WARSAW UNIVERSITY OF LIFE SCIENCES

OB-RPPD CZARNA WODA

7th International Conference on Wood Composites Modification and Machining

Conference proceedings

September 03-05., 2025

Kiry, Poland

WARSAW UNIVERSITY OF LIFE SCIENCES

OB-RPPD CZARNA WODA

7th International Conference on Wood Composites Modification and Machining

September 03-05., 2025
Kiry, Poland

Conference proceedings

7th International Conference
on Wood Composites Modification and Machining

The aim of the Conference is to meet at a forum of scientific, research, pedagogical and technological specialists, where the current problems of wood and wood composites modification and processing can be presented and discussed.

Members of Scientific Committee

Prof. Ladislav DZURENDA – Technical University in Zvolen, Slovakia
Prof. Dorota DZIURKA - Poznań University of Life Sciences, Poland
Prof. Jarosław GÓRSKI - Warsaw University of Life Sciences, Poland
Prof. Kazimierz ORŁOWSKI - Gdansk University of Technology, Poland
Prof. Alena OČKAJOVÁ – Technical University in Zvolen, Slovakia
Prof. Tomasz ROGOZIŃSKI - Poznań University of Life Sciences, Poland
Prof. Jan SEDLIAČIK - Technical University in Zvolen, Slovakia
Prof. Janusz ZAWADZKI - Warsaw University of Life Sciences, Poland
Doc. Ing. Zdeněk KOPECKÝ, CSc. - Mendel University in Brno, Czech Republic
PhD, DSc Cezary GOZDECKI - Kazimierz Wielki University, Poland
PhD, DSc Paweł KOZAKIEWICZ - Warsaw University of Life Sciences, Poland
PhD, DSc Sławomir KRZOSEK - Warsaw University of Life Sciences, Poland
PhD Marek BARLAK - National Centre for Nuclear Research Świerk, Poland
PhD, DSc Izabela BURAWSKA - Warsaw University of Life Sciences, Poland

Organizing Committee

PhD, DSc Piotr BORYSIUK – president
PhD Jacek WILKOWSKI – v-ce president
MSc, Leszek DANECKI - v-ce president
PhD Mariusz CYRANKOWSKI - secretary
PhD, Radosław AURIGA – secretary
PhD, Karol SZYMANOWSKI – secretary
MSc, Jarosław POMARAŃSKI – secretary

Contact
Institute of Wood Sciences and Furniture
Nowoursynowska Str. 159
02-776 Warsaw, Poland
phone: +48 22 59 38 565
+48 22 59 38 547
e-mail: conference_kiry@sggw.edu.pl

Contents

Intelligent efficiency control of automated technological to produce wooden doors

Tomasz Rogoziński[a,*], ORCID: 0000-0003-4957-1042
Zdzisław Kwidziński[a,b], ORCID: 0000-0002-8522-9650
Marta Pędzik[c], ORCID: 0000-0003-3607-8128

[a] Department of Furniture Design, Faculty of Wood Technology, Poznań University of Life Sciences, ul. Wojska Polskiego 38/42, 60-627 Poznań, Poland
[b] Porta KMI Poland, ul. Szkolna 54, 84-239 Bolszewo, Poland
[c] Łukasiewicz Research Network – Poznań Institute of Technology, ul. Ewarysta Estkowskiego 6, 61-755 Poznań, Poland
*Corresponding author: tomasz.rogozinski@up.poznan.pl

Introduction

Implementing a new, intelligent technology for formatting and milling custom-made, wood-based door frames, PORTA KMI Poland with an industrial plant located in Elk, conducted extended line performance tests in the period 2024-2025 to determine the production efficiency during the production of a wide portfolio of products in one production plan. The aim was to check whether the planned constant efficiency is achieved with a variable series of technical door frames.

Materials and Methods

The paper describes how the processing time changes for door frames with different beam and frame angle designs and dedicated fittings.
On this basis, the average time was calculated for several variants of different sets of door frames produced on the same production line at the same time. The constant minimum efficiency for each of these variants was also calculated.

Results

With the aim of extending the product life cycle in mind, the construction of wooden door frames has also been expanded to include a version based on WPC composite.
The processing time was shown to vary depending on the door frame design.

Conclusions

The implementation of intelligent technology allows monitoring and maintaining production efficiency across a diversified product portfolio. The planned constant performance is achieved with a variable range of technical door frames.

Specific cutting work of reclaimed wood beam during drilling

Barbara Prałat[a,*], ORCID: 0009-0006-2160-4809
Zbigniew Potok[a], ORCID: 0000-0001-9356-0426
Dorota Michalak[a],
Sergei Trofimov[b], ORCID: 0009-0007-2534-1302
Tatiana Nikitina[c], ORCID: 0000-0002-8983-4612
Krzysztof Wiaderek[a], ORCID: 0000-0001-9356-0426
Tomasz Rogoziński[a], ORCID: 0000-0003-4957-1042

[a]Department of Furniture Design, Faculty of Wood Technology, Poznań University of Life Sciences, ul. Wojska Polskiego 38/42, 60-627 Poznań, Poland
[b]Department of Technology and Design of Wooden Articles, Faculty of Forest Engineering, Materials Science and Design, Belarusian State Technological University, Minsk, Sverdlova 13A, 220006 Minsk, Belarus
[c]Department of Engineering Constructions, Architecture and Graphics, Higher School of Engineering, Northern Arctic Federal University, Severnaya Dvina Emb. 17, Arkhangelsk 163002, Russia
*Corresponding author: barbara.pralat@up.poznan.pl

Introduction

The growing demand for sustainable resources in the furniture industry has increased interest in reusing wood from dismantled buildings. Reclaimed timber extends the life cycle of wood, reduces pressure on forests, and supports circular economy goals. This study tested an 80-year-old pine beam recovered from a rural cottage. Previous research has shown that pine beams of comparable age often retain sufficient mechanical properties, suggesting potential for reuse.

Materials and Methods

The methodology followed by Pakuła et al. (2024) assessed energy consumption during the drilling of furniture joints using a CNC drilling and milling machine. In this study, drilling tests were carried out on samples of reclaimed pine. Energy demand was recorded, and specific cutting work (SCW) was calculated according to the formula: $SCW = Ep / V$, where Ep is the energy per joint [J] and V is the drilled hole volume [mm³].

Results

The reclaimed pine demonstrated stable machining efficiency. For dowel joints, V = 1658.77 [mm³], Ep = 1.0555 [Wh], SCW was 2.29 [J/mm³]. For confirmat screws, V = 1742.59 [mm³], Ep = 1.571 [Wh], SCW reached 3.25 [J/mm³]. Local variations in density and hardness were noted, which aligns with previous findings that environmental exposure influences the behaviour of aged timber.

