish the feasibility of using a modified aspen wood as a raw material for thermomechanical pulp (TMP) in the production of newsprint. Modification of wood chips can increase the proportion of aspen wood in combination with spruce up to 30% without reducing the strength of quality newsprint. When this process is accelerated and the grinding timber increases reactivity of hemicelluloses and lignin, but also leads to lower energy consumption.

Introduction. Today, despite the development of high technology, paper consumption is growing steadily. In this regard, consumption of fiber of semi-finished for its production is increasing. Recently, intensive development of production technology of mechanical wood pulp obtained from wood chips, such as thermomechanical pulp (TMP) and chemi-thermomechanical pulp (CTMP) [1]. These promising fibrous semifinished used as a substitute for the expensive cellulose in various types of paper.

Newsprint is the most common type of paper production, the volume of production constitute more than 70% of the total output of printing paper types [2]. At the same time, for newsprint used as a raw material TMP softwood, usually spruces, which allows to obtain the finished product with high quality. At the same time, extensive use of spruce wood resulted to a deficit of varietal coniferous raw materials. The solution of this problem can be use hardwood as raw material. The most suitable for TMP is aspen wood, which has a light color, low density and low lignin content (16–17%) [3]. Its reserves in the Republic of Belarus are quite large – about 150 mln. m^3, accounting for 30% of all hardwood [4].

At the same time, we know that it is problematic enough paper production with high quality on the basis of obtaining of fibrous semifinished products from aspen wood [5]. In our opinion the problem can be solved, given the characteristics of the anatomical structure, physical and chemical properties of aspen wood, and the ultrastructure of its basic elements. Of particular relevance are the dimensional characteristics of the anatomical elements that constitute the wood, it depends on parameters of steaming process and milling of wood in the process of obtaining TMP [3, 4].

Main part. TMP is obtained in the manufacture of newsprint at RUE "Zavod gazetnoy bumagi" in Shklou in Belarus. Newsprint is produced from spruce TMP with grinding chips RTS method in the enterprise, according to the technological regulations. The method is based on a combination of short-time steaming wood chips (thermal hydrolysis treatment) of 10 to 20 seconds in a temperature range 160–170ºC produced by feeding in the chips a saturated vapor at the inlet to the disk mill. A distinctive feature of the grinding is a high speed rotor refiner, about 2600 min^{-1}, which is more than one and a half times higher than adopted in the traditional grinding chips [3].

Heat is supplied to the wood chip with a distributed thermal hydrolytic treatment mainly in the extracellular space and cavities wood fibers, whereby the cell walls are elastic and grinding at high speed does not occur undue destruction of the fibers themselves. The mechanical strength of the mass increase due to this thermal hydrolytic effects and temporary, and a whiteness half-stuff not reduced.

Table 1

Main characteristics of thermomechanical pulp after the first refining stage

The composition of wood chips: of spruce wood / of aspen wood, %	Quality grinding, °ShR	Fractional composition mass, %			
		>30 mesh	<30 / >50 mesh	<50 / >100 mesh	<100 mesh
without chemical treatment					
100 / 0	25	63.9	10.2	5.3	20.6
80 / 20	28	58.3	11.7	6.0	24.0
with chemical treatment					
100 / 0	22	62.7	9.9	4.6	22.8
80 / 20	23	66.3	9.7	2.8	27.1

Studies have been conducted to establish the possibility of using aspen wood in the composition of TMM in the production of newsprint in the department of chemical processing of wood EI BSTU and RUE "Zavod gazetnoy bumagi".

TMP obtained from spruce wood (traditional technology) and the composition of chips, including 80% of spruce and aspen 20%, which was formed at the stage of debarking and chipping balances by alternately feeding on debarker spruce and aspen in a predetermined ratio. The chips were ground by the method RTS. Chips are milled at a temperature of (167 ± 2)°C at a rotational frequency of the mill discs (S 2060 firm refiner Andritz, Germany) 2300 rev/min, in accordance with the process mode of the enterprise. Meanwhile chemical treatment of wood chips was done by feeding it into the grinding chamber of a chemical reagent in a first grinding step in the refining of the brand S 2060 from the company Andritz. In this case, the load is not adjusted to the refiner.

