



DETERMINATION OF VARIABILITY THE REPOSE ANGLE OF THE CHIPPED WOOD

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Abstract

This report presents the results of the study of the angle of repose of some types of chipped wood in a calm state and its variability in the process of dynamic effects. The results of experimental studies can be used to solve problems of transportation, bunkering and cumulative storage of some common breeds of chipped wood (sawdust, shavings, grinding dust). When studying the effect of dynamic influences (shaking) on the angle of the repose of loose material, a special laboratory test stand was used to regulate the drive of the motor's rotation speed by means of inventory. Taking into account the flow characteristics of chipped wood of different types is the basis for improving technical solutions and operating rules for equipment (for example, conveyor belts with roller bearings on the working branch).

Key words: *chipped wood; variability of repose angle; slope angle, dynamic effects*

INTRODUCTION

In the processes of wood processing, a huge amount of chipped wood is formed, transported and used in the form of production waste and products of special purpose for technological needs. Taking into account the properties of bulk material is necessary for transportation, bunkering, cumulative storage and solving a number of other practical production tasks. One of the important characteristics of the chipped wood is the size and variability of the angle of repose of this material. This figure is affected by the fractional composition and geometry of the particles, the wood's species and moisture, the temperature of the medium, and many other factors, including the dynamic effects on the material. The basis for obtaining data on the magnitude of the angle of the repose and its variability are experimental works. The results of the study are of practical interest and can serve as a basis for improving certain types of equipment and technological processes with the presence of chipped wood.

MATERIALS AND METHODS

Experimental work was carried out on the example of several species (pine, beech, oak) and types of dry chipped wood (sawdust, shavings and grinding dust) without preliminary

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sorting by fractions. Experimental material was obtained from enterprises in the form of waste generated in the technological processes of some woodworking industries.

When studying the variability of the angle of a natural repose, the type of chipped wood and the frequency of dynamic impacts (shaking) were considered in conditions of modeling the operation of a conveyor belt with roller bearings. Taking into account the specificity of the object of experimental research, for tape and some other conveyors, the amount of material in experimental portions was taken as small.

Determination of the angle of repose of chipped materials can be carried out in several ways using different equipment [1–5 and etc.]. There are information about several patents for the design of devices for performing these works. In Fig. 1 shows some examples of some simple frequently used devices.

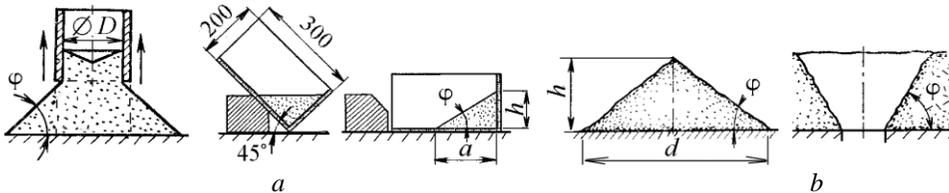


Fig. 1 Determination of the angle of repose of the cargo in a calm state
 a – using a cylinder and a box; b – with free pouring and collapse

During the experimental work to determine the angle of repose of the chipped wood and its variability under the influence of dynamic influences on the bulk material, a specially designed laboratory test stand with an adjustable shaking frequency was used, simulating the conditions of cargo transportation with a belt conveyor with rollers on the working branch (Fig. 2). The control of the speed of shaking was done by the inventor.



Fig. 2 Laboratory test stand for determining the angle of repose of chipped wood in a calm state and under conditions of dynamic shaking effects

The experiments began with the precipitation of chipped wood from two cylinders (Fig. 1a) without a horizontal horizontal flat surface of the conveyor belt. Fig. 4 illustrates the work done with two cylinder-accumulators of diameters ($D = 100$ and 150 mm), and Tab. 1 contains a sample of experimental results.