Conclusions

The results indicate that reclaimed pine beams can be processed with moderate energy demand and machining stability. Together with evidence of mechanical strength from earlier studies, this supports their reuse as a valuable raw material. Reclaimed beams provide both environmental and technical benefits, offering a practical solution for eco-design and sustainable furniture production while reducing reliance on virgin resources.

Influence of UV radiation on color changes of beech wood with false heartwood after steaming

Ladislav Dzurenda*, ORCID: 0000-0002-1794-8709
Michal Dudiak, ORCID: 0000-0002-0281-6447

Faculty of Wood Sciences and Technology, Technical University in Zvolen, 960 01 Zvolen, Slovakia, *Corresponding author: dzurenda@tuzvo.sk; xdudiak@tuzvo.sk

Abstract

Fagus sylvatica L. wood with false heartwood was steamed with saturated water steam at t = 120 °C in order to unify the color difference and acquire a rich brown-red color. Subsequently, samples of unsteamed and steamed beech wood with false heartwood after drying were irradiated with a UV lamp in the Xenotest Q-SUN Xe-3-H in order to test the color stability of steamed beech wood with false heartwood. The color change of the wood surface was evaluated using measured values in the CIE L*a*b* color space coordinates. The results show that the surface of unsteamed beech wood darkened and browned to a brown-yellow color due to UV radiation. The deep brown-red color of the surface of beech wood steamed with saturated water steam at a temperature of t = 120 °C lightened to a brown-yellow color. From the analysis of changes in the CIE L*a*b* color space coordinates, it follows that the greater the darkening and browning of beech wood by steaming, the smaller the changes in the ΔL*, Δa* Δb* values of steamed beech wood caused by UV radiation.

Acknowledgement

This experimental research was prepared within the framework of the grant project: APVV 21-0051 "Elimination of color differences between beech sapwood and false heartwood by steaming", project VEGA 1/0256/23 and APVV 17-0456, as a result of the work of the authors and significant assistance from the APVV agency and the VEGA grant agency.

Contact drying of birch wood using different drying pressures

Ivan Klement, ORCID: 0000-0003-3349-0125
Tatiana Vilkovská *, ORCID: 0000-0001-7406-2325
Peter Vilkovský, ORCID: 0000-0002-2832-4619

Faculty of Wood Sciences and Technology, Technical University in Zvolen, 960 01 Zvolen, Slovakia,
*Corresponding author: tatiana.vilkovska@tuzvo.sk

Introduction

Research on the drying conditions of birch wood reveals that different drying methods can have a significant impact on its properties and overall quality. Birch, a wood species valued for its unique characteristics, including strength, flexibility, and aesthetic appeal, is highly suitable for a wide range of applications in industry. However, the drying process plays a critical role in determining the final quality, dimensional stability, and usability of the wood. As such, understanding the drying behaviour of birch wood is necessary for optimizing drying techniques, preserving its desirable properties, and ensuring its suitability for various products. One particularly interesting drying method is contact drying, which offers reduced drying times and lower heat consumption compared to traditional drying techniques. In this study, experimental samples were prepared from birch logs. The moisture content, moisture gradient, residual stresses, and density were measured, and drying was conducted under various pressures of 1.0 MPa, 1.4 MPa, and 1.8 MPa, with a drying temperature of 170°C. The results indicated that higher pressures led to an increased final moisture content, and substantial dimensional changes were observed during the drying process. Remarkably, the density of the wood increased by 13.03% to 19.55%, depending on the applied pressure. The study concluded that the optimal pressure for contact drying of birch wood is between 1.4 MPa and 1.8 MPa.

Acknowledgements

This work was supported by the Slovak Research and Development Agency under the Contract no. APVV-21-0049 and work was supported by the Scientific Grant Agency of the Ministry of Education, Science, Research and Sport of the Slovak Republic and the Slovak Academy of Sciences – project VEGA No. 1/0063/22.

Analysis of shape changes during different stages of air drying at the hornbeam (*Carpinus Betulus* L.)

Hugo M. Uličný,
Peter Vilkovský, ORCID: 0000-0002-2832-4619
Ivan Klement, ORCID: 0000-0003-3349-0125

Faculty of Wood Sciences and Technology, Technical University in Zvolen, 960 01 Zvolen, Slovakia,
*Corresponding author: xvilkovsky@tuzvo.sk

Introduction

This study focuses on the analysis of shape changes at the hornbeam lumber (*Carpinus betulus* L.) during different phases of air drying. The main objective was to identify and quantify warp bow, warp crook, warp cup, and warp twist at various drying stages. The research was conducted on hornbeam lumber samples that were subjected to air drying. Measurements were carried out at regular intervals throughout the drying process, with the influence of moisture on the development of different types of warp being observed. The results showed that warps increased exponentially at the beginning of air drying, with twist-warp being most pronounced in radial-type lumber. Significant changes were observed when the relative humidity of the air was reduced from 80.2% to 40.3%, and the temperature was lowered from 11.1°C to 3.3°C. The greatest shape change increase was recorded in November. The warp of some samples was found to have increased up to 25 mm. The observed variability in warp was closely linked to the original position of the samples within the log and the spiral grain structure. This study provides essential insights for optimizing the drying process of hornbeam lumber to minimize shape changes.

Keywords: Hornbeam, Warps, Air Drying, Lumber, Twist

Acknowledgements

This work was supported by the Slovak Research and Development Agency under the Contract no. APVV-21-0049 and work was supported by the Scientific Grant Agency of the Ministry of Education, Science, Research and Sport of the Slovak Republic and the Slovak Academy of Sciences – project VEGA No. 1/0063/22.

Modeling of technological parameters of CNC milling of solid wood based on the targeted quality of the surface roughness

Lukáš Adamčík, ORCID: 0009-0009-4774-2814
Richard Kminiak, ORCID: 0000-0001-6866-3386
Adrián Banski, ORCID: 0000-0003-0655-7996

Faculty of Wood Sciences and Technology, Technical University in Zvolen, 960 01 Zvolen, Slovakia,

Abstract

The aim of this paper is to create a comprehensive model for the selection of technological parameters of CNC milling based on the surface irregularities. The regression model assesses the effects of the two most important technological parameters, namely feed rate and rotational speed, on selected surface roughness. The model for CNC milling of spruce, oak and beech wood with a spiral shank cutter is created from data measured on the Keyence VHX-7000 digital microscope. The paper deals with surface irregularities comprehensively, while the measurements are supported by microscopic analysis. The experiment proved that the spiral shank cutter primarily created surface roughness. For this reason, the polynomial regression models created describe changes in the parameters R_a and R_k at changing rotational speed and feed speed. The models describe the change of both roughness parameters with a high value of the coefficients of determination, and it is possible to determine the most optimal combinations of milling parameters for the individual investigated types of wood, i.e. combinations with the lowest surface roughness.

