ENERGY EFFICIENCY OF THE FIBER SEMI-FINISHED PRODUCT GRINDING PROCESS

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This paper presents the results of experimental studies of the process of grinding fiber semi-finished products, the specific power consumption for its implementation with different refining disks in the production of fiberboard.

Keywords: refiner disk, fibrillation, fibrous semi-finished product, grinding, specific power consumption.

Fiber semi-finished product preparation (grinding) is the main, most significant and energy-consuming (65-70% of the entire production process) technological stage in the production of paper, cardboard, various wood-fiber materials. In particular, knife disk crushers (defibrators and refiners) are used for grinding during the fiberboard production [1,2]. In the process of grinding, wood fibers exposed to a knife tooling acquire certain dimensional and qualitative characteristics, such as average length (Lav), diameter (dav), their ratio (L/d), the ratio of various fiber fractions (coarse (Fc), medium (Fm), fine (Ff)) in the total mass, degree of grinding (DS) [1,2]. In turn, the characteristics and composition of the fiber semi-finished products determine the physical and mechanical properties of the finished product. By adjusting main parameters of the grinding (grinding tooling design, operation gap between the rotor and stator disks, wood pulp concentration), it is possible to increase the efficiency of the process and production as a whole, improve the quality parameters of the semi-finished and finished products, while the energy consumption can be reduced [1-5]. During our studies [1], on the basis of the Industrial Technology and Machine Engineering Department of Reshetnev Siberian State University, we developed a new grinding tool design which provides a fibrillating effect on wood fibers (patent No. RU 2652177).

Figure 1 and Table 1 show the results of the experimental studies of wood fiber grinding process and its energy consumption when using various tooling for the fiberboard production, all other things being equal [1]. The wood fiber was ground after the first grinding stage (after being processed by a defibrator) (DSd = 10.5 DS; Lav_d = 8.57 mm; dav_d = 0.32 mm; L/d_d = 26.6; Fc_d = 48%; Fm_d = 32 %; Ff_d = 20%).

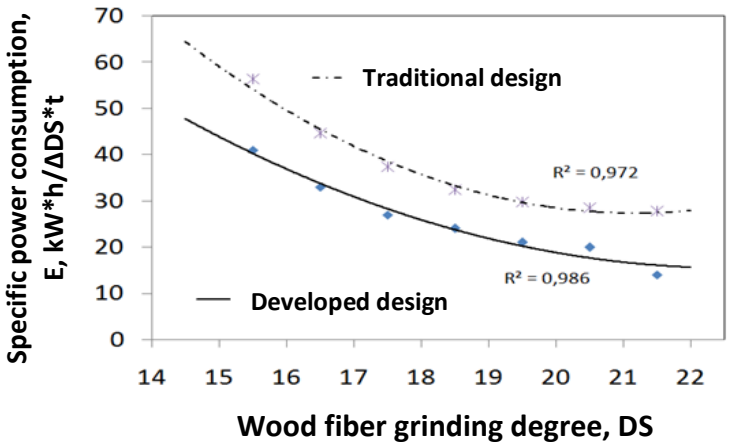

Figure 1 – Specific power consumption when grinding semi-finished product

The figure demonstrates that the average specific power consumption when reaching the same degree of grinding has lower values in the semi-finished product grinding with the equipment under study, in comparison with the traditional equipment design used in fiberboard production. For example, to achieve a semi-finished product grinding degree of up to 20 DS, the difference in energy consumption is ≈ 23%.

Table 1

Results of fibrous semi-finished product grinding by different types of tooling

Tooling design	**Dimensional and qualitative characteristics of fibrous semi-finished product**							**Physical and mechanical properties of fiberboard**	
	DS	Fc, %	Fm, %	Ff, %	Lav, mm	dav, mm	L/d	strength (σ_{bend}), MPa	density (P), kg/m3
Developed	20	21-23	47-50	28-31	4-4.3	0.05-0.06	80-93	44-45	925-930
Traditional	20	28-30	26-27	44-45	5.1-5.3	0.12-0.13	40-48	35-36	860-865

Table data analysis shows the difference in the fiber characteristics and the percentage of fractions in the semi-finished product total mass. The semi-finished product of the same degree, obtained in the grinding process under the fibrillating effect of the developed tooling design in comparison with the traditional tools, differs in that the medium fraction prevails in the total mass (Fm, %) – developed (47-50), traditional (26-27), with a decrease in the coarse fraction (Fc,%) – developed (21-23), traditional (28-30) and fine fraction (Ff,%) – developed (28-31), traditional (44-45). The quality parameters of the semi-finished product are generally improving, there is a more intense (two to three times) decrease in the fiber diameter (dav, mm) – developed (0.05-0.06), traditional (0.12-0.13), that contributes to an increase (twice) in the fiber length ratio to its diameter (L/d) – developed (80-93), traditional (40-48). In turn, improving the semi-finished product quality enables the manufacturing of board products (fiberboard) without the use of bonding resins while increasing their physical and mechanical properties [1].

Thus, the results of the experimental studies indicate the preferred splitting of wood fibers along the weak bonds in the longitudinal direction. This type of destruction is caused by the prevalence of normal forces, causing the fibrillating effect of the developed tools, which, in comparison with the traditional ones, provide high efficiency of the grinding process while reducing the specific power consumption, all other fiberboard production conditions being equal [3,4].

Acknowledgments: The authors express their gratitude to the Center for Collective Use of KSC SB RAS for supporting the research.

Funding: The research was carried out under the governmental task issued by the Ministry of Education and Science of Russia for the "Technology and Equipment for the Chemical Processing of the Plant Biomass Material" project by the Deep Plant Material Processing Laboratory (FEFE-2020-0016).

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