POSSIBILITIES OF DETERMINING THE CHARACTERISTICS OF WOODCHIPS USING IMAGE ANALYSIS IN THE MATLAB PROGRAM

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ABSTRACT

This article deals about the possibilities of obtaining information from a sawdust sample using the Matlab program. Using sawdust analyzing during chip machining, it makes it possible to determine unsuitable conditions by cutting and woodworking, such as dulling of the tool, unsuitable cutting conditions, overheating of the tool and others. Such conditions can have negative effects on the operation and economics of the company.

Commonly used sawdust sizing methods, such as sieving, obtain only partial information about a given sample. On the other hand, by means of image analysis of a sawdust sample, it is possible to find out much more, for example the largest and smallest dimension of each single particle, its circularity, area, perimeter, eccentricity, convex hull major and minor axis length, or color of the particle. For some other particle analysis methods, it is not appropriate to repeat the experiment with the same sample, because it may occur damage of the sample during the measurement. This can happen during sieving, where the sample is mechanically stressed and can crumble. In the image analysis, the sawdust is scattered on the substrate and a digital image of these sawdust is create. Therefore, there is no mechanical damage on the sample.

Key words: Sawdust, image analysis, dimensions measurement, Matlab.

INTRODUCTION

The development of industry and the economy puts pressure on the speed of production of products and goods. In addition to the advantages, this trend also has many negative aspects, for example, excessive production of waste material that can be largely recycled. Waste in the form of chips is also generated during the production of semi-finished products. It is mainly sawdust and dust that must be removed so that they do not affect the production process and the operators.

The size of the generated sawdust and dust can tell different information about the production process, as well as about the safety of work in a dust-polluted environment. Nowadays woodworking with CNC technologies is an integral part of thewoodworking industry. The range of used CNC machines is very wide in the so-called CNC-machining centers (Korčok et al. 2018, Kos et al. 2004). Even with these modern computercontrolled machines, we cannot avoid the problem of removing secondary material, whicharises during machining – chip (Kučerka, 2022).

Evaluates the carcinogenic risk to humans posed by occupational exposures to wood dust and formaldehyde. A number of occupational situations that involve exposure to wood dust also entail exposure to formaldehyde, as in plywood and particle board manufacture, during furniture and cabinet-making, and during parquet floor sanding and varnishing. The highest occupational exposures were noted to occur in wood furniture and cabinet manufacture, especially during machine sanding and similar operations, in the finishing departments of plywood and particle-board mills, and in the workroom air of sawmills and planer mills near chippers, saws, and planers. Citing findings from several recent well-designed case-control studies, the monograph concludes that occupational exposure to wood dust is causally related to adenocarcinoma of the nasal cavities and paranasal sinuses (International Agency for Research on Cancer, 1995).

The aim of the article is the design and testing of an optical method for the analysis of fractional particles produced during chip woodworking.

MATERIALS AND METHODS

The measurement of dimensions was performed on a milled birch lumber (Figure 1). This samples were milled on a lower spindle milling machine FVS(Czechoslovakia Music Instruments, Hradec Králové, Czech Republic) and feedingmechanism ZMD 252/137 (Frommia, Fellbach, Germany) at the Technical University in Zvolen.

Subsequently, the sawdust was photographed using a Nikon D550 camera (Koleda, 2021).

Figure 1: Sample of Birch wood chips.

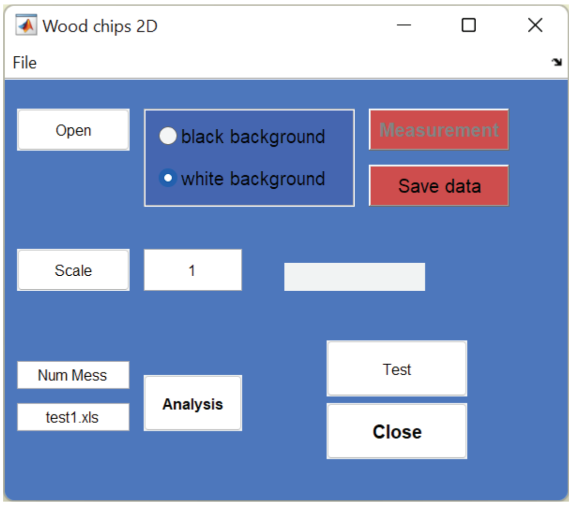


Figure 2: Created program in matlab

This image is subsequently processed in the proposed program in Matlab (Figure 2).