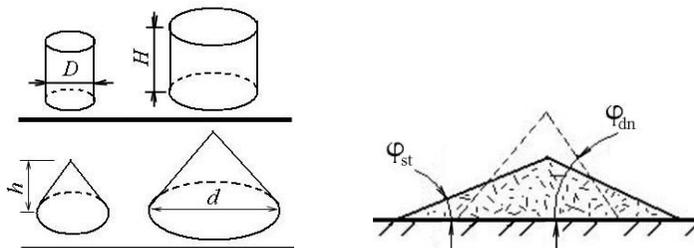


Fig. 4 Measurement of static φ_{st} and dynamic φ_{dn} the angle of chipped wood repose

Based on the measurement of the height h and the diameter d of the base of the vaulting cone (Fig. 3), the repose angle of the material in the quiescent state φ_{st} was determined and after the dynamic shaking effects φ_{dn} by the formula

$$\varphi = \arctg (h/(d/2)), \quad (1)$$

where: φ – the angle of repose of the chipped wood, deg.; h – height of the cone or profile of the material layer; d – the diameter of the base of the cone or the width of the base of the profile of the layer of material.

During studying the properties of chipped wood, various indicators characterizing it were determined, including the angle of the repose and the influence of a number of factors on it. Experimental studies of the influence of dynamic influences on bulk material were carried out on a specially manufactured laboratory test stand with an adjustable shaking frequency simulating the transportation of goods by a belt conveyor with roller bearings on the working branch.

The fractional composition of the chipped wood was determined using standard sieves. The sieves were arranged top-down in direction of meshes' lessening and placed on a vibrating holder of a sieving machine AS 200c (Retsch, Germany) with an adjustable frequency and amplitude of oscillation.

A laser particle sizer "Analysette 22 Microtec Plus" (Fritsch, Germany) with measuring range 0,08–2000 μm was used in this stage of experiments. Dust sizes up to 100 μm were taken into consideration in the analysis.

An example of the results of analysis of the fractional composition of the experimental material in the form of histograms of particle size distribution is shown in Fig. 5.

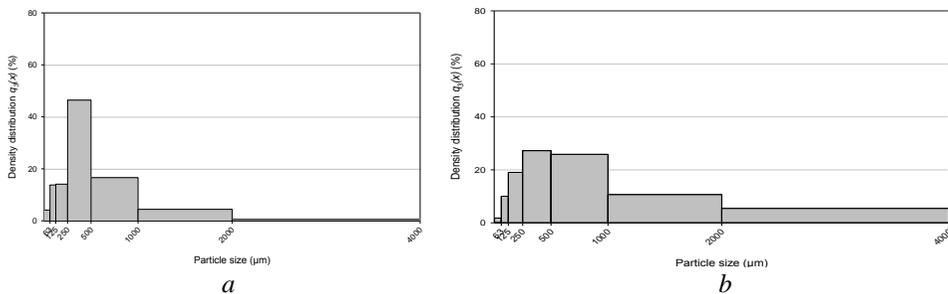


Fig. 5 Particle size distribution: *a* – birch dust of grinding plywood; *b* – pine sawdust

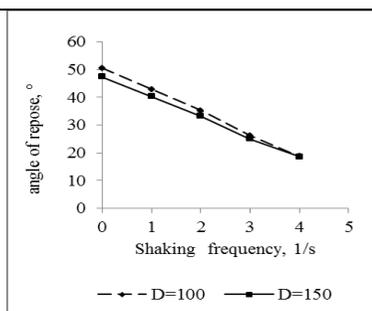
RESULTS AND DISCUSSION

The main results of research of shaking are given in Tab. 1 and are illustrated by the graphs in Fig. 6.

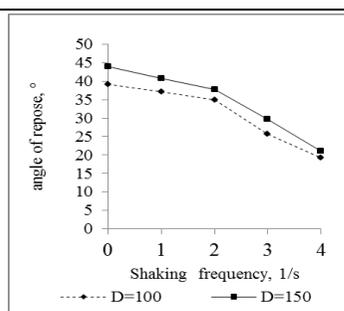
The materials of Tab. 1 and Fig. 6 characterize the variability of the chipped wood repose angle, depending on the type of material and the frequency of the dynamic shaking effects. They indicate a significant decrease in the angle of the repose with an increase in the shaking frequency.

