RESEARCH PAPERS
FACULTY OF MATERIALS SCIENCE AND TECHNOLOGY IN TRNAVA
SLOVAK UNIVERSITY OF TECHNOLOGY IN BRATISLAVA

2013 Special Number

MINIMUM IGNITION TEMPERATURE OF WOOD DUST LAYERS

Martin PASTIER, Ivana TUREKOVÁ, Zuzana TURŇOVÁ,
Jozef HARANGOZÓ

ABSTRACT

Fire characteristic (properties) are used to determine the fire risk and explosion hazard of materials. They are defined as numerical values which describe behavior in the process of burning. They can be determinate by standardized test methods. In this paper is described the most important fire technical characteristic of dust layer (minimum ignition temperature) and the results of standard laboratory method determination for wood dusts, aswell.

KEY WORDS

wood dusts, fire characteristic, minimum ignition temperature, dust layer

INTRODUCTION

Fires and dust explosions are one of the biggest threats in many industries where dust layers and/or clouds forms during technology processes, which are capable of ignition [1]. Due to the wide application of wood and wood based materials is just wood dust one of the most common industrial dusts [2].

An accumulated combustible dust layer on some hot process equipment such as dryers or hot bearings can be ignited and result in fires when the hot surface temperature is sufficiently high. Hot surface ignition temperatures of dust layers refer the minimum surface temperatures which can ignite a certain thickness of dust layers. For layer thickness found that the thicker the layer is, the lower the ignition temperature is. As a dust layer thickness increases, the temperature gradient in the dust layer becomes smaller, which reduces the conduction rate consequently. This results in the local temperature increases, exothermic reaction, and ignition at lower temperature of hot plate. About the particle size, the more complete oxidation occurred in smaller particle until a certain critical size. If the particle size is much bigger, surface area and rated combustion are too small to overcome the rate of heat dissipation. The dust layer depth is the most important factor affecting the ignition temperature and particle size is not important and packing density affected the ignition temperatures of only thin layers [3].

Martin PASTIER, Ivana TUREKOVÁ, Zuzana TURŇOVÁ, Jozef HARANGOZÓ - Slovak University of Technology in Bratislava, Faculty of Materials Science and Technology in Trnava, Department of Safety Engineering, Paulinska 16, 91724 Trnava, Slovak Republic, martin.pastier@stuba.sk, ivana.turekova@stuba.sk, zuzana.turnova@stuba.sk, jozef.harangozo@stuba.sk

When a dust layer is positioned on a hot plate a heat transport occurs from the plate surface, through the layer up to its opposite surface where the heat energy is dissipated to the environment. The heat flux causes temperature rise in the layer and starts a chemical reaction in the dust that in turn leads to further increase of temperature inside the layer. The rate of the chemical reaction also depends on temperature. Therefore, if the temperature inside the layer reaches a certain critical value the rate of heat transfer to the surrounding air will be too low to compensate the rate of heat production in the chemical reaction. As a result an ignition of the dust layer occurs [4].

MATERIAL AND METHODS

Three samples of wood dust resulting from the manufacture of wood and wood based materials in wood workshop were tested. The samples consist of particles of different sizes resulting from the cutting of material. A sample of material particles are formed when cutting particleboard and fibreboard on the saw. Sample B was collected from the forming saw where the raw slabs from the poplar, spruce, alder and ash tree are processed. Sample C consists of particles that arise when cutting chipboard. Before setting a minimum ignition temperatures sieve analysis was performed. Size distribution of dust samples is shown in Figure 1.