This program allows you to open processed images with sawdust. Before analyzing the images, it is necessary to determine the conversion coefficient for converting pixels to the metric system (milimeters). This is determined by taking a single image containing a known distance – 100 mm on the ruler (Figure 3).

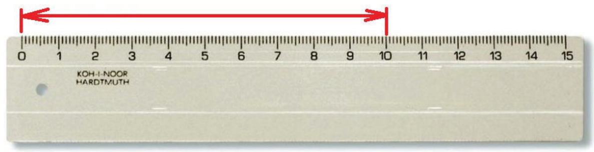


Figura 3: Determining the conversion factor to metric dimensions.

In this image are selected by clicking 2 points that are 100 mm apart. The program determines how many pixels represent this distance, which determines the conversion coefficient for measuring dimensions in mm.

Subsequently, the analyzed image is opened, in which it is necessary to select the background color of the sawdust, whether there are light sawdust on a black background, or dark sawdust on a white background. These combinations are suitable for the contrast between the searched sawdust and the background, so that they can be easily identified. In the case of a background with a similar color to the searched objects, particles may be incorrectly assigned to the background, or false objects may be created.

For next analysis, this image is converted into binary form using a function:

$$im2bw(I, \text{graythresh}(I)) \quad \textbf{(1)}$$

I – a variable representing the loaded image.

Function *im2bw* converts the input image to a binary form in which the pixels belonging to the sawdust have the value 1 (white), the other pixels have a value 0 (black). The decision level for this transfer is calculated using a function *graythresh*(*I*). This computes a global threshold T from grayscale image I, using Otsu's method. Otsu's method chooses a threshold that minimizes the intraclass variance of the thresholded black and white pixels (Otsu, 1979). The result of binarization is shown in the figure 4.

Figure 4: Binarized picture.

During this binarization may be fictitious holes created, due to the structure of the sawdust. These are subsequently removed using the function:

imfill(BW,'holes') **(2)**

BW – input binary image,
'holes' – parameter of the *imfill* function.

Function *imfill(BW,'holes')* fills holes in the input binary image *BW*. Using parameter *'holes'* are removed only holes in objects (Figure 5). Hole is a set of background pixels that cannot be reached by filling in the background from the edge of the image.

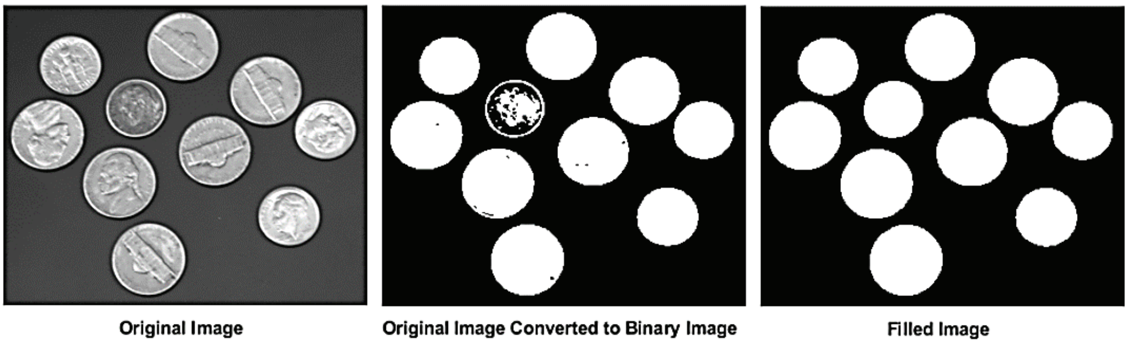


Figure 5: Removing holes in objects

In the thus modified binary image, the dimensional characteristics of the sawdust are subsequently detected by pressing the „Measurement" button.

It is possible to determine the dimensional parameters of the sawdust in the digital image modified in this way. In Matlab program were to determine sawdust parameters used functions

regionprops(BW,properties)
bwferet(BW,properties) **(3)**

BW – input binary image,
properties – specified required calculated properties.