Acknowledgement

This experimental research was prepared within the framework of the grant project: APVV 21-0051 "Elimination of color differences between beech sapwood and false heartwood by steaming", as a result of the work of the authors and significant assistance from the APVV agency.

Treatment of UF adhesives with modified collagen for scavenging of formaldehyde emission from wood-based panels

Ján Matyašovský[a,*], [*] ORCID: 0000-0003-3246-1840
Peter Jurkoviča ORCID: 0009-0006-6610-6467
Igor Novák[b], ORCID: 0000-0002-0568-7847
Ján Sedliačik[c] , ORCID: 0000-0003-0014-594X

[a] VIPO, a.s., Gen. Svobodu 1069/4, Partizánske, 958 01 Slovakia
[b] Polymer Institute, Slovak Academy of Sciences, Dúbravská cesta 9, 845 41 Bratislava, Slovakia
[c] Technical University in Zvolen, T.G. Masaryka 24, 960 01 Zvolen, Slovakia
*Corresponding author: jmatyasovsky@vipo.sk

Introduction

At present, polycondensation urea-formaldehyde (UF) resins are the most widely used wood gluing adhesives, but their main disadvantage is their low resistance to water and moisture, which causes the subsequent release of formaldehyde emissions from finished products. The aim of the study was to reduce the release of formaldehyde emissions from wood materials by developing and testing new, more effective modifiers that bind formaldehyde during polycondensation. For this study, research was focused on the biopolymer collagen after its modifications with alkaline silicate and sulphur additive at 125 °C for 2 hrs.

Materials and Methods

The samples were characterised by X-ray photoelectron spectroscopy (XPS) and FTIR-ATR spectroscopy. Perkin-Elmer DSC7 DSC calorimeter with a high-pressure measuring head was used to study the thermo-oxidative stability. Formaldehyde emission from 5-layer beech (Fagus sylvatica L.) plywood was evaluated by the desiccator method according to EN ISO 12460-4 and bonding quality according to EN 314-1 and EN 314-2.

Results

The XPS spectrum of the modified collagen depends on the modification method, with the total amount of sulphur increasing to 6.1% after modification, which was subsequently reflected in the increase in the antioxidant stability of the collagen sample, studied by differential scanning calorimetry (DSC). In the FTIR spectrum, absorption bands typical of functional groups of protein-type materials are observed. In the region of 1010.5 cm-1, there is a band that can be assigned to the Si-O group. The bands in the region of 776.5 cm-1, 669.0 cm-1 and 652.9 cm-1 are characteristic of (C-S) alkyl sulphide and (C-S) di-alkyl sulphide stretch vibrations. The most significant decrease in formaldehyde emission compared to the reference by up to 38% determined after 7 days was achieved with a 1% application of a sample of modified Collagen to the UF adhesive mixture.

Conclusions

Technical applications have focused on reducing the release of formaldehyde from glued wood-based panels. Measured values of extinctions of tested samples confirmed the decrease of formaldehyde emissions for each concentration of modified collagen in comparison with the reference sample. Tested plywood fulfils the requirements of the standard for gluing class 1.

Acknowledgement

This work was supported by the Slovak Research and Development Agency under contracts No. APVV-18-0378, APVV-21-0051, APVV-22-0238, APVV-23-0224 and VEGA 1/0077/24.

European hardwoods treated by atmospheric discharge plasma

Igor Novák[a] ORCID: 0000-0002-0568-7847
Peter Jurkovič[b*] ORCID: 0009-0006-6610-6467
Ján Matyašovský[b] ORCID: 0000-0003-3246-1840
Peter Duchovič[b]
Angela Kleinová[a] ORCID: 0000-0002-0537-3397
Matej Mičušík[a] ORCID: 0000-0003-2751-5381
Ján Sedliačik[c] ORCID: 0000-0003-0014-594X

[a] Polymer Institute, Slovak Academy of Sciences, Dúbravská cesta 9, 845 41 Bratislava, Slovakia
[b] VIPO, a.s., Gen. Svobodu 1069/4, Partizánske, 958 01 Slovakia
[c] Technical University in Zvolen, T.G. Masaryka 24, 960 01 Zvolen, Slovakia
*Corresponding author: pjurkovic@vipo.sk

Abstract

The surface of various European hardwood species (beech (Fagus sylvatica L.), maple (Acer pseudoplatanus L.) and birch (Betula pendula L.)) was treated by atmospheric discharge plasma (ADP). The aim of low-temperature discharge plasma modification of wood surface was to improve the hydrophilicity and the adhesive properties of wood. The ADP modification in air was suggested as an appropriate, efficient and ecologically friendly method for the increasing of the polarity of wood surface. The increase of polar component of surface energy of plasma-treated wood was observed. The contact angles on the investigated wood surfaces diminished with prolonged time of ADP modification from 74° to 30°. The water contact angle of plasma-treated wood surfaces in the course of ageing increased after two days from 37° to 67°. The results of FTIR investigation confirmed the increase of the wood hydrophilicity and/or polarity in all cases caused by the increase of –OH group concentration due to irradiation by ADP plasma. The concentration of COOH, C–O and C=O groups after plasma treatment significantly increased. The plasma-treated wood surfaces are interactive for application of adhesives or paints and varnishes up to 2 days of ageing.

Acknowledgement

This work was supported by the Slovak Research and Development Agency under contracts No. APVV-17-0456, APVV-20-0159, APVV-21-0051, APVV-23-0224 and VEGA 1/0450/25.

Properties of Particleboards with Partial Replacement of MUF Resin by Lignosulfonates

Iryna Lytvyna
Nataliya Bekhta[a], ORCID: 0000-0003-4336-2901
Iryna Kusniak[a], ORCID: 0000-0003-3980-3110
Pavlo Bekhtaa,[b]*, ORCID: 0000-0002-4320-5247
Ján Sedliačik[b], ORCID: 0000-0003-0014-594X

[a]Ukrainian National Forestry University, Gen. Chuprynky 103, 790 57 Lviv, Ukraine
[b]Technical University in Zvolen, T.G. Masaryka 24, 960 01 Zvolen, Slovakia
* Corresponding author: bekhta@nltu.edu.ua

Introduction

Although resin makes up only 2% to 14% of particleboard's dry weight, it accounts for 30% to 50% of material costs due to its high unit price, making its optimization crucial for enhancing production efficiency and profitability. This study investigates the feasibility of partially replacing melamine-urea-formaldehyde (MUF) resin with lignosulfonates (LS)—specifically sodium lignosulfonate (NaLS) and magnesium lignosulfonate (MgLS)—to reduce costs while maintaining board performance.

