SEPARATE DIMENSIONAL AND QUALITATIVE CHARACTERISTICS WOOD FIBERS DURING PROCESS ITS REFINING

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This paper presents the results of experimental studies of the process of refining fiber semi-finished product, its dimensional and qualitative characteristics when using with different refining disks in the production of fiberboard.

Keywords: refiner disk, fibrillation, fibrous semi-finished product, refining, dimensional and qualitative characteristics.

The process of refining fibrous semi-finished products is one of the main technological stages in the production of various wood-fiber materials, such as paper, cardboard, fiberboard, etc. The feedstock of these industries is technological chips [1], obtained in particular from lumpy sawmill waste and substandard wood. Thus, these productions solve the problem of more complete and efficient processing and utilization [2]. In the process of refining process chips, a wood-fiber semi-finished product is obtained, the characteristics of which are acquired during the processing of fibers in refining installations, as a rule, in knife disk mills (defibrators, refiners) and directly determine the final quality of the finished product.

The working body of disk units is a refiner disk, the design of which primarily affects the efficiency of the refining equipment, the regulation of the main factors of the refining process of a fibrous semi-finished product (working gap between the refiner discs, mass concentration, rotor speed, etc.) [3,4,5].

When refining a fibrous semi-finished product, tangential and normal force components are created from the side of the knife elements of the headset, which in the first case leads to their destruction in the transverse direction (shortening), and in the second case, they provide longitudinal splitting along weak bonds (fibrillation). Depending on the design of the refiner disk, the ratio of the components of the effort changes, determining the effect on the semi-finished product, and as a result, its composition and dimensional and qualitative characteristics (refining degree - DS, fibrillation degree - Fbr, content of coarse, medium, fine fiber fractions, etc.) , and, accordingly, the physical and mechanical properties of products obtained from it [3,5].

Currently, there are many constructions for refiner disk for cellulose and recycled fibers, however, for grinding wood fiber, the pattern of the knife surface has not been given due attention for a long time [3,4], which does not allow the full potential of refining equipment to be revealed in the process of refining wood fiber semi-finished products.

The main technological parameters characterizing the efficiency of the refiner disk are: the number of intersection points (t) of the cutting edges of the rotor knives with the stator knives, second cutting length (Ls), cyclic elementary length (Lω.el.), refining surface (F). According to studies [3,4,5], the smaller the number of intersection points (t) and the larger the value of the second cutting length and, accordingly, the cyclic elementary length, the refining surface, the more the refining disk is characterized by a fibrillating effect, high efficiency of the process of refining fibrous semi-finished products in refining plant.

Thus, when studying the process of refining fibrous semi-finished products in the production of fiberboard by the wet method, a new design of the refining disk was developed, which has a predominantly fibrillating effect on wood fiber, which improves the quality indicators of the semi-finished product, and, accordingly, the physical and mechanical properties of the products obtained from it [3]. According to the developed methods for evaluating the efficiency of refiner disk, using modern software for the proposed set, in comparison with the traditional design, the main technological parameters (t, Ls, Lω.el., F) were determined, taking into account their design features and the resulting forces on wood fiber [3,4].

The results of calculations of the main technological parameters, taking into account the design features of refiner disks for the preparation of wood fiber in high-speed disc mills, are summarized in Table 1.

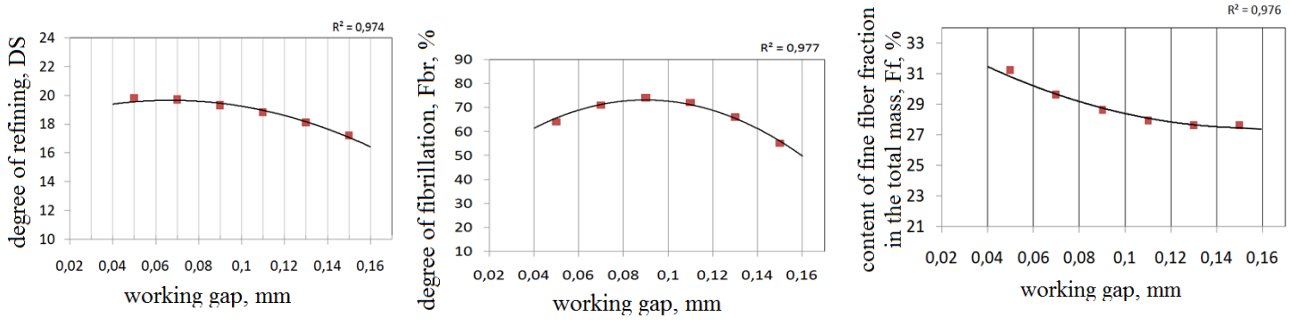
Table 1 - Design features and technological parameters of refiner disks

Width, mm		cell depth, h, mm	Angle, degrees				Quantity, pcs.		True value of second cutting length Ls, м/с	Number of intersection points, pcs.		Cyclic elementary length $L_{ω.el}$, m	surface of the entire refiner disc area F, m^2
knife,δ	interknife cell,L		setting of the 1st knife of the rotor,$α_2$	setting of the 1st knife of the stator,$α_1$	pattern repeatability	crossings (in dynamics)	sectors π/ψ	sectors with pattern repeat		on a disk sector	total disk surface		
Traditional design									*Rotor speed 980 rpm*				
3	9	9	12,4	168,2	60	24,2	6	6	91072	166	996	5,59	0,03
Developed design									*Rotor speed 980 rpm*				
4	6	6	15	15	30	0-15	6	12	136450	44	528	15,65	0,06-0,1