Table 1 shows the main characteristics of TMP obtained from the composition of chips using a chemical treatment or without, obtained after the first refining stage [6, 7].

Table 1 shows that the freeness TMP increased by 3ºShR without of chemical treatment by the introduction of 20% aspen wood. Fractional composition TMP changed content close-grained fraction increased by 4% due to the decrease of content a coarse fraction.

Introduction of a chemical in the composition led to an increase in the degree of swelling of the fibers and increase the reactivity of the hemicellulose, which are involved in the formation of additional bonds, responsible for increasing the strength of paper. From Table 1 shows increasing a coarse fraction of 8%, which serves as a scaffold for the formation of the paper sheet.

Party newsprint was made for further study of the properties of the modified pulp. Table 2 shows the parameters of quality of newsprint produced from TMP with chemical treatment and without it during the pilot tests [6, 7].

From the data presented in Table 2 shows that the reduction in strength properties of newsprint was replaced with 20% of spruce wood aspen during delivery TMP without chemical modification and subsequent release therefrom newsprint.

The indicators characterizing the optical properties of the paper, virtually unchanged compared to similar, achieved in the production of paper from spruce TMP. Breaking length paper increased to 4470 m, the whiteness increased by 2.4% at a chemical modification of the composition of wood chips on the grinding stage. The changes have occurred in the paper structure as indicated by an increase in the smoothness.

As can be seen from the data presented in Table 2, the chemical treatment leads to transformations in the structure of the paper sheet in the grinding process. Distinguish between micro- and macrostructure paper [8–11]. Features of the geometry of the paper web is meant by macrostructure. The mutual disposition and arrangement of the elements in the fibrous sheet of paper – a microstructure. The structure of the paper based on TMP received in the laboratory of spruce and aspen and studied using the BET method and scanning electron microscopy.

It is known that the paper is a capillary-porous material [8]. It relates to a macroporous type systems, i.e. its pore size is more than 50 nm. Determination of the specific surface of the paper is confirmed, based on the obtained fibrous elements of thermomechanical pulp of hardwood by Brunauer - Emmett – Teller (BET) [9]. Specific surface of the paper obtained under identical conditions of standard samples (weight 100 g/m^2) was a small amount – from 17 to 25 m^2/g (Table 3).

Table 2

Indicators of quality newsprint received during the pilot tests

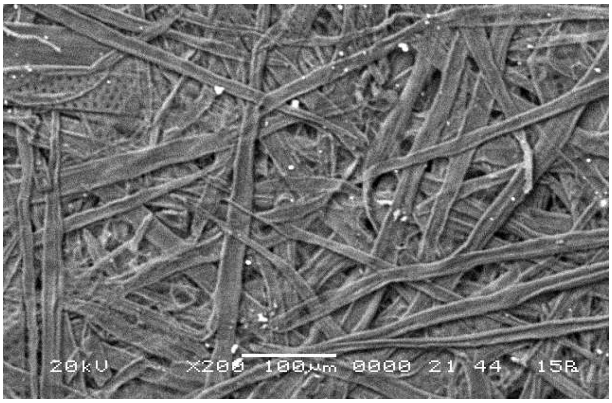
Indicator	The requirements according to GOST 6445 for brands O	Indicators of quality of newsprint			
		without chemical treatment		with chemical treatment	
		100 / 0	80 / 20	100 / 0	80 / 20
Weight 1 m^2, g	45.0 ± 1.5	45.7	45.8	45.3	45.9
Breaking length, m, longitudinal / transverse	3100 / –	4200 / 1260	4000 / 1180	4240 / 1260	4470 / 1310
Tear resistance, mN	Not less than 196	287	249	275	239
Yellowness, %	–	8.5	8.7	8.0	8.4
Whiteness, %	Not less than 60	60.5	60.0	61.1	62.4
Opacity, %	Not less than 90	93.5	94.0	93.9	94.3
Smoothness, s, upper / mesh	Not less than 30 / 30	43 / 37	40 / 35	48 / 38	45 / 37