Materials and Methods

The adhesive system consisted of MUF resin, paraffin emulsion, urea, ammonium sulphate, NaLS, and MgLS. Particleboards were produced with MUF resin partially substituted by 10%, 20%, and 30% NaLS or MgLS by weight, alongside control boards using 100% MUF for comparison.

Results

The study found that both the type and amount of LS significantly affect board properties, with NaLS generally outperforming MgLS, and that substituting MUF resin with up to 30% LS—especially 10–20%—can yield boards meeting EN 312 standards for indoor use, though higher substitution levels decline in internal bond strength and reduced hydrophobicity.

Conclusions

Partial replacement of MUF resin with LS—especially NaLS—presents a viable strategy for reducing production costs without compromising the essential performance of boards.

Acknowledgement

The EU NextGenerationEU supported this work through the Recovery and Resilience Plan for Slovakia under project No. 09I03-03-V01-00124 and by the Slovak Research and Development Agency under the contracts No. APVV-18-0378 and APVV-22-0238.

Effects of sugar beet pulp on the properties of particleboards

Pavlo Bekhta[a,b,c*], ORCID: 0000-0002-4320-5247,
Volodymyr Hamanchuk[a]
Tomáš Pipíška[b], ORCID: 0000-0001-8096-4376
Jozef Ráheľ[b], ORCID: 0000-0002-2850-8039
Iryna Kusniak[a], ORCID: 0000-0003-3980-3110
Ján Sedliačik[c], ORCID: 0000-0003-0014-594X

[a]Ukrainian National Forestry University, Gen. Chuprynky 103, 790 57 Lviv, Ukraine
[b]Mendel University in Brno, Zemědělská 3, 613 00 Brno, Czech Republic
[c]Technical University in Zvolen, T.G. Masaryka 24, 960 01 Zvolen, Slovakia
* Corresponding author: bekhta@nltu.edu.ua

Introduction

Agricultural waste constitutes a significant yet underexploited source of biomass. Various technologies for converting agrarian residues into composite materials are currently the focus of active research and development worldwide. This study presents a comprehensive investigation into the utilization of waste sugar beet pulp (SBP) as a raw material in the production of particleboard.

Materials and Methods

Particleboards were manufactured using SBP, industrial spruce wood particles, and pMDI resin as the binder. The pressing process was conducted under the following conditions: a pressure of 3.5 MPa, a temperature of 180 °C, and a pressing cycle comprising 30 seconds of platen closing, 240 seconds at maximum pressure, followed by 80 seconds of venting with a continuous reduction in pressure.

Results

The SBP-containing boards showed good bonding performance, which was attributed to the formation of strong chemical bonds between the SBP particles and the pMDI adhesive. Prepared panels are formaldehyde-free as environmentally friendly product.

Conclusions

The findings confirm that SBP is a promising choice for developing particleboards with improved characteristics. The incorporation of SBP (at substitution levels of 25% and 50%) not only maintains acceptable material performance but also offers potential environmental benefits by reducing dependence on virgin wood resources and supporting the development of a more sustainable and circular materials economy.

Acknowledgement

This work was supported by the EU through the Recovery and Resilience Plan for Slovakia under project No. 09I03-03-V01-00124. This work was supported by the Slovak Research and Development Agency under the contract No. APVV-22-0238.

Effect of grain direction on particle size distribution during sanding of spruce, beech and oak wood

Kučerka Martin [a,*], ORCID: 0000-0002-3875-0232
Alena Očkajová [a], ORCID: 0000-0001-9347-4501

[a] Poznan1Faculty of Natural Sciences, Matej Bel University, Banská Bystrica 974 01, Slovakia
*Corresponding author: martin.kucerka@umb.sk; alena.ockajova@umb.sk

Introduction

This paper focusses on the impact of the direction orientation of the sanding of selected wood types on the particle size distribution. In the experiment, a hand-held GBS 100 AE belt sander was used, with particles obtained through two sanding models: at angles of 0 ° and 90 ° with respect to the wood structure. The study examined the effects of cutting orientation on the particle size distribution in beech, oak and spruce wood sawdust. Statistical analysis was used to characterise the particle size distribution, and a combination of orientations was compared for each type of wood. Statistical analysis revealed significant differences in the particle size distribution between the two cutting orientations, with p-values of 0.018 and 0.0002 for beech and spruce, respectively. On the contrary, oak did not show minimal statistically significant differences between orientations ($p = 0.912$). The results highlight the crucial role of the wood microstructure in determining the effect of cutting orientation on particle morphology. Specifically, spruce showed the highest sensitivity to orientation changes, while oak remained relatively stable in different cutting directions.

Keywords: Wood sawdust, Particle size distribution, Cutting orientation, Belt sanding, Beech, Oak, Spruce, Sieve analysis

Low-temperature drying mode of beech lumber in chamber hot-air dryers without changing the color of the wood

Ladislav Dzurenda, ORCID: 0000-0002-1794-8709

Faculty of Wood Sciences and Technology, Technical University in Zvolen, 960 01 Zvolen, Slovakia, dzurenda@tuzvo.sk;

Abstract

The paper presents technological conditions for low-temperature drying of beech lumber with a thickness of h = 40 mm in hot-air lumber dryers while maintaining the original color of the wood. The proposed mode is longer compared to the mode specified in the ON 49 0651 standard. The extension of the drying time of beech lumber is caused by the lower temperature of the drying medium during the evaporation of free water. The heat consumption standard of the proposed drying mode of beech lumber has the value QTZN = 303.9 kWh.m^{-3}, which is 9.4% more than the heat consumption during drying according to the standard. The increase in heat consumption for drying 1 m3 of beech lumber is caused by increased heat consumption to cover the heat losses of the kiln due to the extended drying process.

Acknowledgement

This experimental research was prepared within the framework of the grant project: APVV 21-0051 "Elimination of color differences between beech sapwood and false heartwood by steaming", as a result of the work of the authors and significant assistance from the APVV agency.