Tab. 1 Mean values of the angle of repose depending on the type and kind of wood and the shaking frequency

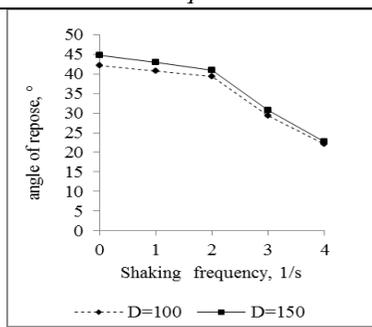
Kind of chipped wood	Source of chipped wood	Diameter of storage cylinder, D , mm	The average value of the angle of repose of the chipped wood, φ , deg. at a shaking frequency, n , 1/s				
			0	1	2	3	4
Shavings dry pine	Four-side planer "Powermat-500"	100	50,5	-	35,2	26,2	18,8
		150	47,4	-	33,2	25,0	18,6
Shavings dry beech	Four-side planer "Unimat-500"	100	39,2	-	35,0	25,7	19,3
		150	43,9	-	37,8	29,8	21,1
Sawdust oak, after sawing were dried	Log band saw "Wood Mizer"	100	42,2	-	39,3	29,4	22,2
		150	44,8	-	40,9	30,7	22,7
Birch dust when grinding plywood	Grinding machine "Steinemann"	100	32,0	-	27,5	21,2	16,0
		150	34,6	-	29,2	22,7	17,9
Sawdust sawing of MDF boards	Circular saw "Solco" for cutting plates	100	32,3	-	25,5	18,2	14,7
		150	35,2	-	26,3	18,6	14,2
Shavings dry pine	Four-side planer "Grigio"	100	33,9	-	25,0	19,2	15,1
		150	36,3	-	25,7	19,4	15,4
Pine sawdust, after sawing were dried	Log saw canter machine "TT5/550/320"	100	47,7	-	36,5	26,3	20,8
		150	45,4	-	32,8	25,0	20,4



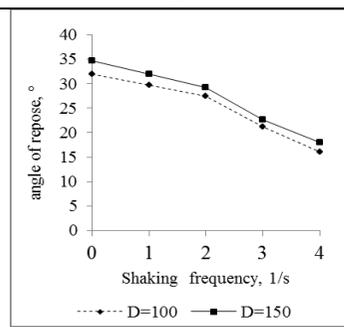
1



2



3



4

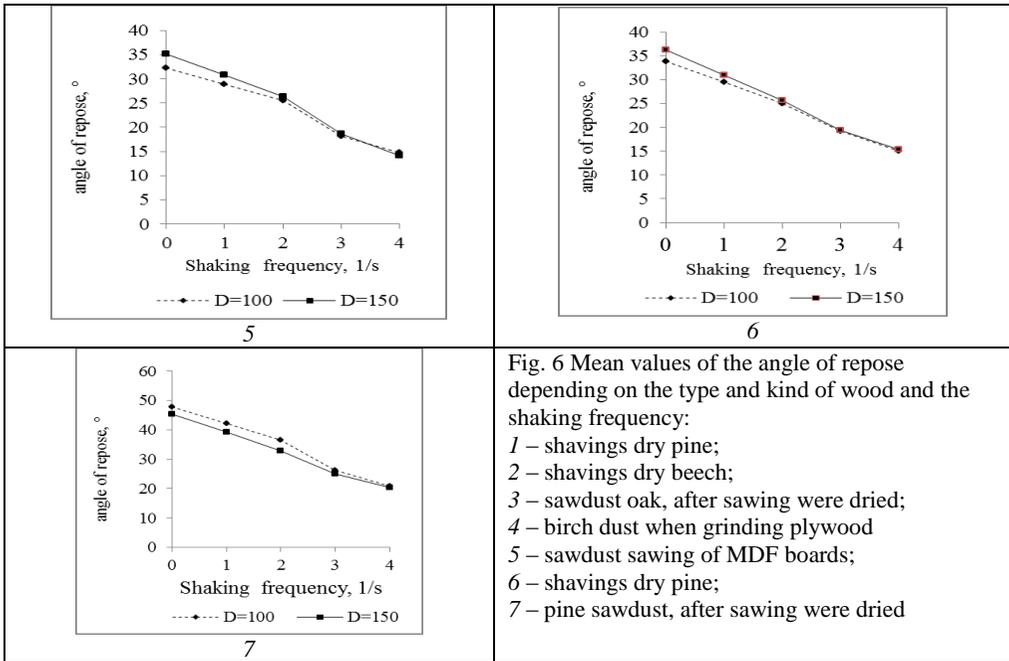


Fig. 6 Mean values of the angle of repose depending on the type and kind of wood and the shaking frequency:
 1 – shavings dry pine;
 2 – shavings dry beech;
 3 – sawdust oak, after sawing were dried;
 4 – birch dust when grinding plywood
 5 – sawdust sawing of MDF boards;
 6 – shavings dry pine;
 7 – pine sawdust, after sawing were dried

Experiments carried out with storage cylinders of diameter $D = 100$ and 150 mm showed good convergence of the results, which confirms their sufficient reliability.

