TRIESKOVÉ A BEZTRIESKOVÉ OBRÁBANIE DREVA, 8(1): 185–190, 2012
Zvolen, Technická univerzita vo Zvolene, ISBN 978-80-228-2385-2

ANALYSIS OF THE INFLUENCE OF THE METHOD OF SIGNAL FILTRATION ON THE SURFACE ROUGHNESS ON NATURAL THERMOMODIFIED ROBINIA WOOD GROUND BY AN ABRASIVE BELT

Maciej Kowalski[1] – Paweł Karolczak[1] – Grzegorz Wieloch[2] – Zdeněk Kopecký[3]

Abstract
In the contribution the possibilities of using the wavelet-based analysis are presented as an additional instrument destined to filtering signals received after roughness measurement. The results of experimental examination are discussed concerning the description of characteristic features of roughness profiles that appear on the surface of natural robinia wood, not thermomodified as well as being subject to thermo-modification.

Key words: *wood, geometrical structure, filtration, thermomodification*

1. INTRODUCTION

In modern production techniques the most important goal consists in obtaining a good, reproducible quality of the products. One of the connected therewith main problems is the quality of the upper layers of the treated/machined piece. This problem includes the whole scope of methods of producing surfaces that fulfill determined exploitation requirements.

Measurements and examination of the upper layer can be destined to achieve different goals, among which the most important are: verifying the conformity of the technological effect with the construction assumptions based on exploitation experiences, getting acquainted with the geometrical structure of the surface and with the conditions of contact of two surfaces, determining the relation between the method of production resulting in shaping the upper surface, and the possibility of performing the being designed exploitation function by these surfaces.

As a result of measurements of the geometrical structure of the upper layer it is possible to get information concerning errors of shape, waviness and roughness appearing on the real surface. When changing the kind and method of signal filtration it is also possible to adapt their character to the needs of the being performed analyses. A correct way of performing the filtration as well as selecting appropriate filters is very essential for obtaining reliable information concerning the being estimated surface.

In the contribution a trial has been undertaken of carrying out the analysis of the influence of thermomodification on the state of the upper layer of natural robinia wood being ground by an abrasive belts, and a trial of applying the wavelet-based analysis to

[1] Wrocław University of Technology, ul. Łukasiewicza 5, 50-371 Wrocław, Poland
[2] Poznań University of Life Sciences, ul. Wojska Polskiego 28, 60-637 Poznań, Poland
[3] Mendel University in Brno, Zemědělská 3, 613 00 Brno, Czech Republic

filtering data obtained as the result of the performed measurements of the geometrical structure of surfaces.

2. THERMOMODIFICATION OF WOOD

Wood, like other construction material, is characterized by advantages, but also by imperfections and defects, among which the following can be enumerated: low stability of dimensions and shape, water affinity, low resistance to the destructive influence of biotic factors, insufficient durability, flammability, low hardness and abrasion resistance, anisotropy of properties etc. In order to improve wood to a possibly highest degree different kinds of modification are carried on, with the goal of correcting its characteristics.

The course of the technological process of modification of wood depends upon conditions being maintained in the modification chambers when performing this operation. Here the following conditions can be considered: temperature of the process, use of oxygen or nitrogen, evaporation, dry or wet process, use of oil etc.

The most advanced research concerning the technology of wood thermomodification is carried out in Finland, where a mass-scale, industrial process of thermomodification has been developed, named „*ThermoWood*". A visible effect of application of such thermal treatment is the change of the coloration of wood – wood obtains a characteristic, dark brown tint (Fig. 1) [4,5].

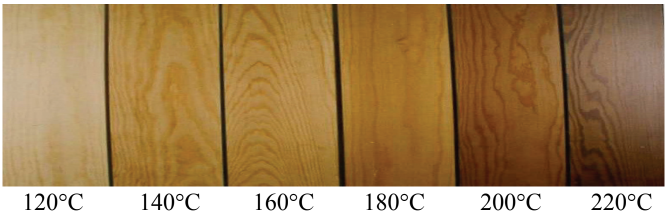

Fig. 1. Change of coloration of pine wood during thermo-modification in different temperatures [5]

Much more essential than changes of coloration and look of wood are changes of properties of wood; and here can be taken into consideration: the improvement of hardness, the improvement of resistance to the influence of moisture, fungus, the measuring stability of the wood, the reduction of shrinkage and swelling, the improvement of thermal isolation, the lack of resin, the relaxation of internal stresses, etc. On the other hand, a disadvantageous effect connected with wood thermomodification is the increase of its cleavage and the decrease of its bending strength – wood becomes more fragile (short) [4].

3. METHODOLOGY OF EXPERIMENTAL RESEARCH

The examination of the geometrical structure of the surface has been performed on cuboids of natural robinia, size 40x40x50 mm. Some samples were subject to thermomodification according to process parameters included in Table 1 (technology Finforest – sawmill „Stefan" Włoszakowice).

