

## Tilt Angle of Wood Dust

ALENA OČKAJOVÁ<sup>1</sup>, ADRIÁN BANSKÍ<sup>2</sup>, TOMASZ ROGOZIŃSKI<sup>3</sup>

<sup>1</sup> Department of Technique, Faculty of Natural Sciences, Matej Bel University in Banská Bystrica, Slovak Republic

<sup>2</sup> Department of Woodworking, Faculty of Wood Sciences and Technology, Technical University in Zvolen, Slovak Republic

<sup>3</sup> Department of Furniture Design, Faculty of Wood Technology, Poznań University of Life Sciences, Poland

**Abstract:** *Tilt Angle of Wood Dust.* The aim of this article is to point out a risk factor – wood dust, which settles on various structures, inclined surfaces in operation and, if not regularly cleaned, it is a source of secondary dust, because it is swirled up again with any movement. By measuring the tilt angle of bulk wood material obtained from sawing on a table circular saw, using different saw blades and wood dust from longitudinal and transverse sanding on a hand belt sander, we determined which characteristics affect it. We found that the size of the particles is an important characteristic, the larger they are, the smaller the tilt angle and also the surface of the pad on which the dust particles settle, wood did not play a significant role in this case. The smallest tilt angle was measured for sawdust from longitudinal sawing of 27°, and the largest tilt angle for wood dust from transverse sanding of oak and was 57° on beech pad.

*Keywords:* wood dust, tilt angle, cleaning of dust, way of machining

### INTRODUCTION

A healthy working environment, without risk factors, is one of the basic requirements for quality work performance and maintaining the health of employees. Not every workplace meets this requirement and it is mainly due to the specific technology, processed material, used machines, tools, etc. Even the woodworking industry does not meet the conditions of a healthy working environment and ranks among the most risk sectors of the industry due to: physically demanding work, high noise of machines, a lot of moving and rotating parts, unsuitable microclimate, high dustiness, etc.

Every employer should try to solve his workplace in such a way as to eliminate risk factors as much as possible and, if this is not possible, to at least reduce them to an acceptable level (HPVA, 2014, HSE 2012a, 2012b). One of the aids for the specific solution of the mentioned facts in practice is also the guide "Basics of risk assessment - Good for you, Good for your company" (<http://osha.europa.eu>), where for the wood processing industry the guide presents a comprehensive checklist of hazards, respectively endangered. In terms of our long-term interest, we focused on the item "Air quality", where we want to point out the item "Do you clean and wipe dust from ceilings, partitions on the walls and cable lines?" but also on the stacked material (which is as if in stock). This is very important, because this settled dust (if it is not regularly removed) is re-swirls with any movement and is a source of secondary dustiness.

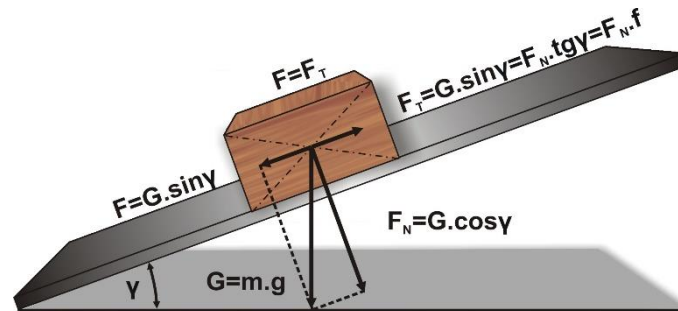
All dusts are harmful to humans (EN 481:1993, EN 689:2018 + AC:2019), not excluding wood dust (Očkajová et al. 2020, Marková and Očkajová, 2018). In woodworking, in construction and carpentry operations, we already work with dried wood approx. (8-12%) and e.g. during the sanding process, a large number of dust particles with a size of  $\leq 100 \mu\text{m}$  are created, which are defined as airborne dust particles (Očkajová et al. 2018, 2019), and thus the problem outlined above is a reality of these operations.

The aim of the presented paper is by measuring the values of tilt angles of bulk material (sawdust and sand dust), to point out the risk of settled dust on various inclined surfaces, which can be a source of secondary dustiness if they are not regularly cleaned.

## TEORETICAL BACKGROUND

The tilt angle is the angle measured in degrees from the horizontal plane at which the bulk material begins to slide on the inclined surface of the pad (STN 26 0070).