Table 3

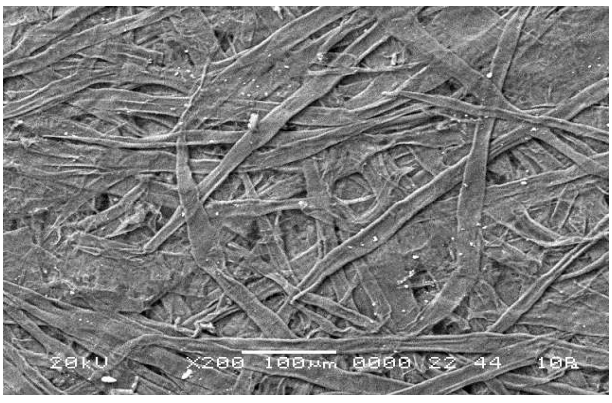
BET surface area

Name of sample	Value of indicator, m^2/g
Paper from spruce TMP:	
original (without modification)	19
chemical modification	17
Paper from aspen TMP:	
original (without modification)	25
chemical modification	20

The value of this measure has changed relatively insignificant for all of the samples, but with a clear decrease in the modification. This means that the wood species and the use of the chemical reagent does not cause significant changes in the macrostructure sheet of paper, but indicate that the fibrous elements swell, so that the structure of the sheet is densified. To confirm this assumption, the microstructure of the surface of the paper sheet was examined using scanning electron microscopy. The resulting scans are shown in picture.



a



b

Scans the surface of the paper based on thermomechanical pulp from aspen wood: *a* – initial TMP; *b* – chemically modified TMP

Scans, submitted in picture, can be clearly seen that the surface of the paper is inhomogeneous reticulated, interfiber bonds are formed mainly due to accidental mechanical interlacing fibrous elements. It has a characteristic tubular structure for hardwood and focused mainly on the same plane. Large dimensional heterogeneity of structural elements visible through the interlacing bundles of fibers libriform and narrow vessels.

Samples of paper TMP, obtained without treatment with a chemical agent, have a loose structure. Most clearly observed in the case of scanning the surface of the paper from aspen TMP, where are visible fibrous and non-fibrous fractions. Last represented by small splinter and matches. The fibrous fraction mainly consisting of wood anatomical elements of different length, the cell walls are damaged by the middle plate and primary shell. It represent bundles of fibers. This indicates that the structural elements of the original TMP sealed surface due to a significant reduction of the width of the gaps between the fibers. Voids are filled between the long fibrous elements fine fraction, which is represented by the characteristic anatomical elements of hardwood, such as the cell radius and wood parenchyma, fragments of vessels, damaged fiber bundles libriform. Consequently, the paper surface became more homogenous. Also, the separation of fibrils from the main beams tissue is clearly visible in the modified TMP fiber elements, which means the destruction of not only primary but also secondary cell wall membranes. Deeper damage to the cell wall is observed in a modification of aspen wood.

Established by dint of scanning electron microscopy and the adsorption method using a conventional model Brunauer–Emmett–Teller modified fibrous elements that all investigated wood to swell and become crimped form, thus increasing the total area of interfiber contacts the paper sheet. It is reflected positively on the strength characteristics of paper made on the basis of TMM.

Conclusion. Using additional processing chips chemical reagent prior to grinding in the process of manufacturing TMP increases the strength of paper produced from it by 10%. Modification of wood chips can increase the proportion of aspen wood in combination with spruce up to 30% without reducing the strength characteristics of quality newsprint. Increasing the share of aspen wood can positively affect the optical and printing properties of newsprint, as well as reduce the consumption of energy expended in grinding wood chips.

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