When determining the cyclic elementary length (Lω.el.), as is known [3,4,5], an increase in the number of intersection points (contacts) of the rotor knives with the stator knives characterizes and contributes to a greater shortening of the fibers than their fibrillation. According to the results of

calculations of the main technological parameters of the set (Table 1), we can observe that the proposed design, in comparison with the traditional refiner disk, is characterized by a smaller number of knife intersection points (author's design - 528 pcs., traditional - 996 pcs.) and higher values of cyclic elementary length (author's version -15.65 m, traditional -5.59 m), refining surface (author's version - 0.06-0.1 m^2, traditional - 0.03 m^2). The decrease in the number of contacts with an increase in technological parameters is ensured by a decrease in the angle of crossing of the rotor and stator knives, indicating the predominance of the normal components of the forces over the tangents, causing the fibrillating effect of the headset [3,4,5]. The traditional design of the refiner disk used in the production of fiberboard does not provide high values of technological parameters and belongs to the shortening type.

In order to confirm the theoretical data obtained, numerous experimental studies were carried out on the process of refining a semi-finished wood product, implemented on a semi-industrial disk mill MD on the basis of the MAPT laboratory of the Reshetnev Siberian State University of Science and Technology using the developed design of the refiner disk, all other things being equal, the conditions for the production of fiberboard. As an example, Figure 1 a-c shows the dependences of the dimensional and qualitative characteristics of a semi-finished wood fiber product (degree of refining - DS), degree of fibrillation - Fbr, %, content of fine fiber fraction in the total mass - Ff, %) on the value of the working gap (z) between grinding discs obtained at a mass concentration (c) = 2.5%.



а) DS от z б) Fbr от z в) Ff от z

Figure 1 - The influence of the working gap on the dimensional and qualitative characteristics of the semi-finished product

Refining was subjected to wood fiber with initial quality indicators: DS=12 DS; Fbr=20%; Ff=22%).

From the graphical dependencies presented in Figure 1 (a-c), it can be seen that with an increase in the working gap (z), the increase in the degree of grinding decreases, as a result of a decrease in the specific pressure in the gap between the rotor and stator knives. Along with a slight decrease in the degree of refining, there is an increase in the number of fibrillated fibers of the semi-finished product with a working gap of ≈ 0.08-0.1 mm, as well as a decrease in the intensity of the formation of fine fibers. It should be noted that even with an increase in the specific pressure, the formation of a fine fraction of fibers is weakly expressed. The increase in the degree of refining of the

semi-finished product is determined by the development of wood fibers, and is also directly related to the change in the percentage and ratio of their various fractions in the total mass, in our case, mainly the middle fraction [3].

An increase in the Fbr index of the semi-finished product has a positive effect on its quality, since the predominance of well-developed fibrillated fibers contributes to the development of strong interfiber bonds in the wood-fiber carpet and, accordingly, in the finished board.

Thus, analyzing the presented dependences of dimensional and qualitative characteristics, we can conclude that the nature of the change and the quantitative values of the indicators of the semi-finished product when using the new design indicate the effective impact of the headset on the wood fiber and its predominant destruction in the longitudinal direction due to the predominance of the normal components of the efforts in the process of its refining.

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References

1 Vititnev A., Mokhirev A., Zyryanov M., Ryabova T. Evaluation of possibility of obtaining woodchips from wood residues // Journal of Applied Engineering Science. Institut za Istrazivanja I Projektovanja u Privredi, Belgrade - 2019. № 2., Vol.17. Pp. 140-143. DOI: 10.5937/jaes17-20453

2 Vititnev A. Yu, Rubinskaya A. V., Pister E. I., Ioffe A. A., Karaseva M. V. Optimization of recycling strategy for solid industrial waste // IOP Conference Series: Materials Science and Engineering, Krasnoyarsk, 2018. - Vol. 450., DOI: 10.1088/1757-899X/450/6/062016

3 Vititnev A. Yu. Sovershenstvovanie processa razmola voloknistyh polufabrikatov v proizvodstve drevesnovoloknistyh plit. Dis. cand. tehn. nauk. [Improvement of the process of grinding fiber semi-finished products in the production of wood-fiber boards. Cand. techn. sci. diss]. Krasnojarsk, SibGU Publ., 2019, 152 p.

4 Alashkevich Yu. D., Kovalev V. I., Nabieva A. A. [Effect of the headset pattern on the process of grinding fibrous semi-finished products]. Monograph.2010, part 1, 168 p (In Russ.).

5 Chistova N. G. Pererabotka drevesnyh othodov v tehnologicheskom processe poluchenija drevesnovoloknistyh plit. Dis. dok. tehn. nauk. [Processing of wood waste in the technological process of obtaining wood fiber boards. Dr. techn. sci. diss]. Krasnojarsk, SibGTU Publ., 2010,415 p.