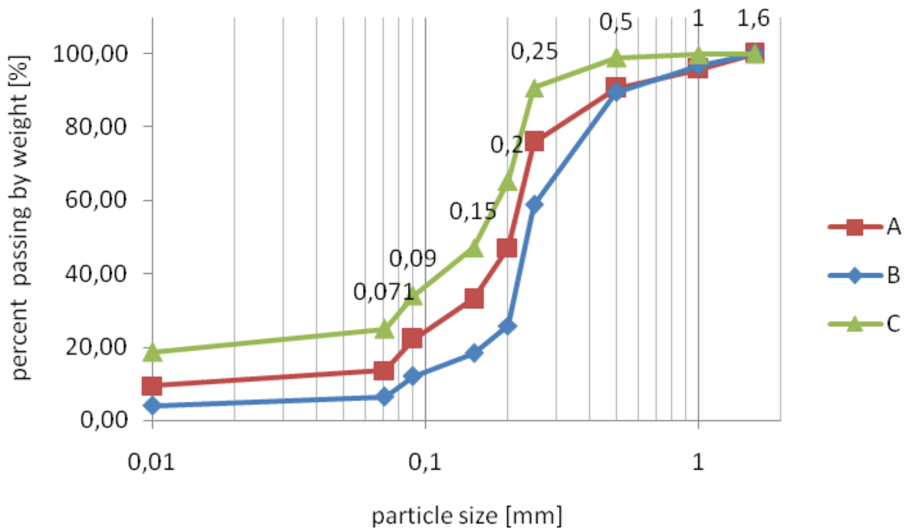

Fig. 1 *Size distribution of dust samples*

In all cases, the the dust consists of approximately 90% of particles finer than 0.5 mm. For determining the minimum ignition temperature of dust layers were all samles sieved through a sieve. The mesh size of the sieve was 0.5 mm. Particles larger than 0,5 mm were removed from the samples of dust.

The minimum ignition temperature was determined on an electrically plate 185 mm in diameter according to STN EN 50281-2-1: 2002 Electrical apparatus for use in the presence of combustible dust. Part 2-1: Test methods. Methods for determining the minimum ignition temperatures of dust. This standard define minimum temperature for ignition of a dust layer as a minimum temperature of a hot surface by which can arise an ignition of a dust layer with a setting thickness located on that hot surface.

According to STN EN 50281-2-1:2002 as an ignition of dust layer is considered the case when arises smouldering or creating of flames in the material or a measured temperature is

450°C or higher by a test or can be warmer in 250 K or in higher above the temperature is set for a hot surface. It characterise a dust according to its ability to ignite in the layer by a heat stress by a hot environment or with a contact with a hot surface [5].

RESULTS AND DISCUSSION

Test samples were dried and undried and tested in two heights layer for 5 mm and 12.5 mm. Samples were dried 12 hours at 103 °C. The measured humidity values are shown in Table 1.

THE MEASURED HUMIDITY VALUES OF DUST SAMPLES

Table 1

Sample	Humidity [weight %]
A	4,7
B	5
C	3,2

Behaviour of the sample during the measurement showed the fact that smouldering and flowingly ignition was visible mainly by edges of the circle. The sample was thermally forced by a metal circle and therefore has a better conductivity than an individual dust sample and the heat were spread more quickly. A dust layer forced to heat carbonated, after volume decreasing it was realized a separation of the sample from the circle edges. This enables an oxygen input into this zone and it was followed by a sample ignition. The behaviour of dust sample during the measurement is shown in Figure 2.

Fig. 2 *Carbonization of dust sample during the testing*

From the setting of minimum ignition temperatures of the tested dusts were defined minimum temperatures of hot surfaces, where is a probability of ignition of 5 mm dust layer. There were observed the conditions of initiation process of burning by a different dust layer thickness located on the warming surface. The behaviour of undried and dried samples of dust was also monitored. The aim was to set the influence of the thickness of the layer on the result value of the minimum ignition temperature. There were compared values of minimum ignition temperatures of the wooden dusts in the layers 5 mm and 12.5 mm. In Table 2 are shown the results from the measurement of minimum ignition temperature of organic dust layers.

RESULTS FROM TESTING OF MINIMUM IGNITION TEMPERATURE OF WOOD DUST LAYERS

Table 2

	Undried		**Dried**	
Layer	5 mm	12.5 mm	5 mm	12.5 mm
Sample	Minimum ignition temperature [°C]			
A	350	300	340	300
B	330	300	330	300
C	340	300	340	300

The highest minimum ignition temperature at 5 mm layer was determined for sample A in undried state. The lowest minimum ignition temperature was determined for the sample B in the dried and undried state. Figure 3 shows the course of temperatures of dried and undried sample B at 300 °C of heated surface and this temperature was determined as minimum ignition temperature.

