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APPLICATION OF EQUIPMENT FOR AEROLOGICAL RESEARCHING OF CHARACTERISTICS OF WOOD DUST

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ABSTRACT

Wood dust is the one of the main injurious factors for workers of wooden processing industry. Nowadays there is a lot of technology which help reduce dusting from warehouse. This technology can't include all characteristics. The main goal of this article is creating method of researching wood dust aerological characteristics and simulation process of transfer wood dust.

Aerological characteristics are realized as a result of influence of air stream to dispersible material. The speeds of the stream vary from 0.8 to 6.5 m/s.

On the first stage of measuring defined the speed of air stream in different places of the stand. On the second stage realized weight of dust depends on the speed of stream.

As an element of the original scheme of analysis dust dispersion in three dimensions is used. According to laboratory experiment and calculations the specific dust blowing-out from the surface of 1 m^2 is 0.0109 tons per year.

Keywords: wood dust, Aerology, airflow, air flow speed, mass of dust particles, correlation factor, Student criterion.

INTRODUCTION

Wood dust is one of the most important factors of diseases in wood processing companies. In addition to that it represents one of the main types of organic waste which significantly pollutes the environment (RUSAK, MILOHOV 1975).

Wood dust represents a mix of of 250 microns on average and an abrasive powder formed in the processing of wood material. The content of abrasive material in the wood dust may be up to 1% by weight.

Fractional composition of wood dust has particles which size ranges from 40 to 500 microns (BARTKNECHT 1987). The composition of dust produced by the same machine is unstable and depends on several factors: characteristics of the material, its moisture, grit sandpaper, etc (DI BENEDETTO *et al.* 2010).

The main aerological characteristic of wood dust is volatility. Volatility is the ability of dust particles to move by the gas stream in any direction, to soar in a gaseous medium (VORONIN 1977).

Warehouse of wood dust is the main source of dustiness for working area. In present time there are different types of technology which reduce dusting from warehouse, for example: irrigation, extraction ventilation, covering surface of speck of dust by special solution, etc (STEEDMAN 2002, WYPYCH *et al.* 2005). However, modern methods haven't necessary quantity of characteristics which consider description of wood dust transfer. Simulation of blowing wood dust on the stand is the way for improve the methods.

MATERIAL AND METHODS

Dust is created by fine dispersed solid particles of an organic or inorganic origin; their size is in the range 10^{-3}–10^{-7} m.

These small solid particles land in the air by their weight and they may float for a certain time. Dust may be a product (flour) a semi-finished product (medicine before tableting), or rubbish (abrasive wood dust) (SLABÁ, TUREKOVÁ 2012).

Dust occurs in two forms. Dust layer on walls, horizontal constructions and surfaces of the production equipment is called aerogel. A dust cloud is called aerosol. The dust may change forms easily. Dust layer may become whirled by vibration, jogs, air stream, etc., and vice-versa a dust cloud changes by sedimentation its state into loose (DAMEC 1998).

A characteristic of dust is that it can create, together with air, a two-particle dispersion system, where one element (air) is a continuous medium and the second (dust) is a dispersed substance, or dispersoid. Dust dispersion has a significant influence on its combustibility and explosibility (BRÁZDA, ZEGZULKA 2011).

The composition of wood
Wood is a natural, heterogeneous colloidal system of structurally similar substances.
Main components (polymers) 90−97%, of which

1. ➢ Carbohydrates part - Cellulose (35−50%)
   - Hemicellulose (20−35%)
   ➢ Aromatic part - Lignin (15−30%)
2. The accompanying (subsidiary, extractive) ingredient of (3−10%) and the
   ➢ Inorganic mineral substances
   ➢ Organic monomers and polymers

Tab. 1 Chemical composition of wood (POŽGAJ 1997).

Chemical element (%)	Tree species		
	coniferous species	broadleaved species	timber species
C	51.2	50.0	50.5
H	6.2	6.15	6.1
O	42.2	43.25	42.2

In our experiments we used wood dust, which represents a mix of particles of 225 microns on average and an abrasive powder formed in the processing of wood material. The content of abrasive material in the wood dust may be up to 0.9% by weight. Fractional composition of wood dust has particles which size ranges from 40 to 500 microns.

Before the experiment, wood dust is laid down in form of the hill opened from all sides. After that wood dust is tested for resistance against air stream with the speeds from 0.8 up to 6.5 m/s.

TESTING STAND

A special stand in form of aerodynamic box was constructed for this experiment (Fig. 1).