Kinetics of drying beech wood contain red false heartwood

Patrik Halčin[a,b]
Ivan Klement, ORCID: 0000-0003-3349-0125
Tatiana Vilkovská *, ORCID: 0000-0001-7406-2325
Peter Vilkovský, ORCID: 0000-0002-2832-4619

Faculty of Wood Sciences and Technology, Technical University in Zvolen, 960 01 Zvolen, Slovakia,
*Corresponding author: tatiana.vilkovska@tuzvo.sk

Abstract

The article is focused on the analysis of differences in the drying of beech wood (*Fagus sylvatica* L.) containing red false heartwood. The woodworking in the Slovakia is oriented towards an increased use of beech wood as the main material. The occurrence of beech red false heartwood has a noticeable on the quality of sawn timber. It is necessary to know the false heartwood of beech and its influence during the drying. Differences in drying kinetics in sections of stable and decreasing drying rate, moisture loss, moisture gradients, temperature and stress in the dried wood were analyzed. From the measured values, differences in drying intensity between red false heartwood and mature beech wood were found, which are caused by the changed structure in the red false heartwood and the change in permeability to liquids and vapours.

Keywords: Air Drying, Beech, Drying Kinetics, Red False Heartwood

Acknowledgements

This work was supported by the Slovak Research and Development Agency under the Contract no. APVV-21-0049 and work was supported by the Scientific Grant Agency of the Ministry of Education, Science, Research and Sport of the Slovak Republic and the Slovak Academy of Sciences – project VEGA No. 1/0063/22.

Strength characteristics of furniture elements with particleboard cutting waste core

Krasimira Atanasova, ORCID: 0000-0003-4660-1218
Dimitar Angelski, ORCID: 0000-0001-6266-9306
Dobriyan Dobriyanov,
Tsacho Tsachev

[a] University of Forestry, Sofia, Bulgaria
*Corresponding author: k_atanasova@ltu.bg

Abstract

The circular economy principles for environmentally friendly and waste-free production can be effectively applied to furniture production by utilizing cutting particleboard waste. The aim of the presented study is to establish the influence of the laminating sheet characteristics on the bending strength and modulus of elasticity of three-layer elements with a core formed from laminated particleboard cutting waste. For lamination, medium density fibreboard (MDF) with a thickness of 2.7 and 4 mm, one-sided veneered MDF with a total thickness of 3.2 mm, and three-layer poplar plywood with a thickness of 3 and 4 mm were used. The lamination was carried out with polyvinyl acetate adhesive at a temperature of 50℃ and a specific pressure of 0.075MPa. The obtained dependencies are presented in tabular and graphical form.

Keywords: particleboard cutting waste, furniture elements, lamination, MDF, plywood

Application of polyurethane adhesive in laminating furniture elements with particleboard cutting waste core

Dobriyan Dobriyanov,
Valentin Yonchev

[a] University of Forestry, Sofia, Bulgaria
*Corresponding author: d.dobriyanov@ltu.bg

Abstract

Cutting laminated particleboards waste utilization is an environmentally friendly and cost-effective approach to streamlining furniture production. The aim of the study is to determine the effect of using polyurethane adhesive on the strength characteristics of three-layer elements with a core formed from laminated particleboard cutting waste. Waste parts, arranged according to an established pattern, were laminated on both sides with HPL with a thickness of 0.8 mm. Jowapur 687.22 1-Component PUR Prepolymer was used. Lamination was carried out on a hydraulic press at a temperature of 23℃ and a specific pressure of 0.075MPa for 60 min. The impact of the use of PU adhesive, and the width and orientation of the core details, on the bending strength and elastic modulus of the three-layer elements was determined. The obtained dependencies are presented in tabular and graphical form.

Keywords: waste utilization, laminating furniture elements, particleboard, HPL, polyurethane adhesive

.

Influence of diamond grain size on the basic properties of WC-Co/diamond composites used in tools for wood-based materials machining

Joanna Wachowicz[a,]*, ORCID: *0000-0002-7942-3959*
Jacek Wilkowski[a], ORCID*: 0000-0001-5798-6761*

[a] Department of Mechanical Processing of Wood, Institute of Wood Sciences and Furniture, Warsaw University of Life Sciences, Nowoursynowska Street, 166, 02-787 Warsaw
*Corresponding author: joanna_wachowicz@sggw.edu.pl

Introduction

Sintered WC-Co carbides are a widely used tool material. However, there has recently been an increasing demand for new tool materials that can withstand higher machining parameters. One such material is a WC-Co composite containing dispersed diamond particles. Traditional consolidation methods cannot be used to produce this composite due to the graphitization process of diamond. Therefore, an innovative FAST (Field Assisted Sintering Technique) method was employed. The aim of this study was to produce a WC-Co composite containing dispersed diamond particles and to determine the effect of diamond particle size on the hardness and density of the composite.

Materials and Methods

The density of the sinters was measured using the Archimedes method. The properties were tested using a Hitachi S3500N SEM microscope, a FutureTech FM-700 hardness tester and a Philips PW 1140 diffractometer. The sinter was produced using ultra-fine cobalt powder, WC and diamonds with gradations of 2.5–5μm, 8–10μm and 16–20μm.

Results

The lowest relative density was characteristic of composites with the smallest diamond particle size. Composites with larger diamond gradations had much higher relative densities. As the size of the diamond particles increased, so did the hardness of the WC-Co/diamond composites. Composites containing diamond particles: 8–10μm and 16–20μm, were characterized by well-anchored diamond particles in the matrix. Images of the fracture microstructure show numerous transcrystalline breaks through the diamond particles, indicating good bonding to the matrix. The low density and hardness of composites containing 2.5–5 μm diamond particles are related to the presence of graphite, as confirmed by phase composition analysis.

Conclusions

Using the new consolidation method, a solid WC-Co/diamond composite containing 8–10μm or 16–20μm diamond particles can be obtained at 1050 °C under a load of 100 MPa.

Influence of the type of element implanted into the surface layer of WC-Co tools on the cutting forces during the milling of wood-based materials

Jacek Wilkowski [a,*], ORCID: 0000-0001-5798-6761
Marek Barlak [b], ORCID: 0000-0003-1416-7461

[a] Department of Mechanical Processing of Wood, Institute of Wood Sciences and Furniture, Warsaw University of Life Sciences, 159 Nowoursynowska St., 02-776 Warsaw, Poland
[b] Materials Research Lab, Material Physics Department, National Centre for Nuclear Research Świerk, 7 Andrzeja Sołtana St., 05-400 Otwock, Poland
[*]Corresponding author: jacek_wilkowski@sggw.edu.pl

Introduction

The cemented tungsten carbides (WC-Co), a combination the hard and brittle carbides and a relatively soft and ductile metallic binder, gives an exceptionally attractive properties such as strength, hardness, fracture toughness, refractoriness, stiffness, resistance to compressive deformation and wear resistance at room temperature as well as at higher temperatures up to 400°C.