The conditions of balance on an inclined plane for determining the tilt angle are shown in Fig.1.



**Figure 1.** The condition of balance on an inclined plane for determining the tilt angle (Dzurenda, 2007)

The size of the tilt angle depends primarily on the size of wood dust particles, the friction between the dust particles and the pad, material of pad and fineness and stickiness of the dust.

## MATERIALS AND METHODS

### Material

Sawdust (total dust) obtained from the process of longitudinal sawing of spruce (*Picea abies* L.) and beech (*Fagus sylvatica* L.), with moisture content of  $w = 10 \div 12\%$  on a table circular saw.

Sand wood dust (total dust) obtained from the process of longitudinal and transverse sanding of spruce (*Picea abies* Karst.), pine (*Pinus sylvestris* L.), oak (*Quercus robur* L.) and beech (*Fagus sylvatica* L.), with moisture content of  $w = 6 \div 8\%$  on a hand belt sander.

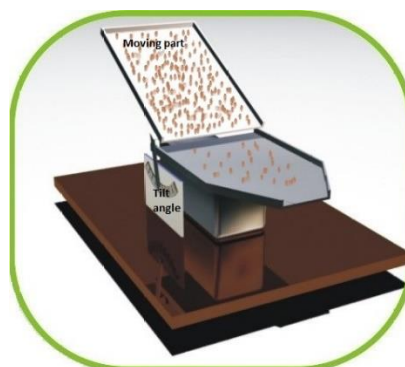
### Tool

SB1 – saw blade with tipped swage setting teeth

SB2 – saw blade with triangular asymmetric spring setting teeth

Sand belts – grit size 80.

Experimental device for measuring of tilt angle, Fig. 2:



**Figure 2.** A device for tilt angle measuring

The pad surfaces of the moving part of the device for tilt angle measuring were for:

- sand dust – aluminum, PVC foil, synthetic rubber and beech veneer,

- sawdust – aluminum.

Measuring procedure:

The measured sample was evenly stratified on the whole area of the moving part (the area of 13 700 mm<sup>2</sup>) so that its three raised rims (cca 5 mm) were covered and levelled by the measured sample.

We slowly tilted the moving part. At the moment of starting moving the sample, we stopped tilting, and we subtracted the tilt angle on the scale in the range from 0° to 90°.

Measuring was repeated 10 times for every samples. The result is an average value from these measurements.

## RESULTS AND DISCUSSION

The experimental results are given in Table 1 and Fig. 3

**Table 1.** Tilt angle

Sample	Sanding	Al	PVC foil	Rubber	Beech veneer
		Tilt angle (°)			
Spruce	0°/90°	34/38	34/39	39/47	43/55
Pine	0°/90°	35/37	33/41	43/49	46/57
Beech	0°/90°	35/39	33/37	42/44	42/46
Oak	0°/90°	42/44	39/47	38/48	46/57
Sample	Sawing				
Spruce	SB 1/SB 2	30/34			
Beech	SB 1/SB 2	27/30			

### Sand wood dust (total)

When sanding wood, a high percentage of dust particles < 100 µm in size is created, where the percentage shares rank from approx. 85 ÷ 95 % (e.g. for beech dust from a narrow-belt sander, this value is 91.95%; for hand belt sander, it was 94.28% and for hand disc sander the share of these particles was up to 96.29%) and therefore the assessment of the tilt angle is very important - the characteristic that gives us an idea of how settled dust on different surfaces can behave in operation.

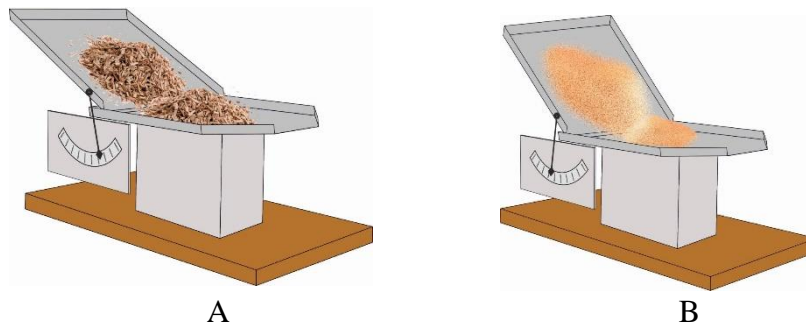
When sanding along the wood grains, larger dust particles are produced than in the model of sanding perpendicular to the grains, which was also reflected in smaller values of the tilt angle. The smallest tilt angle was 33 ° among all investigated samples. The base of the moving pad was made of PVC foil. The largest value of tilt angle was 57° and it was measured at wood sanding dust perpendicular to the wood grains. A wooden beech veneer was used as a pad of the moving part.