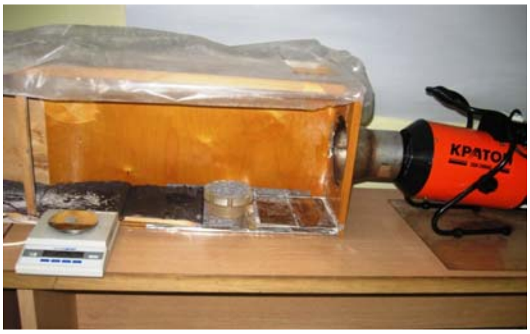


Fig. 1 The laboratory stand for blowing off of a dispersive material.

Testing stand consists from two main components: plastic box (metrics 350 × 30 × 30 cm) and air-blowing machine. Control consol has different types of regulations (rate of air movement, moving directions, air temperature etc).

Both sides of the box have round holes. One of the holes is connected with an air-blowing machine. The speed of the air stream is settled by resistor. The front side of the box is made from organic glass and used for observing the experiment (KOVSHOV 2013). In the centre of the laboratory stand we can see special platform which changing configuration of dusting area.

On the floor of the stand placed 10 square samples (20 × 20 cm) which disposed on the direction of the air stream by terns. Further, samples should be weighted.

TYPES OF MEASUREMENTS

The climatic conditions of the measurements conform to climatic conditions of the real industrial process (temperature 18−24 ºC, humidity <75%, rate of air movement <0.3 m/s).

The main types of measurements:

1) Rate of air movement 1 m/s;

2) Rate of air movement 4 m/s;

3) Rate of air movement 10 m/s.

However during the experiment the step of rate of air movement was 0.1 m/s. It can be possible make the modelling dusting process open air and inside.

At the first stage of the experiment a value of the wind stream in various zones was received by fulfilling many repeated measurements (Fig.2).

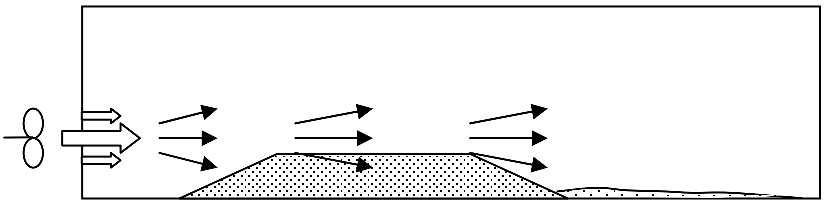
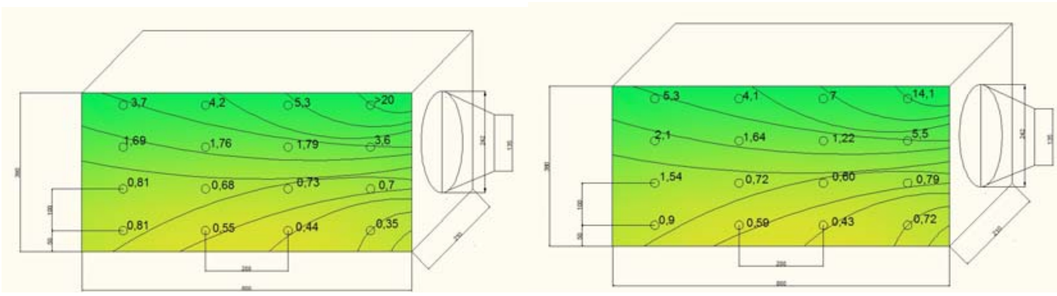


Fig. 2 Blowing dry particulate material.

The measurements were made in 16 points which were on distance of 20 cm across and on 10 cm on a vertical from each other. The blowing was carried out by 2 various wind installations. As a result isolines of air stream distribution were drawn. The most suitable point for carrying out the further tests was chosen. The results of the first stage of the experiment are presented on Fig. 3.



a **b**

Fig. 3 Distribution of air stream: a - sample №1, b - sample №2.

RESULTS AND DISCUSSION

At the second stage of the experiment dependence of changing of the dust weight on a wind speed was defined. For this purpose the loose material put down on the bottom of aerodynamic box. Than it was blown by an air stream with various speed (0.8; 1; 1.2; 1.8; 2.1; 3.5; 4.1; 6.5; m/s). After some period of time (t=3 minutes) the dust which had been blown off from a hill was weighted (Tab. 2).

Tab. 2 Results of the experiment.

Speed (m/s)	0.8	1	1.2	1.8	2.1	3.5	4.1	6.5
Weight of blowing dust (mg)	1.6	22.7	33.7	91.6	146.0	168.5	359.1	970

The dependence of change of the wood dust weight on a speed of the wind stream was drawn (Fig. 4).

