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Sliding angle of repose and pickup velocity of chosen types of chipped wood

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Abstract: *Sliding angle of repose and pickup velocity of chosen types of chipped wood*. The report presents the results of the study of conditions sufficient for the motion or immobility of a layer of chipped wood on an inclined plane of sliding and the value of the air velocity in a horizontal duct for lifting or settling a layer of particles of bulk material. When performing the work, special laboratory units were used with adjustment of the angle of inclination of the sliding plane and air velocity in the pipeline. The results of experimental studies can be used to solve issues of transportation, bunkering and storage of some common species and types of chipped wood (sawdust, shavings, sanding dust).

Keywords: chipped wood, mobility layer, sliding, inclined plane, lifting, horizontal duct, air velocity

INTRODUCTION

Moving, bunkering, storing chipped wood (CW) and bulk materials with its content may require the provision of conditions for the movement or immobility of the cargo layer on the supporting surface. The absence or insufficiency of relevant data is a frequent reason for inadequate design and design decisions in terms of reliability, energy efficiency and safety. The results of studies of the properties and physico-mechanical indicators of the mobility of CW and other bulk materials are reflected in numerous and diverse sources of information. For example, theoretical aspects of the motion of a heterogeneous system of particles in an inclined pipeline, aeration and pneumatic homogenization during unloading of the hopper are given in (Urban, 1967). Methods for determining the properties of dusts are considered (Kouzov et al., 1983). Information about the characteristics of the backfill CW during gravitational motion in the bunkers contains (Lozovetski et al. 2016). The article (Bacherikov and. Lokshtanov, 2016) provides information on the influence of temperature and humidity on the angle of repose of bulk wood materials. The data on the variability of the angle of repose of various types of CW at rest, slip (sliding angle), and under the conditions of dynamic effects of shaking contain (Trofimov and Rogoziński, 2018; Rogoziński et al. 2017).

However, the continuation of work on the study of the properties and characteristics of CW remains relevant. The reason for this is: the intensification of technological processes, updating standards (for example, ГОСТ Р 8.961–2019, etc.), increasing requirements for environmental, fire safety and energy efficiency of production, the emergence of new types of composite, adhesive and protective and decorative materials, foreign impurities and also wood modification methods. In order to replenish the data bank on the mobility of the CW layer, we continue to carry out experimental work with several types of bulk wood materials.

MATERIALS

The studies were carried out for several species (pine, beech, oak), MDF and types of dry CW (sawdust, shavings and sanding dust) at this stage without preliminary sorting by fractions. Experimental material was obtained from enterprises in the form of waste generated in the technological processes of some woodworking industries. Average values of bulk density of materials of experimental batches (kg/m^3): shavings (pine - 64.6 - 77.4, beech -

71.8; sawdust (pine - 99.8 - 109.3, oak - 139.5); sanding dust (oak - 158.6, birch plywood - 62.6, MDF - 164.9); shredded (oak waste mixture - 271.4). As an example in fig. 1 shows micrographs of several types of experimental material.

1 2 3

Figure 1. Microphotographs of chipped wood: 1 – shavings pine 4-side planer; 2 – dust grinding plywood, birch; 3 – grinding dust MDF

In the process of research at BSTU (Belarussian State Technical University) and PULS (Poznań University of Life Sciences), special laboratory equipment was used to experimentally determine the mobility indices of the CW layer when sliding along an inclined plane (Fig. 2) and lifting loose material settled in a horizontal duct (Fig. 3).

Figure 2. Laboratory test stand for research mobility layer CW to the oblique sliding plane (start of sliding)

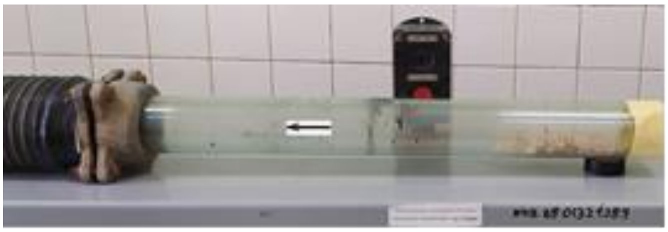

Figure 3. Laboratory test stand (fragment) for research pickup velocity air flow of CW settled in an horizontal duct

As a result of the experiments, data were obtained on the minimum required angles of inclination of the supporting sliding surface of gravitational descents providing CW motion. Experimental work was carried out for several types (milling chips, sawdust, dust) and species (pine, birch, beech, oak) CW, as a product of mechanical processing of wood and wood materials (plywood and MDF boards).