WC-Co composites are most popular tool materials used in the wood-based material machining, in the furniture industry and wood-based panels industry, due to many properties listed above. Unfortunately, the tools life made of this material is still insufficient, especially during of the particleboard machining - the most popular in furniture.

The ion implantation is the relatively cheap, one of several methods of the surface doping materials. This is a good process for the modification of the tools, because the modified region is not an additional layer, hence no adhesion problem occurs (no delamination) and a change of dimensions and of the surface finish of the implanted material is negligible.

Nitrogen is the most common element used in the ion implantation processes and the most life-time increase (more than 100%) was observed for the tools implanted with energy of 50 keV. The mentioned above nitrogen, with the atomic mass of 14.0067 u, is a reactive gas. The research proposed the ion implantation of three noble gases, with the different atomic mass (i.e. 4.002602 u for helium, 20.1797 u for neon and 39.948 u for argon), for the similar SRIM modelled values of the projected range and the range straggling (similar depth position and similar full width half maximum of the dopant peak), to the check the cutting forces effect of the modified WC-Co tools, used in wood-based materials machining. The modelled values of the projected range and the range straggling for nitrogen implanted with 50 keV ion energy in W-C-Co material are about 44 nm. The similar values can be obtained for 63 keV neon - the gas with a similar atomic mass to nitrogen, for 125 keV argon - the popular in the laboratories and in the industry gas, with about 3- fold higher atomic mass and 13.7 keV helium, often used to alpha particles simulation of the radiation damages, with about 3.5-fold smaller atomic mass.

This approach allowed for a comparison of the effects of reactive and inert gases of similar atomic mass (nitrogen vs. neon) on the modified tool material (potential mechanisms for microstructural strengthening) and cutting forces during milling of wood-based materials. Furthermore, the effect of atomic mass on tool material properties and cutting forces was observed for three inert gases (helium, neon, and argon).

Materials and Methods

The modification of the WC-Co indexable knives by the gas ion implantation process was carried out at the Helmholtz-Zentrum Dresden Rossendorf (HZDR) in Germany according to the implantation plan shown in Table 1.

The workpieces of the three-layer particleboard with dimensions 1000×400×18 mm^3 were milled on CNC Busellato Jet 100 working center. The grooves (with the width equal to the tool diameter, i.e. 40 mm) were made in the particleboard panels on the depth of 6 mm. During the machining, constant cutting parameters (the feed speed of 2.7 m/s, the spindle speed of 18000 rpm and the feed per tooth of 0.15 mm) were maintained. Ten repetitions were made on each workpiece. The measurement of tool wear was carried out after each passage (1 m of the feed distance), using a workshop microscope. The maximum width of wear observed in clearance surface (direct, geometrical indicator VB_{max}) was estimated. The machining was stopped when the wear width was equal to or higher than 0.2 mm. This value (VB_{max} = 0.2 mm) was assumed as the tool wear criterion (Figure 4). The cutting length up to achieve the tool wear criterion was its durability indicator.

During the machining process, cutting forces were measured in real time. A three-component piezoelectric sensor (Kistler 9601) integrated with the machine's electrospindle and cooperating with a charge amplifier (Kistler 5036) was used for this measurement. This system allows for the measurement of cutting forces in three mutually perpendicular directions, aligned with the directions of the numerically controlled axes of the CNC machine. The measurement signals were digitally recorded using a National Instrument PCI-6111 data acquisition card with a sampling frequency of 50 kHz. Data acquisition and subsequent processing were performed using an application developed in the NI LabVIEW 2015 programming environment.

Tab. 1 WC-Co tool implantation plan at HZDR.

sample name	material	size	side	ion species	energy (keV)	fluence (cm^{-2})	temperature (°C)	tilt angle (°)	twist angle (°)
1-14	WC-Co	14 pc. × (2×30 mm^2)	longer clearance faces	N^+	50	5e17	RT	0	0
15-28	WC-Co	as above	as above	He^+	13.7	5e17	RT	0	0
29-42	WC-Co	as above	as above	Ne^+	63	5e17	RT	0	0
43-56	WC-Co	as above	as above	Ar^+	125	5e17	RT	0	0

Results

The analysis of results included basic statistical tests, in pairs: modified tools (subsequent variants) and control tools. Before testing the means, the assumptions of normality of the variable distribution and homogeneity of variance of the analyzed groups were verified.

For the three compared pairs of mean forces obtained for implanted tools with respect to control tools (He-K, N-K, Ne-K), the null hypothesis of equality of means in the compared groups was rejected in favor of the alternative hypothesis of statistically significant differences between the compared means. Therefore, the implantation of helium, nitrogen, and neon ions had a statistically significant effect on the mean cutting force, causing its increase (Fig. 1).

For the mean values of cutting forces with tools modified with argon ions and control tools (Ar-K), there was no basis to reject the null hypothesis of equality of means, meaning the differences between these means were not statistically significant (Fig. 1).

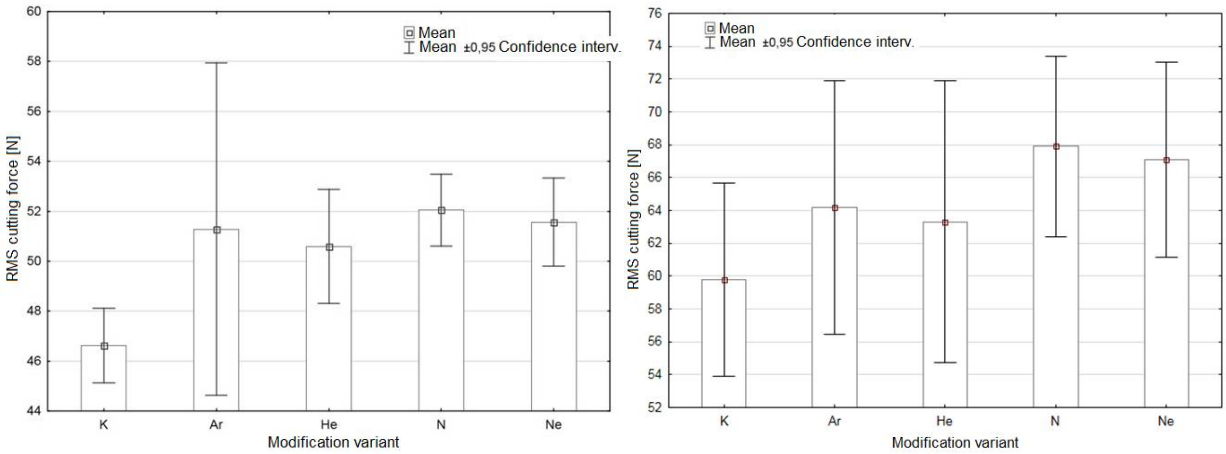


Fig. 1 Average RMS values of cutting force with a new tool (left) and throughout the tool life (right) with 95% confidence intervals for modification variants (K - unmodified tools, control, Ar - tools implanted with argon, He - implanted with helium, N - nitrogen and Ne - neon).