Using *regionprops* function are calculated the required characteristics of the found objects – sawdust. The list of these characteristics is specified as *Properties* in the function *regionprops*. To dimensions measure of the sawdust, the following were determined: Area, Perimeter, Centroid, Orientation, Circularity, Eccentricity and Bounding Box.

Function *bwferet* measures the Feret properties of objects in an image and returns the measurements in a table. The input properties specify the Feret properties to be measured for each object in input binary image *BW*. The measured Feret properties include the Major and Minor axis length, Feret angles, and endpoint coordinates of Feret diameters.

Area of individual sawdust is determined with a parameter *'Area'*. This parameter counts all pixels belonging to individual sawdust in the binary image.

The Perimeter measurement of sawdust is determined using a parameter *'Perimeter'*. Function *regionprops* computes the perimeter by calculating the distance between each adjoining pair of pixels around the border of the region.

The position of the center of sawdust is determined by a parameter *'Centroid'*, this detects the horizontal and vertical coordinates of the position of the center of particle in the image.

The rotation of sawdust in the image is detected by a parameter *'Orientation'*. It represents an angle between the x-axis and the major axis of the ellipse that has the same second-moments as the region, returned as a scalar. The value is in degrees, ranging from -90 degrees to 90 degrees.

Roundness of objects, returned as a structure with parameter *'Circularity'*. The structure contains the circularity value for each object in the input image. The circularity value is computed as

$$(4*Area*pi)/(Perimeter^2) \quad \textbf{(4)}$$

For a perfect circle, the circularity value is 1. The input must be a label matrix or binary image with contiguous regions.

Eccentricity of the ellipse that has the same second-moments as the region, is detected with parameter *'Eccentricity'*. The eccentricity is the ratio of the distance between the foci of the ellipse and its major axis length. The value is between 0 and 1. (0 and 1 are degenerate cases. An ellipse whose eccentricity is 0 is actually a circle, while an ellipse whose eccentricity is 1 is a line segment).

Position and size of the smallest box containing the region, detected with parameter *'BoundingBox'*. It's returned as a 1-by-(2*Q) vector. The first Q elements are the coordinates of the minimum corner of the box. The second Q elements are the size of the box along each dimension. For example, a 2-D bounding box with value [5.5 8.5 11 14] indicates that the (x,y) coordinate of the top-left corner of the box is (5.5, 8.5), the horizontal width of the box is 11 pixels, and the vertical height of the box is 14 pixels.

The largest and smallest dimensions of each sawdust are determined using parameters *'MajorAxisLength'* and *'MinorAxisLength'*.

RESULTS

The determined dimensional sawdust parameters are stored in an Excel table for further processing. Some of them can be graphically represented in a modified binary image with sawdust (Figure 6): bounding box (blue rectangles), major axis length and minor axis length (blue lines with displayed length), orientation (red ellipse), and position of sawdust center (green star).