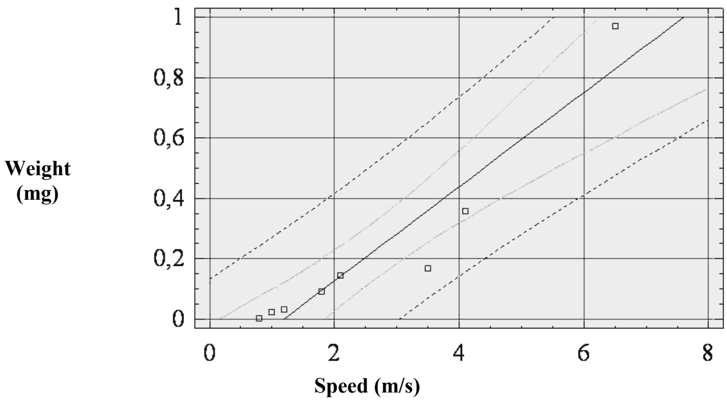


Fig. 4 The schedule of wood dust sample weight dependence from air submission speed.

It is obvious that obtained data is changing under the linear law. Therefore we will set linear function and we will analyze the results received during the experiment. For this purpose it is necessary to define parameters of function $y = ax + b$. We will make function S (ANDRIANOV 1982) (refer with: Eq. 1):

$$S = \sum_{i=1}^{n} \left[y_i - ax_i - b \right]^2 \qquad (1)$$

After have differentiated the expression on *a* and *b* we generate system of the linear equations. Have solved it we receive the following values of parameters:

$$a = 0{,}090656 \qquad b = -0{,}464457$$

Correlation factor satisfies to a parity -1 ≤ *r* ≤ 1. In our case we have *r* <<1 that tells about a close arrangement of points to a line of regress. To check up whether the factor of correlation differs from zero it is possible to use Student criterion. The calculated value of criterion is defined under the formul. (refer with: Eq. 2):

$$t = \frac{\sqrt{n-2}}{\sqrt{1-r^2}} \Rightarrow t=2.45 \qquad (2)$$

Value t is compared to the value taken from the table of Student distribution according to a significance value *a* and number of degrees of freedom *n*-1. In our case it equals 2.36 that testifies the high convergence of results.

Experimental stand allows investigating dust carry parameters with high accuracy and analyzed them by standard methods.

That is why we can use this stand for modelling processes of dust formation and dust blowing out taking into account criteria of similarity.

As an object for analysis a typical warehouse of wood dust was chosen. It is situated in the Roman wood-processing factory (village Romanovka, Vsevologsk district, Leningrad region of Russia).

This dust warehouse is 2.7 m of height, 4.9 m of width and 13.5 m of length.

Such emitter has a dust stream in form of triangle prism (Fig. 5) with peaks AB which lay on closest border of the dust hill.

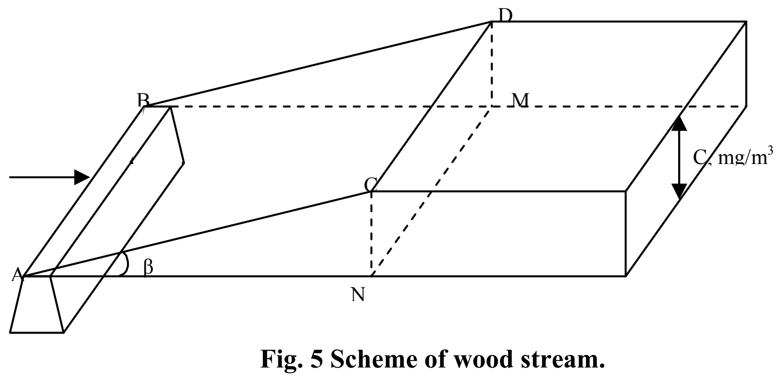


Fig. 5 Scheme of wood stream.

Two other sides CAN and BDM can be defined only symbolically because their borders are eroded by air stream.

The angle of dust blowing β is about 10–15°. This angle remains the same for 50–80 meters form the peak of the prism. Than the higher border of the dust stream goes horizontally for 300–450 meters. After that the dust cloud is dispersed and has no definitive form.

The width of dust stream depends on wind direction. It can be from 6 to 15 meters. The average width is taken according to winds which were the most frequent this year.

The main parameter of the dust stream is concentration of the dust. Its quantity varies according to dust moving. The concentration of the dust depends on dust humidity, dispersed composition, variety of its chemical and substance composition, physical characteristics.

The analysis of grain-size was made by grading screen. The wood dust was classified according to the grain size. As a result we found out that the most part of the grains has diameter 1.6–0.071 mm.

The results of the grain-size analysis have shown that the biggest grains from the dust stream accumulate near the warehouse. So, the quantity of the grains bigger than 1.6 mm decreases dramatically in distance of 10 meters. The grains bigger than 0.63 mm represent only 3 % of wood dust in distance of 50 meters. In distance of 70 meters the main part of the grains has diameter less than 0.14 mm.

