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OPTICAL MEASUREMENTS OF SAWDUST DIMENSIONS

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ABSTRACT

This article deals with optical measuring of sawdust dimensions by IP camera. Optical methods of sawdust dimensions measurement are relatively extended and offer more information about measurement sample than other methods. By descripted method it is possible to specify dimensions, perimeter, area of each particle, as well as eccentricity, centroid position, segmentation of edges and other. Using IP cameras to obtain the image with samples it is possible to measure sawdust, e. g. at the manufacturing, and to evaluate the results at another location (laboratory). This eliminates need to carry a measuring system to measuring location. Compared to other methods (e. g. sieve method), descripted method is repeatable because the samples are not mechanical damaged and crumbed by jolting through the sieves.

KEYWORDS: Measuring, sawdust dimensions, optical method, Matlab.

INTRODUCTION

Wood is considered as a complexity matter that had multi-purpose functions. In the wood sawing process the sawdust is produces as a by-product. Its shape, size and quantity are depend on physical and mechanical properties of the sawn timber as well as on the shape, dimensions and sharpness of cutting tool, and on technical and technological conditions of sawing process. Physical and mechanical wood properties have decisive impact on technological wood processing like pressing, bending, drying, cutting and other manufacturing processes (Husein et al. 2014, Kučerka and Očkajová 2014, Kvietková and Barcík 2015). Today, maximum effort is incurred for searching and using of energy saving solutions in every industry (Kováč et al. 2014). Measurement of wood chips and sawdust dimensions is an important part of the woodworking industry. Such an analysis allows to evaluate the characteristics of the machines used in woodcutting and optimizes the selection of a suitable separating device for contingent sorting of sawdust. The measurement evaluation informs about the potential emissivity of working environment and the health risks while working in such environment for as much as since small wood dust can have negative effects on human body, even it was found out that oak sawdust is carcinogenic (Irša 2006). Appropriate selection of the tool can affect the proportion of the fine fraction of particles (Očkajová et al. 2006).

By descripted method it is also possible to recognize the colour of individual sawdust. Colour can be an important indicator of wood surface quality (Barcík et al. 2015). Currently, the detection of sawdust dimensions uses the sieve analysis. This results into the weight proportion of a certain dimensional fraction based on the total weight of the sample. During this analysis the sample is damaged, whereas the sample is shaken down through the sieves. Therefore it is not possible to repeat the measurements of the same sample. Due to these deficiencies, an optical method of sawdust dimensions measuring is preferable; it also gives more information about the measured sample (Pivarčiová and Brožek 2014).

MATERIAL AND METHODS

The measurement was intended to determine the area and perimeter of sawdust. Sawdust were obtained during splitting wood porous of common oak (*Quercus robur* L.). These were sawn using a table saw Bosch GTS 10 J. Sawdust has gradually been deployed to the mat with white contrasting color and shot with the camera IP IQ Eye 702 (Fig. 1).

Fig. 1: Camera IQEye 702.

Maximum camera resolution is 2 megapixels. At scanning the full camera picture is not processed because unnecessary data would have appeared in the peripheral parts of the scanned image. This step also increases the transmit speed of data from the cameras to remote computer. The Matlab function imread was applied to download images from the camera.

Objects in scanned image have their real proportions after removal of the spherical and perspective distortion. The perimeter and area of particles, average particle size, and maximum and minimum size can be measured using the proposed optical method. The proposed program determines:

- smallest and biggest particle dimension,
- area and perimeter of every particle.

Every individual sawdust particle is identified in the image by thresholding before the measurements. If the threshold is too high, marginal points could be eliminated from the sawdust; if it is too small, the sawdust could be artificially enlarged. In the experiment a threshold value was determined by Otsu algorithm. In this method the optimal threshold for selected image is selected by histogram. For searching of objects it is necessary that the image remains binary after thresholding; black spaces represent measured sawdust and the background remains white. Identification and determination of the necessary characteristics of sawdust in the image are executed in the program Matlab using function "bwboundaries":

[*B*, *L*, *N*, *A*] = bwboundaries (*I1*, 'noholes');

where: B - matrix of objects border,
L - two-dimensional array of nonnegative integers that represent contiguous region,
N - the number of found objects,
A - adjacency matrix; represents the parent-child dependencies between boundaries and holes,
I1 - input binary image, 'noholes' – function argument to search only object (parent and child) boundaries, no holes boundaries.