From the point of view of the applicability of the research results to industrial conditions, it was important to evaluate the cutting forces for throughout the tool life period, from the start of work with a new tool until it becomes blunt, i.e., the blunting criterion value VB_{max} = 0.2 mm is achieved. In this case, significant differences between the mean cutting forces were obtained for the nitrogen-implanted cutting edges compared to the control cutting edges (variants N-K). In the remaining analyzed pairs, the mean cutting forces did not differ statistically significantly (Fig. 1).

Conclusions

Implantation of gaseous ions into the surface layers of WC-Co tools significantly affects cutting forces during CNC milling of wood materials. Among the elements tested, the most significant effects were obtained for nitrogen, both for new tools and throughout the tool life.

Acknowledgement

This scientific work was funded by Polish Ministry of Science and Higher Education (No 5781/HZDR/2024/0) and by IBC at the Helmholtz-Zentrum Dresden-Rossendorf e.V., a member of the Helmholtz Association (Proposal 23003338-ST)

Modelling of the radiation damage in WC-Co and PCD tools used in wood processing

Marek Barlak[a,*], ORCID: 0000-0002-7942-3959
Jacek Wilkowski[b], ORCID: 0000-0001-5798-6761
Jerzy Zagórski[a], ORCID: 0000-0001-6311-947X

[a] Materials Research Lab, Material Physics Department, National Centre for Nuclear Research Świerk, 7 Andrzeja Sołtana St., 05-400 Otwock, Poland
[b] Department of Mechanical Processing of Wood, Institute of Wood Sciences and Furniture, Warsaw University of Life Sciences, 159 Nowoursynowska St., 02-776 Warsaw, Poland
[*]Corresponding author: marek.barlak@ncbj.gov.pl

Introduction

Radiation damage occurs when energetic particles, like protons, neutrons or ions, interact with a material, displacing atoms from their lattice sites to form defects like vacancies or interstitial clusters, altering its microstructure and physicochemical properties. Radiation damage are an important problem for the materials used near the sources of radiation, like nuclear reactors but may be useful in the process of the tools modification [1].

Displacement per atom (dpa) is an unit, which quantifies radiation damage in materials by measuring the average number of times an atom is displaced from its normal lattice position by energetic particles, from the initial collision event until it's no longer energetically possible for the displacement to persist. It is a crucial parameter for predicting the operating lifetime and material integrity of components in nuclear reactors and other radiation environments. For example, the value of 1 dpa (in bulk) can be obtained in nuclear reactor per 1 year. On the other hand, the value of e.g. 150 dpa can be obtained using the ion implanter per 1 day, but for the near-surface region with the thickness from tens to hundreds of nanometers

Materials and Methods

W-C-Co material (substitute of WC-Co composite), including 47.4 at.% W, 47.4 at.% C and 5.2 at.% Co, with the density of 15.2 g/cm^3 and C material (substitute of PCD - Polycrystalline Composite Diamond), including 100 at.% C, with the density of 3.86 g/cm^3 were adopted as the substrate materials to the modelling.

The chemically active nitrogen with the atomic mass of 14,0067 u and three chemically neutral noble gases like: helium (4,002602 u), neon (20,1797 u) and argon (39,948 u) were used as an implanted elements.

The implanted fluence of 5e17 cm^{-2} was applied as a reference value. The energy of nitrogen ions was 50 keV. The energies of noble gas ions were different and calculated to obtain the depth profiles of the implanted ions, similar to nitrogen depth profile. For the simplicity, the sputtering yield values were omitted at the modelling.

SRIM - The Stopping and Range of Ions in Matter [2], freeware type code was used for the modelling of the depth profiles of implanted ions and other necessary data. The displacement per atom was calculated according to the procedure presented by Wyszkowska et al. [3].

Results

The similar shapes and positions of the depth profiles were obtained for the following ions energies: 50 keV for nitrogen, 13.7 keV for helium, 63 keV for neon and 125 keV for argon in the case of W-C-Co substrate material. These values were following: 50 keV for nitrogen, 12.3 keV for helium, 58.5 keV for neon and 118 keV for argon in the case of C substrate material.

Figure 1 presents the modelling results, obtained for W-C-Co (left) and C (right) substrates, for the same scales, for the easier comparison. The depth profiles of the implanted ions were marked by the continuous lines. The damage profiles were marked by the continuous lines with points.

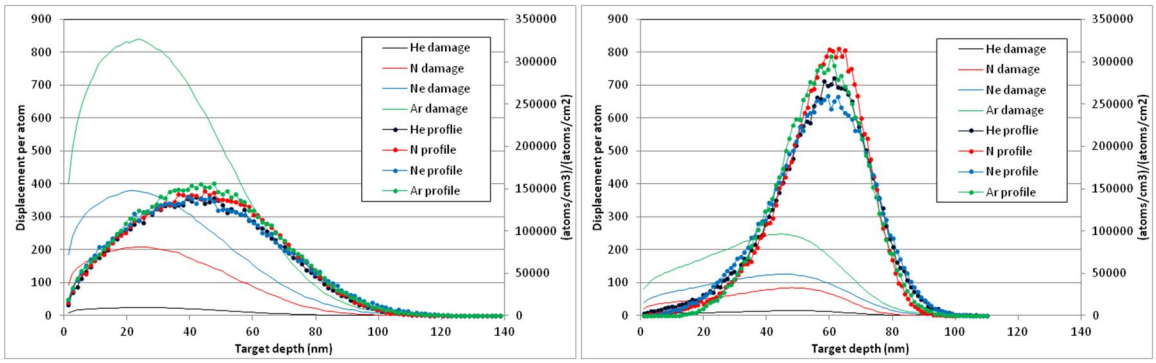


Figure 1. The modelling results, obtained for W-C-Co (left) and C (right) substrates

Conclusions

The obtained results strongly depend on the density of the implanted material and the mass of the implanted ions. The differences are observed for all parameters of the depth profiles of implanted ions, like: projected range, range straggling, peak volume dopant concentrations, kurtosis, skewness. The similar situation is observed for the calculated damage profiles.