With respect to the belt conveyor, the shaking frequency of the material being conveyed depends on the speed of the tape v and the distance between the roller bearings l (Fig. 7). It can be determined by the formula

$$n = v/l, \tag{2}$$

where: n – the shaking frequency of the chipped material, 1/s; v – speed of movement of the traction body of the belt conveyor, m/s; l – the distance between the rollers on the working branch of the conveyor, m.

The results of calculating the frequency n of shaking shredded wood according to the formula 2 are shown in Fig. 7. They allow to determine the range of change of the investigated factor of dynamic impact on cargo.

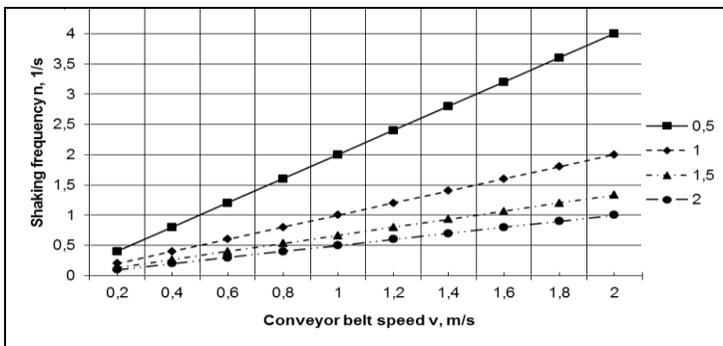


Fig. 7 Influence of conveyor belt speed v and distance between roller bearings l on shaking frequency n

.°The angle of natural repose of chipped wood in a quiet state is often characterized in the literature by the value $\varphi_{st} = 35\text{--}45^\circ$. It depends on the moisture content and fractional composition of the cargo, with simplified depersonalized calculations, the value $\varphi_{st} = 39^\circ$ is usually adopted. However, in reality the magnitude of this angle can vary over a much wider range, a more accurate knowledge of it can avoid errors in design calculations and improve the energy efficiency of mechanical transport devices.

When transporting and shaking the load under the influence of dynamic forces, the angle of the repose considerably decreases over a wide range of deviation, depending on the frequency, type and characteristics of the chipped wood.

CONCLUSION

The results of the research are of practical interest for increasing the effectiveness of technical solutions in the technology of woodworking production. In particular, they make it possible to improve the rationale for constructive parameters and operational limitations on the use of certain types of technological equipment, belt, inertial and vibrational conveyors when they operate at different speeds and reposes. Based on the analysis of the data obtained, can be determined the tasks of the following studies, for example phenomena segregation and seal material.

REFERENCES

- [1] Rogozinski, T. Dust creation during birch plywood production / T. Rogozinski, S. Trofimov. – Annals of Warsaw University of Life Sciences – SGGW. Forestry and Wood Technology. No 98, 2017. – p. 99–103.
- [2] Rogozinski, T. A study on properties of wood dust created during windows manufacturing / C. Dembinski, A. Ockajova, Z. Potok. – Annals of Warsaw University of Life Sciences – SGGW. Forestry and Wood Technology. No 98, 2017. – p. 94–98.
- [3] Bacherikov, I.V. Opredelenie ugla estestvennogo otkosa sipuchih materialov / I.V. Bacherikov, B.M. Lokshtanov // Izvestija Sankt-Peterburgskoj lesotekhnicheskoy akademii. Vip. 214. – SPb.: SPbGLTA, 2016. – s. 167–177.
- [4] Bacherikov, I.V. Vlijanie temperaturi i vlazhnosti na ugol estestvennogo otkosa drevesnih sipuchih materialov / I.V. Bacherikov, B.M. Lokshtanov // Izvestija Sankt-Peterburgskoj lesotekhnicheskoy akademii. Vip. 217. – SPb.: SPbGLTA, 2016. – s. 158–165.
- [5] Kouzov, P.A. Metodi opredelenija fiziko-mehanicheskikh svojstv promishlennih pilej / P.A. Kouzov, L.J. Skrjabina. – L.: Himija, 1983. – 143 S.