In the case of sanding dust, the effect of the wood wasn't clearly manifested, but the direction of sanding. Of course, this is a subjective assessment, but even based on these experiments, we can see that the surface on which the dust is settled plays a very important role, and we could connect it with practice as follows: aluminum surface → metal structures; rubber → conveyors and beech veneer → stocked material.

### Sawdust (total)

When evaluating the tilt angle of sawdust from the sawing process on a longitudinal table saw, the influence of wood as well as the used tool became apparent. The higher the density of wood (beech > spruce), the smaller the angle of tilt, and also the greater the chip thickness – heavier particle (SB1 > SB2), the smaller the angle of tilt. For sawdust from the sawing process on a longitudinal table saw, the tilt angle interval is from 27° to 34°.

From the measured values, it is clear that for the value of the tilt angle, the particle size is a very important characteristic, and sawdust will not settle on tilted inclined surfaces, while dust particles will. Fig. 3 gives a very clear imagination of this characteristic.



**Figure 3.** The maximal tilt angle for sawdust A and sanding dust B

Smaller particles adhered better to the surface of the pad. The size of the particles depends primarily on the used technology and within it on the settings of the tool parameters, material properties and cutting conditions (Dzurenda, 2007; Longauer and Sujová, 2000; Rogozinsky and Dolny, 2004).

Based on many experimental studies, all measures leading to an increase in the average chip thickness reduce the amount of produced dust (Hemmilä and Gottlöber, 2003, Gottlöber and Hemmilä, 2003, Očkajová et al. 2006).

It follows from our results that the larger the particles of the same material, the smaller the tilt angle and vice versa. In the literature (Longauer and Sujová, 2000) it is stated that the value of the tilt angle for most dusts ranges from 40 to 65°, Hejma (1981) gives the value of the tilt angle of wood dust as 42° (the value was measured on a smooth steel surface), Koncz (1977) for coarse wood "flour" reports a tilt angle value of 29° on a steel surface and 45.5° for fine wood "flour". The results of our work come closest to this interval.

## CONCLUSION

Dust is a risk factor in woodworking operations and affects not only air quality, but is a potential source of fire and explosion, and also adversely affects the wear of moving and rotating parts of machines and equipment. And it is with all the mentioned characteristics that we have to take into account, in particular, settled dust, if sufficient cleaning of production facilities is not carried out.

Our experiments showed that the amount of settled dust, especially on inclined surfaces, depends mainly on its size as well as the material of the pad. The finer the dust particles, the better they adhere to the surface and hold on very steep surfaces. The largest value of the tilt angle was measured on the wooden pad and was 57°, which in practice can be connected with the stocked material.

## ACKNOWLEDGEMENT

This work was supported by the Grant Agency VEGA under the project No. 1/0323/23 and by the Grant Agency KEGA 026UMB-4/2021