Thus, the fulfilled research shows that the quantity of big and the smallest dust grains decreases evenly moving away from its source. When the dust stream achieves the industrial buildings it consists mostly from the dust grains with size less than 71 micrometers. That is why while the laboratory research we investigated the quantity of dust which was blown away from the dry surface by the air stream with different speeds.

In laboratory stand the dry warehouse with the wood dust samples from Romanov wood processing manufacture was modelled (Fig. 1). Its surface was 180 cm^2. The size of grains was 1.6−0.71 mm (mostly 0.4 mm). This model of warehouse was blowing through during 15 minutes by the air stream with speeds from 2 to 10 meters per second. This experiment consisted from 5 stages, each had 6 repeats. The results of the experiment are represented in the Tab. 3.

Tab. 3 Results of the experiment of blowing out the dust from the dry surface.

№	Speed (m/s)	Weight of blowing dust (mg)	Intensity of blowing out the dust (mg/s)
1	2	1.6	0.0018
2	4	3.2	0.0036
3	6	6.9	0.0077
4	8	15.0	0.0167
5	10	39.6	0.0440

According to laboratory experiment and calculations the specific dust blowing-out from the surface of 1 m^2 is 0.0109 tons per year.

Due to results of comparative analysis of dust blowing-out parameters in Romanov wood processing factory and experimental data received in laboratory it was deduced that without any dust-suppression means dust blowing-out depends on air stream speed with proportional coefficient $k=10^6$ (Fig.6).

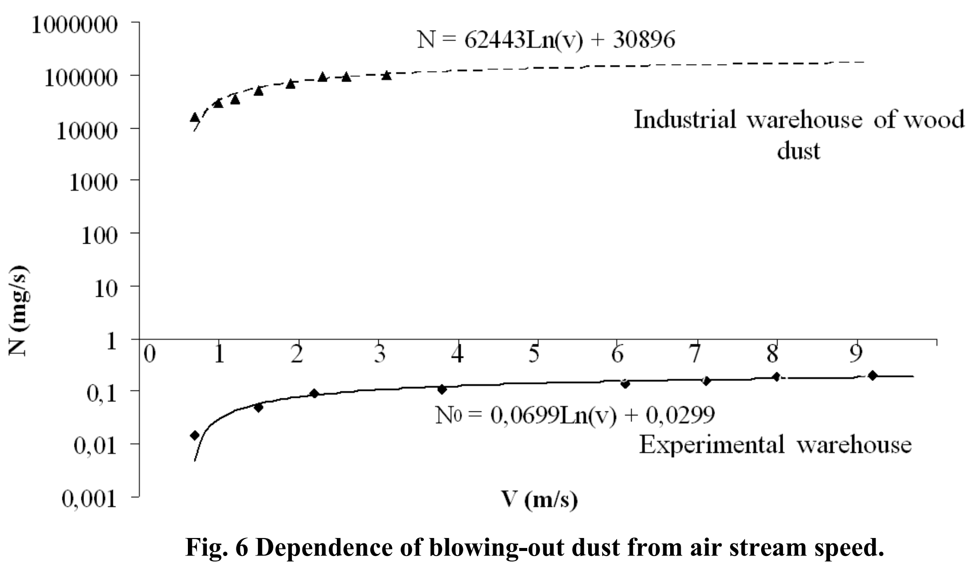


Fig. 6 Dependence of blowing-out dust from air stream speed.

COMPARISON THE RESULTS OF EXPERIMENTS WITH RESULTS OF OTHERS RESEARCHERS

The results are comparable with the results of others researches which described the process of dusting from the similar area (PILÃO *et al*. 2006, STEEDMAN 2002, WYPYCH *et al*. 2005). But there is divergence less than 15%. In accordance with publishing by STEEDMAN (2002), constant of proportionality is $k = 1.1 \cdot 10^6$.

That fact gives possibility to apply extrapolation of parameters for analyzing technologies for dust suppression which are rarely used in wood processing industry. The experience of mining industry proves that these technologies have considerable potential.

CONCLUSION

According to the study the following conclusions can be made:

- a special stand was created for investigating characteristics of wood dust aerology. This stand allows using different air stream speed and forming different shapes of wood dust;
- two diagrams of wood dust dispersion according to typical speeds (from 0,3 to 2,5 m/s) of airflow are drawn;
- the dependence of the removal of wood dust from the air flow is defined (установлено, что эта зависимость является логрифмической);
- analysis of the grain composition has been made. It has shown that the main part of the dust is represented by the grains with diameter 1.6−0.071 mm;
- dependence of dust blowing-out from the distance and grain-size composition is defined;
- comparative analysis of dust blowing-out parameters in real wood processing factory and experimental data received in laboratory has shown that without any dust-suppression means dust blowing-out depends on air stream speed with proportional coefficient $k = 10^6$.

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