For these bulk materials, the values of the minimum required air flow rate in a horizontal pipeline were also experimentally determined as a critical condition for the movement or settling of the CW. The data obtained can be taken into account when designing suction, pneumatic conveying, equipment in their composition (for example, material traps) and duct cleaning systems.

Conditions for conducting experimental work to determine the angle of inclination of the support sur-face of the gravitational descent, ensuring the slip of the ID layer: laboratory installation with adjustment of the angle of inclination of the flat support surface (galvanized steel, [8]), measurement accuracy - 1 degree, thickness of the tested CW layer (humidity wood about 7%) - about 10 mm, the temperature and humidity of the environment are close to normalized (20 ± 2° C and relative humidity of 65 ± 5% according to [9]).

Determination of the minimum air velocity sufficient for lifting and ablation of the layer (about 10 mm) CW settled down in the horizontal was carried out in a glass pipeline not prone to electrification (GOST 8894–2018) with an internal diameter of 56 mm on a laboratory bench with air flow control with a gate. Air velocity was measured with a Testo-512 differential pressure gauge and a Testo-416 anemometer.

RESULTS AND DISCUSSION

Table 1 shows the results of experimental work to determine the minimum angle of inclination of the support surface of the gravitational descent providing a slip layer for several types of CW and the mini-mum air velocity sufficient to lift and carry away a layer of these materials settled in a horizontal pipeline.

Table 1. The results of determining the mobility conditions of the CW layer

Type and source of crushed wood	The average values of the start of motion of the layer of crushed wood	
	Slope angle, deg.	Air flow rate, m/s
Wood shavings, pine, group of machines	38,2	15,2
Shavings, beech, a group of machines	38,0	8,7
Wood shavings, pine, four-side planer	36,6	15,2
Sawdust, pine, circular saw	38,3	10,2
Sawdust, oak, group of machines	34,3	10,5
Sawdust, pine, tenoning machine	38,5	7,8
Dust sanding, oak sanding machine (tenoner)	43,1	9,6
Dust sanding plywood, birch, grinding machine	42,5	3,5
Sanding dust, MDF sandingmachine	45,3	12,0
Crusher - waste mix, oak, crusher (shredder)	31,3	12,2

From the data given in table 1, the following conclusions can be drawn: small dusty particles require the highest value of the angle of inclination of the reference plane of the gravitational sliding descent. This must be taken into account when solving practical problems of transportation without the cost of energy and bunkering of CW.

In the experimental determination of the minimum air flow rate in the pipe sufficient to lift and start the movement of the layer of settled CW, somewhat contradictory results were obtained, which indicate the need to continue research. In addition to pneumatic transport, this data can also be used when considering issues of limiting the speed of movement of the traction body of mechanical conveying devices, for example, conveyor belts.

It is interesting to compare the values of the minimum angle of inclination of the plane, which ensures the gravitational slip of the CW, and the angle of repose of these bulk materials in a calm state during storage, which we presented in [5].

In the process of research, the methods and techniques of experimental work were tested, the next tasks and directions for their continuation were determined to form a data bank of properties and CW characteristics necessary when developing solutions to improve the reliability and efficiency of the functioning of gravity descents, aspiration and pneumatic conveying installations, storage facilities (bunkering) of bulk wood materials. The results are of particular importance for the design and adjustment of dust extraction systems. Woodworking machine manufacturers usually suggest much higher air velocities in the suction cups. It turns out that this speed could be much lower if the suction cups were designed correctly. This also applies to connection pipe systems. As a result of such measures, a lot of energy related to the air flow can be saved (Dolny 1998, Dzurenda 2002).

CONCLUSION

The research results are of practical importance and can be used in the design of gravitational slopes, aspiration and pneumatic conveying installations, storage facilities (bunkering) of bulk wood materials, belt conveyors, CW transfer units from conveyor to conveyor and a number of other applications. By applying the results of this study, it is possible to save energy due to excessively high transport velocity in dust extraction systems.

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Streszczenie: *Kąt zsypu i prędkość startu wybranych rodzajów rozdrobnionego drewna*. W pracy przedstawiono wyniki badań warunków wystarczających do ruchu lub unieruchomienia warstwy rozdrobnionego drewna na nachylonej płaszczyźnie poślizgu oraz wartość prędkości powietrza w poziomym kanale do niezbędnej do startu warstwy cząstek materiału sypkiego. Podczas wykonywania prac zastosowano specjalne zestawy laboratoryjne z regulacją kąta nachylenia płaszczyzny poślizgu oraz prędkości powietrza w rurociągu. Wyniki badań eksperymentalnych można wykorzystać do rozwiązania problemów związanych z transportem i przechowywaniem niektórych gatunków i rodzajów rozdrobnionego drewna (trociny, wióry, pył szlifierski).

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