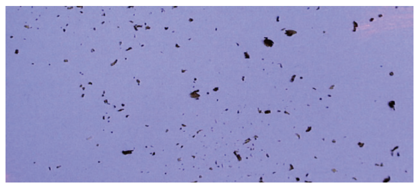

Fig. 2: Image with sawdust sample.

Function bwboundaries returns number of found objects N and an adjacency matrix A. The first N cells in matrix B are object boundaries. Matrix A represents the parent-child-hole dependencies. It is a square, sparse, logical matrix with side of length max (L(:)), whose rows and columns correspond to the positions of boundaries stored in matrix B.

The image of examinable sample of sawdust is shown in Fig. 2. Background from this picture is removed and measurement sawdust are identified using preprocessing algorithms (Fig. 3).

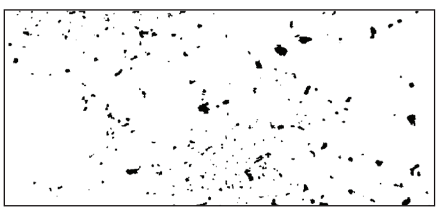

Fig. 3: Identified sawdust.

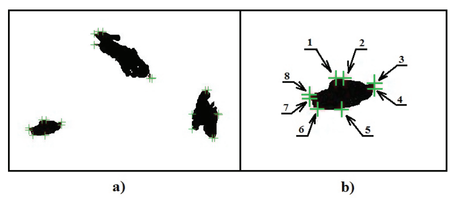

Fig. 4: Extreme points found by function regionprops: a) identified sawdust, b) eight extreme points.

In such founded objects the required information is searched using the function region props. With this function multiple parameters can be specified in binary objects, such as the number of pixels in the objects (their surface), coordinates of the object, the corner points of the object (Fig. 4), the object perimeter, and many others.

During measurement it is necessary to insure appropriate conditions for optical sensing of sawdust. First condition is that the measured particles cannot be overlaid. At the overlay of particles these particles are false identified as one particle. It is useful to sense lesser number of particles at once, alternatively is possibly to use an vibrating equipment which will be uniformly applied sample to the moving conveyor (Liao 2009).

The next condition is to insure appropriate lighting of sensed particles. Particles have to be adequate lighted in order to find and identify them in the image. The lighting should be diffused, cannot be spot in order not to create intense shadows causing false detection of particle boundaries. The interval of appropriate light intensity is from 500 to 1000 lux whereby the optimal intensity is about 1000 lux. By implementation of appropriate lighting settings, we can achieve elimination of details, which are sources of inaccuracy in the process of image evaluation. (Koleda 2013, Šuriansky 2010).

The acquired image can contain errors reducing its quality already at the image shot. If these effects have to be minimalized or supressed, it is necessary to apply a number of operations called image preprocessing. For highlight of the measured object in the image can be used a suitable filter. However, inappropriately filter selection can be lost user data and inserting noise into the image (Al-Thyabat 2006). No new information is obtained by application of image preprocessing, only some information in image signal (important) is emphasized and other (not important and errors) are supressed. Preprocessing allows to eliminate error information and extract information that is directive for its understanding on the base of predefined requirements.

Configured camera system brings up some measurement distortion (Fig. 5). Rotating the camera to scanned plane causes perspective distortion; the camera lenses affect the images by spherical distortion.

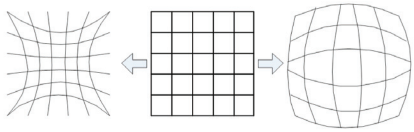

Fig. 5: Spherical distortion effect (Łuczak et al. 2012).