Grinding was executed by abrasive belts *RedWood* (Bosch) 75 mm x 533 mm, grain size: 40, 60, 100, 120 on a stand developed at the Technical University of Zvolen (Slovakia) – Fig. 2. The humidity of the samples was 12% (±1).

The measurement of roughness was performed on a profilographometer FormTalysurf 120L of Taylor Hobson Limited. In Fig. 3 the scheme of the measuring stand is presented.

The measurements of roughness 2D were executed on a measuring length of 15 mm, with a sampling step of 0.25 μm. The so measured profiles were filtered in order to separate roughness from waviness and shape errors, by means of a Gauss filter with „cut-off" size of 0.8 mm.

Table 1. Parameters of the process of thermomodification of robinia wood

Course of the process of thermal treatment of the wood (36÷42 h)		
Phase I	Phase II	Phase III
1. heating to the temp. of 100°C, time: 6 hours 2. drying to the level of wood humidity 3÷4%, time: 10 hours	1. heating to the temperature of 180÷190°C, time: 10 hours (in presence of superheated steam)	1. stabilizing and decreasing the temperature – moistening the wood, time: 6÷10 hours 2. cooling the wood time: 4÷6 hours

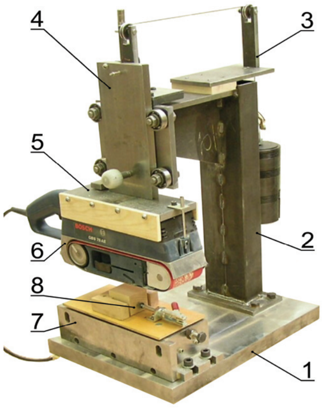

Fig. 2. Sample grinding stand:

1 –base; 2 – bracket; 3 – loading system; 4 –guide of grinder; 5 – grinder fixture; 6 – belt grinder Bosch GBS 75 AE 7 – system of force measuring, integrated with the sample fixture; 8 – sample (TU Zvolen)

Fig.3. Profilographmeter FormTalysurf 120L

4. ANALYSIS OF RESEARCH RESULTS

Values of selected parameters of roughness 2D, obtained after a measurement across the fibres of thermomodified and not thermomodified samples, in three chosen at random places of the examined surfaces, are presented in Table 2. Data included in the tables are mean values of three mesurements performed in each of the measuring points.

Table 2. Selected roughness 2D parameters of samples of natural robinia

	Thermomodified sample				Not thermomodified sample			
Abrasive grain	40	60	100	120	40	60	100	120
Ra	16.51	8.85	5.69	4.43	15.72	11.39	5.56	5.44
Rq	20.85	11.39	7.26	5.89	19.72	14.09	7.32	7.09
Rp	38.21	21.17	15.53	10.79	36.41	25.91	14.24	13.49
Rv	43.99	28.27	19.22	17.07	43.39	31.35	19.87	20.43
Rz	82.21	49.43	33.75	27.87	79.81	57.26	34.11	33.92
RSm	346.91	215.54	169.77	129.52	322.38	289.36	160.01	157.12
Rmr	51.84	54.71	53.35	54.16	51.56	52.95	54.68	52.95

The carried out measurements proved that thermomodification of robinia wood neither has any influence on the course of profiles nor on the values of roughness parameters. The stated differences fall within the limits of measuring error resulting from the being applied contact method of data collection.

In order to obtain additional information concerning the components of the examined roughness profiles and to present essential characteristic features that cause the examined signals to be different, the decision was taken to perform an analysis of the obtained data by a new mathematical instrument, i.e. the wavelet analysis, besides filtering the raw signal by means of a Gauss filter as recommended by standards.

Based upon this recommendation, if the being analyzed signal is characterized by a high sampling frequency, it is possible and necessary to use both these accessible methods of signal decomposition: the discrete (DTF) and/or the continuous (CTF) one. The wavelet destined to analyze the signal has to be selected in such a way as to assure finding a strong correlation of the signal with the possibly lowest number of base wavelets [1,2,3].

In the case of examinated surfaces of ground wood of natural robinia the decision was taken to apply, in the wavelet based analysis of roughness, the following wavelets: Daubechies (DTF analysis) and "mexican hat" (CTF analysis) as the most popular ones and being of wide distribution. For performing the wavelet-based analysis of the obtained roughness profiles the software of The MathWorks, named Matlab, with the packet Wavelet Toolbox, was used. In order to assure an efficient course of computer calculations the decision was taken to reduce the examined measuring segment of roughness to 5 mm. It resulted in 20000 measuring points. In Fig. 4 exemplary CTF transforms are presented, calculated for thermomodified and not thermomodified samples, ground by an abrasive belt with grain size 40.