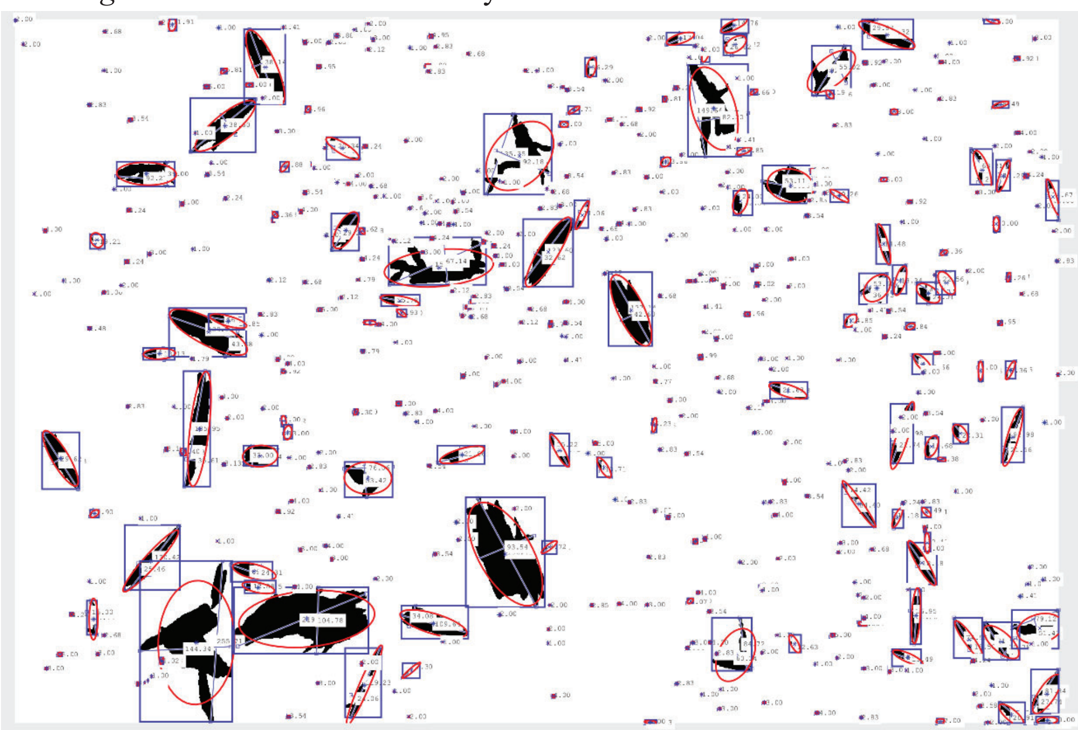
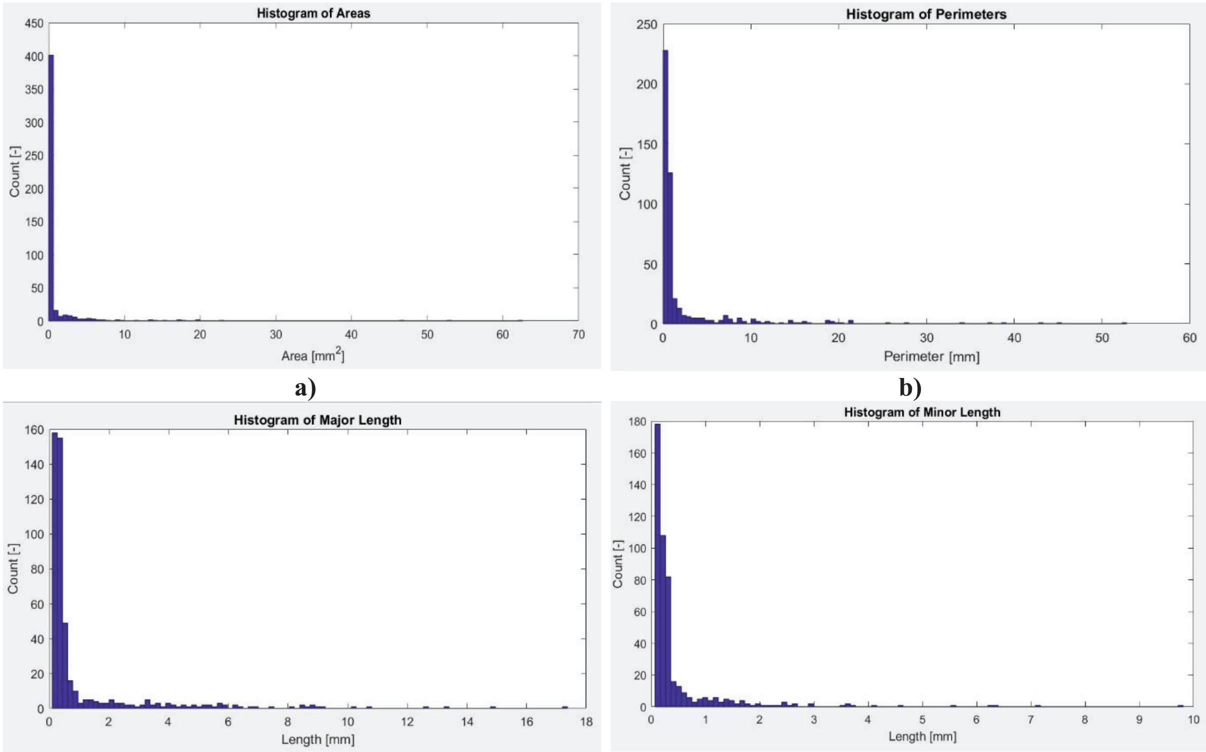


Figure 6: Graphic representation of the detected sawdust.