## REFERENCES

1. DZURENDA, L., 2007: Sypká drewná hmota, vzduchotechnická doprava a odlučovanie, Zvolen, TU
2. EN 481:1993 Workplace atmospheres Size fraction definitions for measurement of airborne particles
3. EN 689:2018+AC:2019 Workplace exposure - Measurement of exposure by inhalation to chemical agents - Strategy for testing compliance with occupational exposure limit values
4. HPVA 2014: Wood Dust Questions and Answers. Hardwood Plywood & Veneer Association ([http://www.hpva.org/sites/default/files/Wooddust\\_QA.pdf](http://www.hpva.org/sites/default/files/Wooddust_QA.pdf) - september 2014)
5. HSE 2012a: Toxic woods. Woodworking Information Sheet WIS30 (Revision 1). Health and Safety Executive (<http://www.hse.gov.uk/pubns/wis30.pdf>)
6. HSE 2012b: Wood dust: Controlling the risks. Woodworking Information Sheet WIS23 (Revision 1). Health and Safety Executive (<http://www.hse.gov.uk/pubns/wis23.pdf>)
7. GOTTLÖBER, CH., HEMMILÄ, P., 2003: Analysis and modelin of human and environmental aspects on the example of peripheral planing, Proceedings of the 16 th International wood machining seminar. Matsue, Japan; 742- 754
8. HEJMA, J. a kol., 1981: Vzduchotechnika v dřevozpracovávajícím průmyslu, Praha, SNTL
9. HEMMILÄ, P., GOTTLÖBER, CH., 2003: Envicut – project how to reduce the amount of dust and noise in woodcatting, Proceedings of the 16th International wood machining seminar, Matsue, Japan; 712-723
10. KONCZ, I., 1977: Odstraňovanie a odlučovanie prachu, Bratislava, ALFA
11. LONGAUER, J., SUJOVÁ, E., 2000: Vybrané vlastnosti tuhých častíc. Vedecké štúdie, Zvolen, TU
12. MARKOVÁ, I., OČKAJOVÁ, A., 2018: Hodnotenie rizika drewných prachov v pracovnom a životnom prostredí [elektronický zdroj] : vedecká monografia Banská Bystrica : Vydavateľstvo Univerzity Mateja Bela - Belianum
13. OČKAJOVÁ, A., BARCÍK, Š., KUČERKA, M., KOLEDA, P., KORČOK, M., VYHNÁLIKOVÁ, Z., 2019: Wood dust granular analysis in the sanding process of thermally modified wood versus its density, BioResources 14, (4); 8559-8572
14. OČKAJOVÁ, A., BELJO LUČIČ, R., ČAVLOVIČ, A., TEREŇOVÁ, J., 2006: Reduction of dustiness in sawing wood by universal circular saw. Drvna industrija 57, (3); 119-126
15. OČKAJOVÁ, A., KUČERKA, M., KRIŠŤÁK, Ľ., IGAZ, R., 2018: Granulometric analysis of sanding dust from selected wood species, BioResources 13, (4); 7481-7495
16. OČKAJOVÁ, A., KUČERKA, M., KMINIAK, R., KRIŠŤÁK, Ľ., IGAZ, R. RÉH, R., 2020: Occupational exposure to dust produced when milling thermally modified wood, International Journal of Environmental Research and Public Health, 17, (5);1-14
17. ROGOZINSKI, T., DOLNY, S., 2004: Influence of moisture content on the apparent densities of dust from sanding of alder wood, Trieskové a beztrieskové obrábanie dreva '04, Zvolen, TU; 205-208
18. STN 26 0070: 1995: Klasifikácia a označovanie sypkých hmôt dopravovaných na dopravných zariadeniach
19. "Basics of risk assessment - Good for you, Good for your company" <http://osha.europa.eu>

**Streszczenie:** Kąt nachylenia pyłu drzewnego. Celem tego artykułu jest zwrócenie uwagi na czynnik ryzyka - pył drzewny, który osadza się na różnych konstrukcjach, nachylonych powierzchniach podczas pracy. Jeśli nie jest regularnie usuwany, jest źródłem pyłu wtórnego, ponieważ jest ponownie zawirywany przy każdym ruchu. Mierząc kąt pochylenia sypkiego materiału drzewnego uzyskanego z piłowania na stołowej pilarence tarczowej, przy użyciu różnych brzeszczotów i pyłu drzewnego ze szlifowania wzdłużnego i poprzecznego na ręcznej szlifierce taśmowej, ustaliliśmy, które cechy mają na to wpływ. Stwierdziliśmy, że rozmiar cząstek jest ważną cechą, im są one większe, tym mniejszy kąt pochylenia, a także powierzchnia podkładki, na której osadzają się cząstki pyłu, drewno nie odgrywało w tym przypadku znaczącej roli. Najmniejszy kąt pochylenia zmierzono dla trocin z piłowania wzdłużnego  $27^\circ$ , a największy kąt pochylenia dla pyłu drzewnego ze szlifowania poprzecznego dębu i wynosił  $57^\circ$  na podkładce bukowej.

Corresponding author:

Alena Očkajová  
Tajovského 40  
974 01 Banská Bystrica, Slovenská republika  
[alena.ockajova@umb.sk](mailto:alena.ockajova@umb.sk)  
+421/48 446 7217