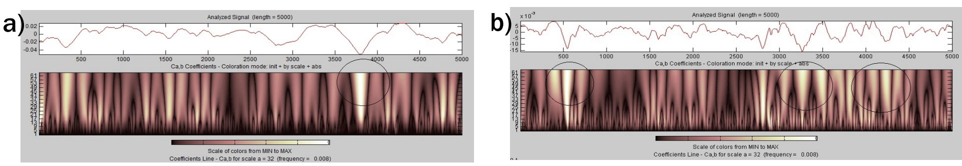

Fig.4. Calculated with the use of the wavelet „mexican hat" CTF transform: a) modified wood, grain size 40, b) not modified wood, grain size 40.

Diagrams of the discrete (CTF) transform provide for detailed information concerning the distribution of extremes (bright maximum and minimum points on the being analyzed course – indicated by a circle in both cases). However, on these diagrams it is possible to observe that, for a considerable part of the course, the information about the points between the extremes is illegible.

Applying the discrete transform (DTF), calculated by means of the wavelets „db3" presented in Fig. 5, makes it possible to obtain a more detailed information upon what happened in the signal between the extreme values. The result of approximation of the signal *„a3"* assures a clear view what concerns the way of the course of the original signal.

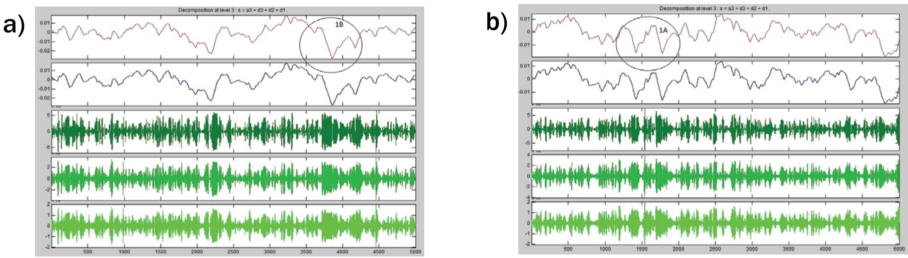

Fig. 5. DTF transforms calculated with the use of the Daubechies wavelet: a) modified wood, grain size 40, b) not modified wood, grain size 40

During the following stage of research, a multidistribution analysis was performed of the examined samples. The values of numerical transforms for the being examined kind of wavelet and samples of raw signal were calculated. A comparison was made for determining whether analyses performed by means of the selected kind of wavelet correlate with the ones that were obtained during measurements. After having calculated the roughness, with the use of values of reconstructed details, the percentage difference between measurements executed of real surfaces and calculations performed during the multidistribution analysis was calculated. Results of exemplary calculations are presented in Table 3.

Table 3. Roughness parameters 2D obtained as a result of measurement of a ground surface of a sample of thermomodified and not thermomodified robinia, and calculated with the use of multidistribution analysis by means of wavelet „db3" (grain size 40)

	Thermomodified sample			Not thermomodified sample		
Roughness parameter	Measurement of 2D roughness	„b3" wavelet	Difference [%]	Measurement of 2D roughness	„db3" wavelet	Difference [%]
Ra	16.51	17.2	4.02	15.72	14.85	5.85
Rq	20.85	19.65	6.1	19.72	18.85	4.61
Rp	38.21	36.86	3.66	36.41	37.95	4.05
Rv	43.99	41.06	7.13	43.39	45.21	4.03
Rz	82.21	85.43	3.77	79.81	74.36	7.32
RSm	346.91	406.36	14.62	322.38	288.68	11.67
Rmr	51.84	59.28	12.55	51.56	60.93	15.37

When analyzing the results collected in Table 3 it is possible to observe that percentage differences for the examined height-oriented parameters of roughness fluctuate, for a thermomodified sample, between 3.66% for parameter *Rp*, and the highest value 7.13% for parameter *Rv*. For the not modfied sample the differences were included between the lowest value 4.03% for parameter *Rv* and the highest value 7.32% for parameter *Rz*. The largest differences between parameters of roughness measured by means of the profilographmeter and calculated with the use of wavelet „db3" were found, in the case of both samples, for the following parameters: the length-oriented parameter *RSm* and the parameter being read from the Abbott curve – *Rmr*.

On the basis of the presented research the conclusion was drawn that Daubechies and „mexican hat" wavelets can be, in the case of analysis of surface roughness, used successfully as an aditional tool for processing the original roughness profile.

5. SUMMARY

In the paper, the wavelet-based analysis is discussed as to be an alternative way of analyzing raw signals obtained after the measurement of the geometric structure of surfaces. Results of calculations of roughness parameters presented in that work show that the wavelet-based analysis is characterized by a high efficiency of filtering the measuring data being encumbered with interference. Filtering measuring data with the use of the wavelet-based analysis seems to be more objective with reference to classical methods of signal filtration that require a subjective assumption of input data upon which depends the final effect of filtering. During the realization of the work it was possible to state that the wavelet-based analysis is characterized by an important efficiency of de-filtration of interference and by getting out the essential characteristic features from the being examined signal.

6. LITERATURE

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