References

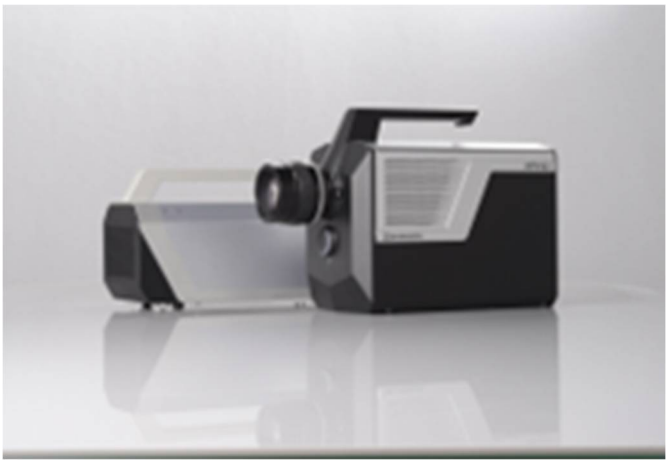
[1] https://doi.org/10.32086/biuletyn.2022.03
[2] http://www.srim.org/
[3] https://doi.org/10.1016/j.jnucmat.2023.154565

Badania z wysokim naprężeniem dynamicznym dla inżynierii materiałowej za pomocą maszyny Shimadzu HITS-X, kamery HPV-X2 i cyfrowej korelacji obrazu

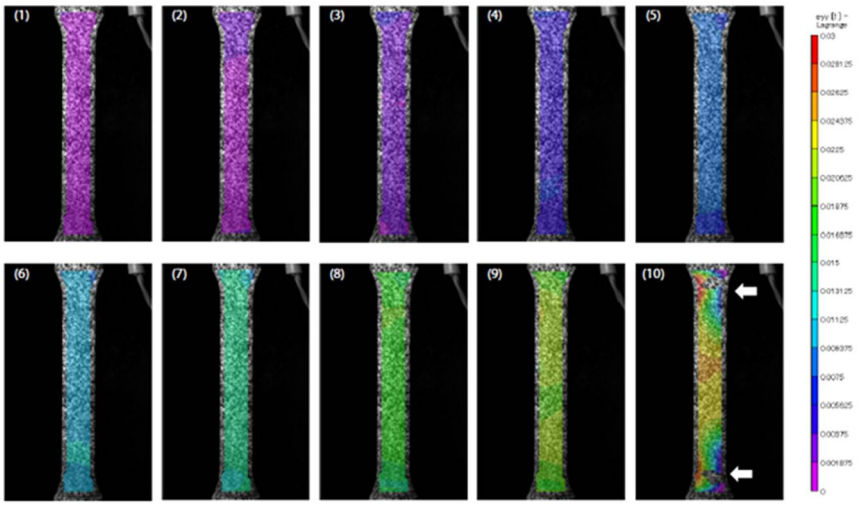
Jan Podgórski

[a] Przedstawiciel naukowy, firmy Shim-Pol, E. Borzymowska-Reszka A. Reszka Spółka Jawna, ul. Kochanowskiego 49A, 01-864 Warszawa, e-mail: janp@shim-pol.pl

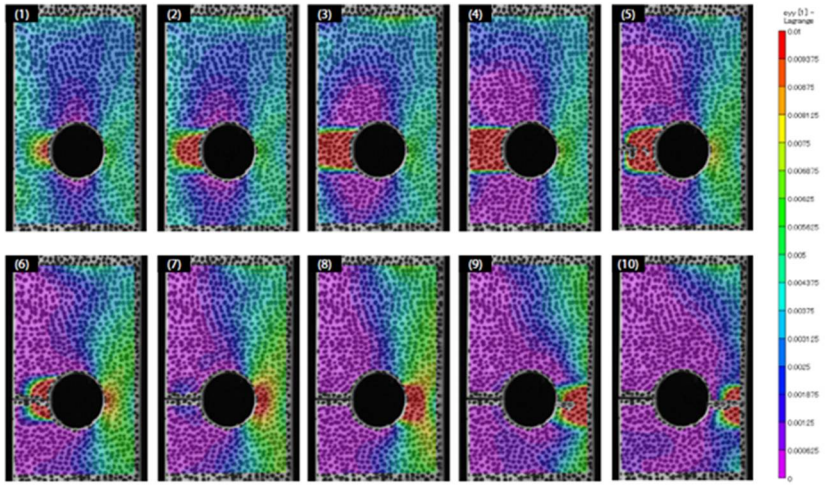
Zastosowanie materiałów kompozytowych stale ewoluuje, wymagając dalszego rozwoju i optymalizacji właściwości mechanicznych tych materiałów. W przeszłości stosowano szereg strategii, wybierając różne rodzaje włókien, żywic i innowacyjne orientacje geometryczne tych wzmocnionych włóknami tworzyw sztucznych. W dzisiejszej dyskusji skoncentrujemy się na żywicach polimerowych i ich zachowaniu podczas dynamicznego odkształcania. Wiadomo, że właściwości mechaniczne materiałów polimerowych wykazują zależność od prędkości odkształcenia. Aby prawidłowo obserwować zachowanie podczas pękania i charakterystykę naprężeń, zastosowano najnowocześniejsze technologie. Ultraszybka kamera wideo HPV-X2 firmy Shimadzu (10 milionów klatek/sekundę) w połączeniu z maszyną wytrzymałościową Shimadzu HITS-T10 (z dynamicznym rozciąganiem 20 metrów/sekundę) i oprogramowaniem DIC (CKO) zostały wykorzystane do wizualizacji koncentracji naprężeń, postępów pękania i spadków naprężeń po inicjacji pęknięcia. Te zaawansowane narzędzia umożliwiają naukowcom i inżynierom materiałowym optymalizację materiałów polimerowych stosowanych w kompozytach w celu poprawy ich właściwości w wymagających warunkach.



Rys. 1. Ultraszybka kamera Shimadzu HPV-X2



Rys. 2. Wyniki analizy DIC próbki testowej (wiosełka), rozkład naprężeń w kierunku wzdłużnym



Rys. 3. Wyniki analizy DIC próbki testowej (z otworem), rozkład naprężeń w kierunku wzdłużnym