Multiple images with analyzed sawdust can be processed for one measurement. If multiple images are being processed, after the measurement, the next image is simply opened and the next measurement is started in the same way. After the last analyzed image, all measured data are saved in an Excel table by pressing the "Save data" button in the program. Data stored in table can be further processed, for example, in statistical software. Some analyzes such as histogram, ANOVA and others, can also be run in the designed application using a button "*Analysis*". The obtained histograms from the test image are shown in the Figure 7.



a) b) c) d)

Figure 7: Histograms: a) Areas, b) Perimeters, c) Major Length, d) Minor Length

CONCLUSION

As described in this article, detailed information of the dimensional characteristics of sawdust can be obtained using image analysis in Matlab. Compared to other methods, such as sieving, this method is non-destructive. However, the disadvantage is the need to separate the scanned sawdust from each other, otherwise they may overlap together. Such overlapped sawdust is subsequently evaluated as a one separate sawdust, what introduces error into the measurement. In addition to the obtained information in tabular form, matlab itself enables to statistical evaluation of the measured samples, for example using histograms. Also, it provides the basic knowledge on image analysis that can be implemented to maximize the executed information from the analysis and minimize the magnitude or error (Jahari, 2021).

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REFERENCES

JAHARI A. F. et al. 2021. Quantification method of suspended solids in micromodel using image analysis. In: Journal of Petroleum Exploration and Production Technology. 11(5). DOI: 10.1007/s13202-021-01153-x.

KOLEDA, P.. BARCIK, S., KORCOK, M., JAMBEROVA, Z., CHAYEUSKI, V. 2021. Effect of Technological Parameters on Energetic Efficiency WhenPlanar Milling Heat-treated Oak Wood. Bioresources 2021, 16, 515–528. DOI: 10.15376/biores.16.1.515–528.

KORČOK, M., KOLEDA, P., BARCÍK, Š., VANČO, M. 2018. Effects of Technical and Technological Parameters on the Surface Quality when Milling Thermally Modified European Oak Wood. InBioResources, 13(4): 8569–8577.

KOS, A., BELJO-LUČIĆ, R., ŠEGA, K., RAPP, A. O. 2004. Influence of woodworking machine cuttingparameters on the surrounding air dustiness. In Holz als Roh-und Werkstoff 62(3): 169–176. DOI:10.1007/s00107-004-0473-2.

KUČERKA, M., OČKAJOVÁ, A., KMINIAK, R., PĘDZIK, M., ROGOZINSKI, T. 2022. The Effect of the Granulometric Composition of Beech Chips from a CNC Machining Center on the Environmental Separation Technique. In: Acta Facultatis Xylologiae. Zvolen, 2022. vol. 64(1), p. 87–97. DOI: 10.17423/afx.2022.64.1.08.

LIAO, K. C., LU, J. H. 2020. Using Matlab real-time image analysis for solar panel fault detection with UAV. In: Journal of Physics: Conference Serie. DOI: 10.1088/1742-6596/1509/1/012010.

INTERNATIONAL AGENCY FOR RESEARCH ON CANCER. 1995. Monographs on the Evaluation of Carcinogenic Risks to Humans: Volume 62 Wood Dust and Formaldehyde. Lyon, France. 1995. ISBN 92 832 1262 2.

OTSU, N., 1979. A Threshold Selection Method from Gray-Level Histograms. In: IEEE Transactions on Systems, Man, and Cybernetics. Vol. 9, No. 1, 1979, pp. 62–66.

REZAEI, H., LIM, C. J., LAU, A., SOKHANSANJ, S. 2016. Size, Shape and Flow Characterization of Ground Wood Chip and Ground Wood Pellet Particles. In: Powder Technology. Vol. 301. P. 737–746. DOI: 10.1016/j.powtec.2016.07.016.

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