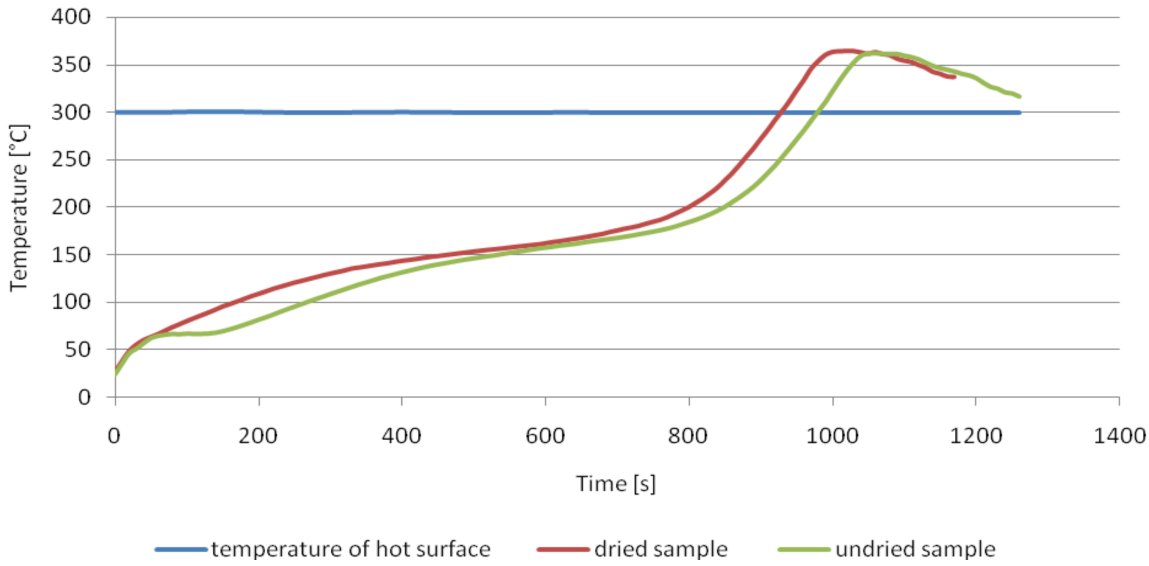

***Fig. 3** The course of temperatures of dried and undried sample B*

From the record of temperatures can be seen the difference between the initiations of dried and undried samples. The minimum ignition temperature was determined equally to 300 ºC. The only difference is the time required to initiation. The temperature increase of undried samples stopped at approximately 70 °C and after 1 minute the temperature increase continued. This holding is caused by evaporation of humidity from the sample. Similar course of temperature was recorded for samples A and C in both layers 5 and 12.5 mm.

CONCLUSION

Regulations concerning safety rules for usage of electric power equipment installed in conditions where flammable dusts are present require that the surface temperature of those machines should not exceed 2/3 of the minimum ignition temperature of the dust cloud, and as regards dusts that create a layer – the temperature on surfaces of various types of equipment has to be at least lower by 75 K than the minimum temperature of the dust layer.

Analysing the minimal ignition temperature on hot plate depends on the thickness of the dust layer. Whenever this temperature was measured for the 12.5 mm layer, minimum ignition temperature was average lower by 50 - 30 °C than the temperature for 5 mm layer of dust. Another important factor is the time to ignition, which depends on the humidity of dust. Humidity of dust samples to 5% prolong time ignition about a minute. Comparing results one can say that ignition temperatures of wood dusts sample differ only slightly from each. The maximum temperature of appliance and machinery in wood workshop should not be higher than 225 °C for the 12.5 mm dust layer. Analysis of minimum ignition temperatures depending on the humidity does not indicate significant changes in minimum ignition temperature, higher moisture content only delays the time to ignition.

The most frequent reason for the aerosol explosion is an initiation from the hot dust layer. From this reason it is important to know a minimum temperature for a dust layer ignition. The ignition of a dust layer is one of the important characteristics of the dust materials. Setting of the lowest temperature for ignition can define the danger grade of ignition of the dust layers.

ACKNOWLEDGMENT

The submitted work was supported by the Slovak Grant agency VEGA MS VVS SR and SAV project No. 1/0446/12.

REFERENCES

1. POLKA, M., SALAMONOWICZ, Z., WOLINSKI, M., KUKFISZ, B. 2012, Experimental analysis of minimal ignition temperatures of a dust layer and clouds on a heated surface of selected flammable dusts. In: *Procedia Engineering,* 45, p. 414 – 423, ISSN: 1877-7058
2. BLAIR, A., S. 2007. Dust explosion incidents and regulations in the United States. In: *Loss Prevent. Process Ind*., 20, p. 523–529. ISSN: 0950-4230
3. ZALOSH, R., G. 2003. *Industrial Fire Protection Engineering*. Wiley, p. 132, ISBN: 978-0471496779
4. DYDUCH, Z., MAJCHER, B. 2006. Ignition of a dust layer by a constant heat flux-heat transport in the layer. In: *Journal of Loss Prevention in the Process Industries,* 19, p. 233–237. ISSN: 0950-4230
5. SLABÁ, I., TUREKOVÁ, I. 2012. *Smouldering and Flaming Combustion of Dust Layer on Hot Surface.* Dresden: Scientific Monographs, 88 p. ISBN 978-3-9808314-5-1