In terms of experiment results relevance, both these distortions must be removed before the measurement (Hoffmann 2006). Before the measurement it is necessary to modify obtained images with measured objects. During this operations the perspective and spherical distortion of camera are removed (Hrčková 2012). Some authors identify the size of measured particles by their circular equivalence (Al-Thyabat et al. 2007). Our proposed system also allows such an analysis.

RESULTS AND DISCUSSION

Measured data are saved into a table in Matlab for next processing in further research. From these data, the statistic parameters are found e. g. histogram of sawdust area (Fig. 6) that describes the number of particles in fractions according to the area. In the bulk there is sawdust with the area to 3 mm^2 in measured sample.

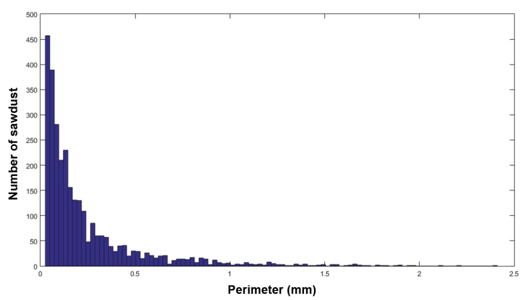

Fig. 6: Histogram of sawdust volume.

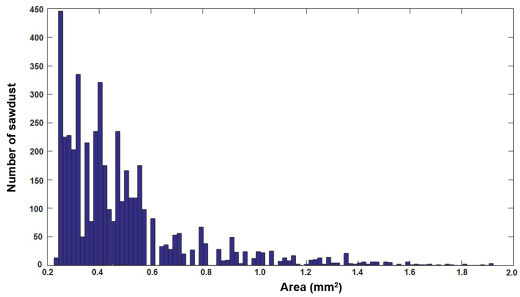

Fig. 7: Histogram of sawdust size.

There are large particles too (area at about 17, 24 and 33 mm^2) that are statistically insignificant in regard to examined sample and they were removed from evaluation.

In the Fig. 7 there is displayed the histogram of sawdust perimeter that describes the number of sawdust in particular fractions according to the perimeter. As well as at the areas histogram, the bulk of particles has the perimeter over 5 mm and there are statistically insignificant particles with extremely long perimeter by comparison with the perimeters of other particles.

Obtained data can be statistically evaluated by means of Matlab. In the Fig. 8 there is displayed the analysis of variance of measured values (ANOVA).

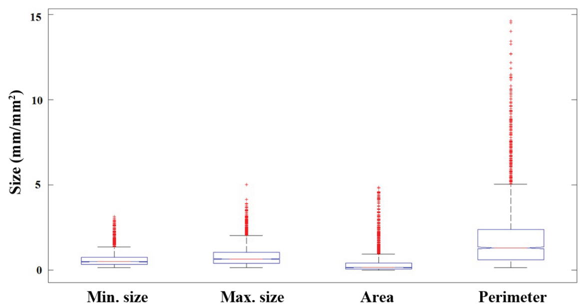

Fig. 8: Analysis of variance.

ANOVA Table					
Source	**SS**	**df**	**MS**	**F**	**Prob>F**
Columns	2669.38	3	889.794	1884.33	0
Error	5643.81	11952	0.472		
Total	8313.2	11955			

Fig. 9: ANOVA Table.

CONCLUSIONS

By described method the dimensional characteristics of sawdust, wood dust and another fractal particles can be measured. By exploring of wood chips and dust size in woodcutting it is possible to determine tool wear and thereby streamline the machining economy. The minimum scanned dimension depends mainly on the applied optical lens and camera system. Although the camera used in the experiment was unable to capture particles smaller than 0.2 mm, it is suitable for the measurement of dust particles in proposed application. For measuring the dimensions of smaller particles, the different, more appropriate camera for close-up shooting should be considered.

The data measured by given method are relatively easy to process, because the output values are saved into MS Excel tabular editor. Compared to other methods, the optical measuring systems provide a much wider data about measured sample and are easier for operating. This method is not consuming for sample preparation, compared to other methods is non-destructive. We are preparing for the future research to improve the system for on-line measurement of the chips dimensions directly in wood processing.

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